


A VIEW OF SURYANAMASKAR FROM ITS FOUNDATION TO ITS APPLICATION TO HEALTH

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Suryanamaskar is considered a part of modern-day yogic practices though it was neither considered an asana nor a part of traditional Yoga. Practicing Suryanamaskar before beginning routine activities vitalizes the practitioner and gives a completely energized day. Starting from the Raja of Aundh who first introduced suryanamaskar, there is a line of eminent people who popularized this dynamic group of asanas including Krishnamacharya, Swami Sivananda, Swami Satyananda from Bihar school of Yoga, so on and so forth. Their contributions resulted in this excellent series of Asanas being introduced to the practitioners. Such a miraculous group of postures also involves dynamic breathing patterns at each posture and gives a form of complete practice involving asanas and pranayama. There are a total of 12 postures in Suryanamaskar practice and 24 steps in one round. This is in the form of salutation to the "Sun" along with chanting the twelve names of the sun god. In this review, we accentuate the importance of Suryanamaskar highlighting its effects on physical, psychological and physiological aspects of the body based on published research. In addition, the usefulness of suryanamaskar as one complete sadhana for the whole body is emphasized. © 2021 The Authors. Published by Elsevier B.V. on behalf of Institute of Transdisciplinary Health Sciences and Technology and World Ayurveda Foundation

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01. Introduction Every day for all living beings begins with the sunrise for there is no life on earth without the sun. The Sun is indeed worshipped as a god in various cultures by the name of Mithras in Persians, Apollo in Greeks, Osiris in Egyptians, and Surya in the vedic period of India and so on [1]. In Ramayana, Sage Agasthya advised Lord Sri Rama to worship the sun god by chanting Aditya Hridayam to achieve victory in his encounter with the demon king Ravana. These verses depict the various forms and names of the sun god, praising his glory and his 12 forms (signifying the shape of 12 months of a year) in the Yuddha Kanda of Ramayana [2]. The sun is considered as the Pratyaksha swarupa (the ultimate power visible to the eye), which represents truth, a manifestation of knowledge, and the giver of intellect & prosperity. The sanctity of the sun god is explained in a chapter containing 132 verses named 'Surya namaskar' in Taittiriya Aranyaka under Krishna Yajur Veda. This is being chanted as a ritual practice among South Indians along with the performance of namaskara (salutation) at the end of each verse [3]. In present times Suryanamaskar is both a physical as well as a spiritual practice. It was inserted into yogic practices owing to its immense potential in maintaining the practitioner's physical and mental health which is the basic requirement for higher yogic practices. We reviewed this spectacular practice of various schools through standard textbooks published by the respective schools and highlight its importance in disease management through research articles indexed in PubMed/Scopus/web of science.

02. Origin of Suryanamaskar

'Suryanamaskar' or the 'sun salutation' a set of dynamic postures, is considered neither an Asana nor a part of traditional Yoga. Suryanamaskar is a complete physical exercise that is believed to be conceived and propagated by the King of Aundh, Late Shrimant Balasaheb Pant Pratinidhi in the 1920s [4] and later by Sri K V Iyer, and Sri Krishnamacharya. The Danda exercises explained in Vyayama Dipika were found to be the basis for Suryanamaskar models presented by Sri Krishnamacharya [5]. Dandaal is an ancient common and important physical training practiced in India by wrestlers, and

Martial artists. The pushups used for bodybuilding purposes in western countries could have been originated from Dandaal. The similarities between Dandaal and Suryanamaskar are schematically represented in Fig. 2 and explained later. Suryanamaskar became a traditional blend of the practice of two different systems such as physical culture and Yoga and thus it heads out to be the forerunner practice of modern-day physical exercises [6]. Further simplified versions were used by other schools of Yoga including Swami Sivananda Yoga Vedanta center, Bihar School of Yoga (BSY), Swami Vivekananda Yoga Anusandhana Samsthana (SVYASA) and were progressively incorporated into modern-day yogic practices.

▪ *The twelve-step way to health (BSY tradition)*

Suryanamaskar of BSY tradition comprises of twelve steps (which constitute half a round) (Table 1) consists of three backward bending and two forward bending postures. To complete one round, the positions are repeated, except Ashwasanchalanasana done with the opposite (left or right) side of the body part in the second half [7] (Fig. 1). Each step is performed with a coordinated breathing pattern along with the physical posture. It starts with normal breathing at step 1. With the chest expansion during backward stretching (steps 2, 4, 7, 9 & 11) the practitioner inhales. While contracting the chest, during forward bending (steps 3, 5, 8, 10 & 12) the breath is to be exhaled. While in Ashtanga namaskara (position 6) where the chest area is in contact with the floor, no movement of air is possible and the breath is held out. The sequence of the dynamic postures as per BSY tradition is schematically depicted in Fig. 2 highlighting the fact that, when steps 5, 6, and 7 are considered alone they represent a complete physical practice similar to Dandaal as mentioned earlier. The design of the postures are in such a way that they help the lungs to breathe naturally at their own pace with alternating inhale and exhale patterns. Therefore, the dynamic postures help the practitioner to improve the lung capacity by the regular practice of surya namaskar [7].

▪ *Suryanamaskar mantras and Beeja mantras*

The practitioner chants the twelve names of Surya while performing the Suryanamaskar (Table 1) [7]. Beeja Mantras are the alternatives for the twelve names of the sun, which does not have any meaning as such but yields tremendous vibrations and energy to the body and mind.

Beeja mantras are generally used during fast Suryanamaskar where chanting of twelve names is difficult. These are chanted four times repeatedly during the performance of one complete round of Suryanamaskar. The twelve steps involved in this group of Asanas as per Bihar School of Yoga tradition, the mantras and Beeja mantras along with the associated Chakra for each posture have been tabulated in Table 1

03. Suryanamaskar from other schools of Yoga

▪ Krishnamacharya Vinyasa Yoga tradition

This comprises thirteen Vinyasas (postures). The first Vinyasa is Samasthiti/pranamasana and then Tadasana/Hasta uthanasana. This is followed by Uttanasana/Pada hasthasana, and Utkatasana (hip stretch pose). Then the practitioner lifts the heels and jumps landing on big toes to Chaturanga dandasana. Then comes the Danda samarpana (complete surrender; similar to Ashtanga namaskar). Coming back from this posture to again Chaturanga dandasana, the practitioner performs Urdhwa mukha swanasana (similar to Bhujangasana), and then Adhomukha swanasana (Parvatasana). Then this is followed by Utkatasana, Uttanasana (Pada hasthasana), Tadasana and Samasthiti (Fig. 3). The performance of correct breathing and chanting of mantras while achieving a posture is strictly emphasized in Krishnamacharya Yoga. The practitioner starts with inhalation and breath is held during Samasthiti and focus shifts on the first mantra, and then inhaling smoothly while raising the arms for Tadasana, and the breath is held while chanting the mantra. Then exhalation while achieving Padahasthasana, inhale and then exhale while bending the knees to reach Utkatasana. The breath is held as a general rule in every posture while mentally chanting the mantra. Then the yogis/yoginis inhale and hold their breath while lifting the heels till landing on Chaturanga dandasana. While on this posture the practitioner exhales and breath is held out and then slowly exhales while changing from the previous posture to Danda samarpana [8]. Though there are some more variations of Suryanamaskar in this tradition we have considered the most common and easier version to compare it with other traditions.

▪ Sivananda Yoga Vedanta Centre tradition

This series includes Phalakasana as step 5 instead of Parvatasana during which the breath is held, and step 8 is named Adhomukha svanasana

Instead of Parvatasana (Fig. 4). The method and breathing patterns of the rest of the postures are similar to the Bihar School of Yoga tradition [9].

▪ Swami Vivekananda Kendra tradition

This tradition has 12 steps similar to the Bihar school of Yoga. It starts with Hastha uthanasana (step 1), Padahasthasana (step 2) and Ashwasanchalanasana (step 3) followed by Phalakasana or Dandasana (step 4). Then step 5 is Shashankasana followed by Shashtanga namaskara (step 6) where eight parts of the body touch the floor. Steps 7 and 8 are the same as that of the Bihar school of Yoga tradition. Step 9 is Shashankasana, which is followed by Ashwasanchalanasana (step 10), Padahasthasana (step 11), Pranamasana (step 12). During Phalakasana the practitioner exhales, during shashankasana, the practitioner inhales while going back and exhales on achieving the final position, while external retention during Sashtanga namaskara. Breathing patterns for all other postures are the same as Bihar School of Yoga mentioned earlier [10] (Fig. 5)



Fig. 1. Pictorial representation of Suryanamaskar postures (Bihar School of Yoga tradition): Final position of each step of Suryanamaskar of Bihar school of yoga tradition. Numbers (1e12) represents the number of each step as given in Table 1. Picture obtained and modified from Swami Satyananda Saraswathi, Asana Pranayama Mudra Bandha [7]

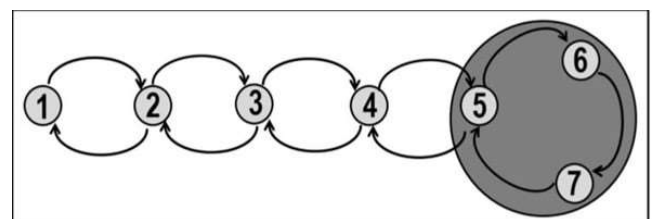


Fig. 2. Schematic representation of surya namaskar postures (Bihar School of Yoga tradition): Schematic of steps of Suryanamaskar of Bihar school of Yoga tradition numbered as per the sequence. Arrow indicates the flow of steps in the respective direction. 1. Pranamasana; 2. Hasta utthanasana; 3. Pada hasthasana; 4. Ashwasanchalanasana; 5. Parvatasana; 6. Ashtanga namaskara; 7. Bhujangasana. Steps 5, 6 & 7 highlighted within the circle by themselves fulfill the steps of Danda practice

▪ **Benefits of Suryanamaskar**

▪ *Physical and physiological benefits*

The mightiness of the sun and its energy if extracted properly gives great benefits to humankind. The dynamic movements in each step of Suryanamaskar make the body contract and expand its muscles alternatively and tone up the joints. This makes the stagnant blood at the inactive muscles and joints to be redirected back to the kidneys and lungs for purification. Regular practice of Suryanamaskar ensures proper and efficient functioning of not only the muscles and joints of the body but also stimulates the internal organs. Especially the stomach and other abdominal organs as it involves alternative stretching and compression at the abdominal area. Suryanamaskar also improves peristalsis of the intestines, stimulates blood circulation throughout the body, massages, and tones up kidneys so that wastes are efficiently eliminated from the body at ease, and helps the body to eliminate toxins through increased perspiration. Toxin elimination is an important process to maintain healthy skin and thus helps prevent skin diseases. Suryanamaskar enhances the gaseous exchange at alveoli and thus improves the rate of respiration. The immune system protects the body against the disease-causing agents by the production of antibodies and other mechanisms. Suryanamaskar increases the efficiency of the immune system [1]. Suryanamaskar increases the mobility of almost all the joints of the body evident from kinematics studies using three-dimensional motion capture in ten healthy Yoga practitioners [11]. Different poses of Suryanamaskar are reported to produce specific muscle activation patterns depending on the practitioner's skill levels [12]. Improvement in physical fitness of school children with Suryanamaskar practice was evaluated using cardiovascular parameters and pulmonary function. Improvement in muscle strength, involvement of isometric contraction, and chest expansion during different postures of Suryanamaskar have been reported. The effects of Suryanamaskar performed at different speeds revealed that fast pace Suryanamaskar is more similar to aerobic exercise and owing to increased muscle endurance and power. Whereas effects of slow pace practice led to a decline in cardiovascular parameters to normal levels similar to Yoga training [13]. Body mass index (BMI) is an important index

For body muscle mass. BMI exceeds the normal levels in obese individuals [14]. The minimum energy production needed for the maintenance of cellular metabolism when the body is in the basal condition is called Basal metabolic rate (BMR) [15]. Surya namaskar is suggested as an ideal exercise to attain optimum physical fitness in college students. A significant increase in muscle strength & endurance and a significant decrease in body fat and BMI was reported [16]. Effect on BMR of healthy Yoga practitioners through a combination of stretching, supine, prone, and sitting postures in which includes Padahasthasana (step 3) and Bhujangasana (step 7) of BSY Suryanamaskar were evaluated. This study revealed a significant decrease in BMR owing to the reduced arousal as a result of the

Table 3
Name of the postures in Suryanamaskar, respective Beja Mantra/Mantras to be chanted, and corresponding Chakra to be concentrated [1].

Steps	Name of the Posture	Beja Mantra/Manttra	Associated Chakra
1	Pranamāsana (prayer pose)	Om Hraam/Om Ahraam Namah	Anahata
2	Hasta Urdhvasana (raised arms pose)	Om Hraam/Om Ahraam Namah	Vishuddhi
3	Padahasthasana (hand to foot pose)	Om Hraam/Om Suryaya Namah	Saandharana
4	Adhva Sanchalanasana (sequence pose)	Om Hraam/Om Bhavaya Namah	Ajaya
5	Parvatasana (mountain pose)	Om Hraam/Om Kshayaya Namah	Vishuddhi
6	Ardhanga Namaskara (salute with eight parts or points)	Om Hraam/Om Parbhaya Namah	Mangarya
7	Bhujangasana (cobra pose)	Om Hraam/Om Anantayagaya Namah	Saandharana
8	Parvatasana (mountain pose)	Om Hraam/Om Marichaya Namah	Vishuddhi
9	Adhva Sanchalanasana (sequence pose)	Om Hraam/Om Adityaya Namah	Ajaya
10	Padahasthasana (hand to foot pose)	Om Hraam/Om Savitrya Namah	Saandharana
11	Hasta Urdhvasana (raised arms pose)	Om Hraam/Om Ahraam Namah	Vishuddhi
12	Pranamāsana (prayer pose)	Om Hraam/Om Bhavayaya Namah	Anahata

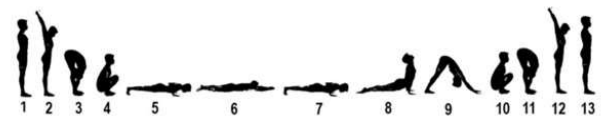


Fig. 3. Pictorial representation of Krishnamacharya Vinyasa Suryanamaskar. Pictorial representation of the flow of postures of Suryanamaskar as per Sri Krishnamacharya Vinyasa tradition. 1. Samasthiti/pranamāsana 2. Tadasana/hasta uthanasana, 3. Uttanasana/pada hasthasana, 4. Utkatasana (hip stretch pose), 5. Chaturanga dandasana. 6. Danda samarpana, 7. Chaturanga dandasana, 8. Urdhwa mukha swanasana, 9. Adhomukha swanasana (Parvatasana), 10. Utkatasana, 11. Uttanasana (Pada hasthasana), 12. Tadasana, 13. Samasthiti. Picture adapted and modified from Ramaswami S. The complete book of Vinyasa yoga [8].

Long-term practice of Yoga [17]. Healthy life demands proper maintenance of BMI and BMR in every human being. This could be achieved just by practicing Surya namaskar regularly. Cardio-respiratory illness is considered a common disorder in day-to-day life. Every human being strives hard in their way to protect their heart and its function by walking, physical exercise, Yoga practice, going to the gymnasium, etc. Reports are evaluating cardiorespiratory responses during Suryanamaskar

Practice in Yoga practitioners [18,19]. Coronary artery disease patients were evaluated for various parameters pre and post-Yoga practice with a set of asanas including Bhujangasana (step 7) and Hasta utthanasana (step 2). This study reported a significant decrease or alteration in various associated physiological parameters namely heart rate, body fat, cholesterol, triglycerides, and LDL levels emphasizing the importance of these Asanas in such patients [20]. Suryanamaskar is recommended as a practice to improve cardio-respiratory efficiency both for healthy individuals and cardiac patients [21]. The practice of a panel of 5 Asanas including Bhujangasana (step 7) showed no significant difference in the systolic time intervals measured in 5 healthy regular Yoga practitioners. This report emphasized that the changes produced in cardiac function during the practice are within the normal functional limit of the heart [22]. Further, Suryanamaskar is suggested as an activity of optimal stress on the cardiorespiratory system. Total energy consumption of 13.91 kcal with an average of 3.79 kcal/min for one complete round of Suryanamaskar was observed in male volunteers from the Indian Army. Oxygen consumption was reported to be the highest while in Bhujangasana [23]. Another study in a 60 kg individual reported the expenditure of 230 kcals of energy/30 min practice session with four rounds of Suryanamaskar [24]. It is inferred that Age, weight, pace, and deep breathing impacts the energy expenditure which tends to vary for each scenario.

- *Effects on endocrine functions*

Suryanamaskar is often considered as a bridge between Sukshma Vyayama (Loosening Exercises) and the practice of other advanced Asanas and Pranayamas. It helps to relieve any kind of mental disturbance. Imbalance in mental health is often associated with or leads to an imbalance in hormones and thus it manifests as a disease or syndrome e.g. Diabetes, Thyroid dysfunction, and so on. Endocrine glands are toned and massaged by regular practice of this excellent group of Asanas. Suryanamaskar stimulates the brain centers and the associated nerve fibers running throughout the body. It is emphasized that in addition to the benefits that these group of Asanas bestows to each physiological system in the body, it also provides a balance between the circulatory, respiratory and endocrine systems with one another and thus helps in the prevention of diseases and so on [1].

During the performance of any Asanas, it is commonly recommended to concentrate on a particular point or the breath for the fact that Yoga is defined as the union of body, mind & breath. These points are the psychic centers and are referred to as 'Chakras'. Endocrine glands and the major nervous plexuses are often associated with the Chakras at the physical level. The Chakra means a 'whirlpool' or a 'vortex'. Chakra lies dormant and inactive in most people and by yogic practices the flow of energy through the Chakra can be stimulated and they can be activated. Each Chakra is connected to the 'nadis' which are the network of psychic channels. Most important Chakras are seven in number and located along the energy channel 'Sushumna' which flows through the center of the spinal cord. The Chakras are depicted as lotus flowers with a distinct number of petals and characteristic colours. The name & location of the seven Chakras and the physical correlation with the glands are tabulated in Table 2 [7,25].

As a general fact, while performing Asanas whichever part of the body is involved, the organ/gland in that particular area is induced to function better. Likewise, during Suryanamaskar performance it is a well-known fact that the concerned endocrine glands are stimulated. Chatterjee & Mondal [26] reported the levels of Serum Growth hormone and Dehydroepiandrosterone (DHEAS) in the yogic training group when compared to the control group. In the yogic training group in which Suryanamaskar is also one of the practices along with other Asanas and Pranayama, a



Fig. 4. Pictorial representation of Suryanamaskar (Sivananda Yoga Vedanta Centre tradition): Pictorial representation of the flow of postures of Surya namaskar as per Sivananda Yoga Vedanta Centre tradition. 1. Pranamasana; 2. Hasta utthanasana; 3. Pada hastasana; 4. Ashwasanchalanasana; 5. Phalakasana; 6. Ashtanga namaskara; 7. Bhujangasana; 8. Adho mukha svanasana; 9. Ashwasanchalanasana; 10. Pada hastasana; 11. Hasta utthanasana; 12. Pranamasana [9].

Significant increase in GH and DHEAS levels was reported when compared to the control group.

Suryanamaskar is reported to activate all glands in the body including pituitary and adrenal glands both of which are responsible for positive neuroendocrine feedback for proper maintenance of GH and DHEAS levels [26]. Moreover, the pituitary gland is said to be the master gland controlling the switching on/off of functioning of all other glands/ organs. Anterior pituitary hormones are tropic hormones that stimulate the secretion of hormones from concerned target organs/glands [14]. This fact could be a probable indirect explanation that the practice of Suryanamaskar modulates the functioning of endocrine glands and thus improves the energy metabolism and paves way for postponing the aging process. However further scientific research evidence is needed to establish the direct connection between the performance of each step of Surya namaskar and the glands concerned.



Fig. 5. Pictorial representation of Suryanamaskar (Swami Vivekananda Kendra tradition): Pictorial representation of the flow of postures of Suryanamaskar as per Swami Vivekananda Kendra tradition. 1. Hastha uthanasana; 2. Padahathasana; 3. Ashwasanchalanasana; 4. Phalakasana or Dandasana; 5. Shashankasana; 6. Shashtanga namaskara; 7. Bhujangasana; 8. Parvatasana; 9. Shashankasana; 10. Ashwasanchalanasana; 11. Padahathasana; 12. Pranamasana [10]

05. Proposed daily practice of Suryanamaskar

We propose the daily practice schedule for various age groups. Starting from children, who are generally active and limitless flexibility, could be involved in fast or slow pace Suryanamaskar depending on their energy levels, need, and body conditions. Teenagers who have active metabolic patterns and are healthy are recommended to perform 12 to 24 rounds of Suryanamaskar followed by Yoganidra (Complete Relaxation Practice) and Pranayama. Middle-aged people are often down with lifestyle disorders these days and they are recommended 6e12 rounds of Suryanamaskar followed by Yoganidra, Pranayama, and meditation. Old age people who are below 70 years can practice Surya namaskar according to their comfort level both with regards to the number of rounds and the postures. These are suggested daily practices for the different age groups of people;

However, the concerned practitioner should consider the contraindications involved for any of these proposed practices according to their body conditions. The proposed practice is only a guideline for those who lead a normal life, however, spiritual aspirants who used to practice more than the stated rounds may stick to their schedule (personal communication).

Table 2
Chakras and anatomical location in the human body [7].

Chakra	Anatomical Location	Physically correlated glands
Mooladhara	Perineum	Gonads
Swadhisthana	Coccyx	Genital organs
Manipura	Navel	Gastric glands, Pancreas, Adrenal
Anahata	Heart	Thymus
Vishuddhi	Throat	Thyroid
Ajna	Top of spine	Pineal
Sahasrara	Crown of the head	Pituitary

06. Disease management with Suryanamaskar

The practice of Suryanamaskar for a prescribed number of rounds has been an integral part of the yogic management of many diseases such as ulcer, constipation (up to 12 rounds), malabsorption states (up to 10 rounds with full awareness of abdominal breath), tonsillitis, diabetes (up to 12 rounds at 4th week of practice), hepatitis (3e7 rounds at sunrise) obesity, Musculoskeletal system and joints (with specific prescriptions based on the disease condition) and menstrual disorders (to increase the vital energy and to balance nervous & endocrine functions) and the list goes on. Men with reproductive disorders are advised up to 12 rounds after a cold shower. Suryanamaskar is suggested to be effective when performed early in the morning facing the newly rising sun. Such practice improves skin health and helps in the management of skin disorders when the sweat is allowed to dry on the body surface while relaxing in Shavasana post-practice [27]. Yogic intervention proved beneficial in a therapeutic viewpoint in treating diarrhea-predominant irritable bowel syndrome in a study conducted by AIIMS, India. In comparison with conventional treatment, yogic treatment showed enhanced parasympathetic reactivity proving it to be beneficial for the patients. This study involved a set of 12 Asanas including Padhahastasana (step 3) [28]. Obesity is an important health concern which is proved to be a risk factor for many diseases. Obese females showed a significant reduction in mean body weight, body fat, improvement in muscle mass, and upper limb muscle endurance post Suryanamaskar practice. These parameters point to Suryanamaskar as an

Effective way to manage weight and physical fitness and improving cardiorespiratory fitness [29]. Thus, from a therapeutic viewpoint, this practice has immense potential as a one-man army to manage diseases like obesity and so on. The summary of research on Suryanamaskar towards disease management and the corresponding outcome has been listed in Table 3.

07. Discussion

Health is defined as “a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity” according to the definition of WHO [30]. The main purpose of Yoga is to achieve and maintain this state of health as defined. In contrast to all other Asanas which work on a particular part of the body, Suryanamaskar is a complete Health capsule for the whole body. We observe from the above discussions that, Suryanamaskar helps in mobilizing the joints and in increasing one's physical stamina by enabling them to breathe to their fullest capacity. Most importantly, it helps them to preserve the health of the spine by allowing them to sustain comfortably in sitting postures for a longer time during the practice of pranayama and meditation. Suryanamaskar is generally practiced as a capsule with other yogic.....

Table 3 (continued)

Study	Study design	Population type, size (n)	Intervention	Comparator	Outcomes	Conclusion
Rhavanan AB et al., 2013	Cohort (Observational) study	Female volunteers from yoga class, 21	Suryanamaskar – 3 rounds and 5 min of quiet sitting in both groups	Experimental controls not participating in Yoga were compared to Yoga training group	Significant increase in heart rate following the practice compared with both external and self-control.	Surya Namaskar is suggested as an effective means to improve neuromuscular abilities
Chatterjee S & Mondal S, 2014	Randomized controlled trial	Untrained volunteers, 45	Suryanamaskar, Shuklabhjaras, Kripas, Anam, pranayama, meditation for 12 weeks. Three combinations comprising of above practices were used. Suryanamaskar, pranayama, meditation 1 h daily for 11 months	Practitioner group compared with control group for 12 weeks	Significant increase in basal levels of GH and IGFAS in blood.	Surya namaskar stimulates all glands and contributes to promote healthy aging.
Sinha B & Sinha TD, 2014	Prospective longitudinal cohort study	Army soldiers, 9	Suryanamaskar, pranayama, meditation 1 h daily for 11 months	Comparison after 3, 6 and 11 months of training	Significant fall in oxygen consumption, heart rate, and carbon dioxide output in 11 months compared to previous phases.	Conditioning of cardio respiratory parameters, no significant reduction in breathing rate across the three phases of training
Ni Met al., 2014	Mixed repeated-measures descriptive study	Trained healthy Yoga practitioners, 30	Suryanamaskar A & B	11 poses of suryanamaskar A and B performed separately for 15 sec, and electromyography were recorded.	Activation of specific muscle groups based on practitioner's skill levels.	Information obtained can be used in designing rehabilitation program.
Jakkhota KA et al., 2015	Comparative controlled study	Obese females, 119	Suryanamaskar	Comparison of circuit training (CT), treadmill walking and modified Suryanamaskar (SN) with control	All three methods were effective in weight and physical fitness management. SN and CT more effective in improving cardio respiratory fitness and upper limb muscle endurance. Only SN was effective in improving body flexibility.	Compared to other two methods Surya Namaskar showed better results in all parameters analyzed such as weight management, cardio respiratory fitness and body flexibility.
Pakarti B et al., 2015	Randomized controlled trial	Individuals with Chronic schizophrenia, 30	Suryanamaskar, 90 min/day for 1 month	Comparison of yoga therapy with pharmacotherapy	After 1 month yoga intervention group showed better rating in Positive and Negative Syndrome Scale (PANSS) variables than pharmacotherapy group.	Yoga practice improves psychopathology resulting in better quality of life.
Gudra AS et al., 2015	Randomized controlled trial	College students, 419	Suryanamaskar for 14 days	Experimental compared to control group (non yoga group)	Significant reduction of reactive oxygen species levels, increase in sperm motility and sperm count, decrease in DNA fragmentation index post 21 day yoga sessions.	Surya Namaskar is effective in leading to R – Disposition like physical relaxation, mental quiet etc and negative emotions as a dispositional level
Dikhan V et al., 2018	Controlled trial	Men volunteers, 42	Lasting practices, Suryanamaskar, Anasana, pranayama, and meditation for 120 min for 21 days.	Comparison between start and end of yoga sessions after 21 days.	Significant reduction of reactive oxygen species levels, increase in sperm motility and sperm count, decrease in DNA fragmentation index post 21 day yoga sessions.	Yoga based lifestyle intervention improves pregnancy outcomes and improves health trajectory of the offspring.
Mullerpratt RP et al., 2019	Cross sectional study	Trained healthy yoga practitioners, 10	Suryanamaskar, 5 rounds, traditional school type and non-traditional school type.	Joint angles of spine, upper and lower extremities were computed.	Principal motion occurs in sagittal plane and joint motion was mostly symmetrical in most of the poses.	Suryanamaskar holds potential to increase the mobility of almost all joints.
Chatterjee S et al., 2021	Quasiexperimental research design and convenient sampling method	Middle aged Healthy volunteers, 86	Kripas, surya namaskar, anam, pranayama, and meditation for 120 min for 6 days/week for 12 weeks.	Standing height, body weight, body mass index, visual reaction time (RT), auditory RT (attention and alertness), and short-term memory were assessed day 1 (pre), 6th week (mid), and 12th weeks (post) of intervention.	Significant increase in alertness, attention and short term memory	Yoga intervention has promoting effects on neurocognitive abilities and thereby promote successful aging.

Practices like Asana, Pranayama, and meditation, however, we limit our discussion to Suryanamaskar as the main practice. According to the yogic system, the best way of breathing is yogic breathing (also known as conscious breathing) which involves expansion of the chest, shoulder as well as abdomen. This helps not only in getting more oxygen to the body but also in breathing out carbon dioxide to the fullest possible capacity. The breathing component incorporated in surya namaskar serves this purpose by aiding the lungs to function to their maximum ability and naturally helps the practitioner to lengthen the inhalation and exhalation duration to achieve the ratio of inhaling and exhale patterns that are often emphasized in Pranayama practice. The major way of eliminating toxins from the body is breathing out, which is corrected and enhanced by the continuous practice of Suryanamaskar. Physical health goes hand in hand with the mental health of a person in line with the proverb “A sound mind in a sound body”. Studies with Schizophrenia patients suggested that Yoga therapy along with conventional medical treatment could improve their psychic states. And thus, it is evident that Surya namaskar works not only at physical, physiological levels but also at the psychic levels of the practitioner [31]. From the scientific point of view, it improves the metabolic functioning of the body and regulates the secretions of the glands. Therefore, it is very clear that the practice of Suryanamaskar

Table 3 Disease management with Suryanamaskar [11–13,30–34,36,37,38,41–44]

Study	Study design	Population type, size (n)	Intervention	Comparator	Outcomes	Conclusion
Srinivasan TM,1990	Cohort (Observational) study	Healthy male volunteers, 5	Bhujangasana, Sirsasana, Sirsasana, Pranayama, Pawanmuktasana, Bhujangasana, Tristambha	Five-Asana, after 1 min stay, after 2 min stay, Post Asana	Changes in the cardiac function post practice were well within the normal functioning limits of the heart.	Emphasizes the importance of systematic interval studies during asana practice.
Sinha B et al., 2004	Comparative controlled study	Male volunteers from Indian Army, 21	Hectic yoga asana: (28 min, kapal bhairi a) yoga study for 2 min, each. Surya namaskar pranayama (10 min), meditation (5 min) for 3 months	Oxygen consumption, energy expenditure and percentage energy allocation in each posture compared with total energy expenditure	Throughout the practice a practitioner remains within the lactate anaerobic threshold	Surya namaskar exerts moderate stress on cardio respiratory system, and thus an ideal form of aerobic exercise
Tareja I et al., 2004	Randomized controlled trial	Dysrhythmic-pronounced irritable bowel syndrome patients, 22	Vajrasana, Shukranamsa, Bhujangasana, Marjaryasana, Pawanmuktasana, Dhanurasana, Tristambha in two variations, (Pawanmuktasana, and Pawanmuktasana), Surya Nam pranayama (right nostril lavishing) two times a day for 2 months.	At 0, 1, & 2 months of practice compared with conventional group treated with loperamide 2–4 mg/day for 2 months	Significant decrease of bowel symptoms and state anxiety in both groups. Enhanced parasympathetic activity in yoga group. Enhanced gastric activity in conventional treatment group.	Beneficial effects of yoga intervention over conventional treatment in Dysrhythmic-pronounced irritable bowel syndrome
Chaya MS et al., 2006	Controlled Clinical Trial	Healthy yoga practitioners, 104	Mixed set of Asana, meditation and pranayama for 6 months. SVYASA Tradition	Yoga and non-yoga group comparison	Significant reduction in BMI compared to non-yoga group	Long term yoga practice leads to decline in BMI in both men and women
Bhaskar PM et al., 2008	Pilot (Observational) study	MBS students, 78	Surya namaskar	Pre- and post- practice comparison	Increases cardio respiratory efficiency and lung capacity	Suggested as a practice for improving cardiorespiratory efficiency.
Rhavanan AB et al., 2011	Comparative controlled study	School children, 42	Suryanamaskar – Fast: 12 postures in 2 min Slow: 30 s hold in each posture 12 postures in 6 min Total duration was 6 months	Comparison of Fast and slow Suryanamaskar	Positive physiological benefits evident from changes in pulmonary functions and resting cardiac vascular parameters.	Effects of fast Suryanamaskar was similar to aerobic exercise while slow paced was similar to yoga training. Introduction of surya namaskar in School children would improve their physical fitness.
Bhaskar MV et al., 2011	Sequential self control study	Healthy individuals, 79	Omkar chanting, Suryanamaskar, Abhayaasana, 24 weeks Yoga Vidya Dham Tradition	Pre and Post practice after 24 weeks	Significant decrease in BMI, significant increase in muscle strength and endurance, significant decrease in body fat percent only in females.	Surya Namaskar is an ideal exercise for optimum level of fitness.
Pai A et al., 2011	Randomized Controlled Trial	Subjects with coronary artery disease, 170	Jala neti, Shantam, Bhujangasana, Shukranamsa, Vajrasana, Dhanurasana, sikhramasana, Hantha urkhasana, Naui shalabha pranayama for 6 months	Intervention group compared with non yoga group who underwent conventional treatment.	Significant reduction in blood pressure, heart rate, body fat percentage, total cholesterol, Triglycerides and LDL after practice.	These practices will be beneficial for cardiac and hypertensive patients.
Modi BS, 2011	Pilot (Observational) study	Healthy Asian Indian Men and Women, 6	Suryanamaskar for 30 min	Heart rate and oxygen consumption were measured while performing 4 rounds of Surya namaskar in 30 min	Average Intensity was 80% HRmax, oxygen consumption was 26 ml/kg/ min, energy expenditure 230 kcal	Regular practice helps improve cardio respiratory fitness and promote weight management.
Nishi R et al., 2012	Prospective, randomized interventional controlled trial	Adolescent females, 96	Suryanamaskar, anam, pranayama, and meditation for 1h/day for 12 weeks	Yoga practitioners compared to physical exercise group	Improvement in glucose, lipid, insulin and insulin resistance independent of anthropometric changes	Yoga was found to be more effective than conventional physical exercise in adolescent girls with PCOS.

Helps in keeping the mental health and the equilibrium of the state of mind, as metabolism and glands directly affect the mind. This is further substantiated from a study in college students which shows that Suryanamaskar helps to attain a quiet mind measuring several parameters in relaxation and stress dispositions. Suryanamaskar practice is suggested as an effective relaxation strategy on highly stressed college students [32] and further Suryanamaskar could be effectively used to improve neuromuscular functions [33]. Meditation is largely known to be a static procedure where the body is passive and the mind is being trained to be still. But some martial art traditions have moving meditation where the mind can be made focused even while the body is in movement in a completely organized and coherent manner with the breath. Surya namaskar becomes a more powerful moving meditation tool considering the physical posture, breathing component, the concerned body part being stimulated, and the concentration on the chakra associated with each posture. This is substantiated by the fact that the slow pace practice of Suryanamaskar resulted in nearnormal levels of cardiovascular parameters compared to elevated levels during fast Suryanamaskar [13]. Further high-speed Suryanamaskar resulted in higher energy expenditure than standard speed Suryanamaskar with a significant difference in the volumes of oxygen consumed and carbon dioxide produced [34]. These points are further supported by the results obtained while performing 4 rounds in 30 min which led to the average oxygen consumption of 26 ml/kg/min during each round [24]. Thus, it is proposed that a single group of Asanas can be tailored to produce distinct benefits by changing just the speed of practice. This unique property can be conferred only to Suryanamaskar and neither to any other asana practice nor other types of aerobic and physical exercises. It is clear from the above discussions that Suryanamaskar plays an important role in balancing the functioning of endocrine glands. This property helps to regulate/delay the transition period between childhood and adolescence in growing children, especially in females. Puberty and followed by Menarche is an important process in every female's life that prepares their body for reproduction. Due to environmental factors and food habits, Puberty/Menarche is advanced to an early age, when the body is not well prepared to undergo

Those processes. This leads to various complications in their menstrual cycle, mood disorders, dysmenorrhea, infertility, complications in childbirth, risks of cardiovascular disease, and decreased life expectancy [35]. Suryanamaskar plays a vital role in delaying the age of puberty in a girl child and prepares the body for the necessary changes to happen. Hence it is important to introduce surya namaskar at a young age as early as 7 years. One-hour Yoga session for 12 weeks comprising of Suryanamaskar, Asanas, Pranayama, and meditation in adolescent girls having polycystic ovarian syndrome (PCOS), showed significant alterations in blood glucose, insulin, and lipid levels [36]. Genetic, epigenetic, lifestyle, and environmental factors are reported to greatly influence fertilization, pregnancy, and childbirth. Yogic interventions in both males and females help in an effective way towards childbirth. Yoga sessions including Suryanamaskar in a group of 42 men resulted in reduced seminal oxidative stress and oxidative DNA damage and improvement in sperm motility and hence positively influences the dynamics of the sperm [37]. Prenatal yoga is vital to alleviate the associated stress, hormonal changes, and labour pain and studies are highlighting the role of yoga during pregnancy [38]. However, asanas are prescribed with caution and considering the contraindications during pregnancy. Prenatal yoga is reported to relieve stress and confer positive effects on musculoskeletal activities in hospitalized high-risk pregnant women. The yoga schedule is comprised of Suryanamaskar, other Asanas, and Pranayama [39]. Recent research studies have reported promising effects of the yogic intervention on neurocognitive abilities promoting successful aging [40]. Several studies highlight that yoga could be a low-cost preventive measure for type 2 Diabetes Mellitus [41,42]

08. Conclusion

Suryanamaskar practice is the most widely adopted sequence of asanas which has its origin from Indian traditional physical training. It also has lots of variations regarding different yogic traditions of India in the modern era. The review presents the physical benefits of the practice with regards to the increasing mobility of joints, extending muscle power, and vitality with the literature reference. The physiological attributes of improving the metabolic rate, cardiovascular stimulation, and increase of respiratory capacity, improvement

Of mental health of the body, and proper functioning of endocrine glands were also discussed. Highlighting the yogic point of view of the benefits of Suryanamaskar practice, the positive effects of Suryanamaskar on puberty, menstrual cycle, and childbirth were also emphasized. We conclude from the above points that the practice of Suryanamaskar is necessary not just for those who are regular yogic practitioners or spiritual seekers but for a common man, to maintain the physical, physiological, and mental health by spending very little time of their choice. If this practice is initiated to children at the age of 7 or 8 it helps grow better not only physically but also with great mental health. We propose that Suryanamaskar practice could be a group activity of the family to ensure total family health. Suryanamaskar is a boon for those who want to involve in yogic practices but yet not dedicate even an hour every day.

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