



Review Article

Insights on Surya namaskar from its origin to application towards health

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ARTICLE INFO

Article history:

Received 16 October 2020

Received in revised form

21 September 2021

Accepted 7 October 2021

Available online 30 December 2021

Keywords:

Surya namaskar

Physical

Physiological

Endocrine

Chakras

Women health

ABSTRACT

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 surya namaskar, there is a line of eminent people who popularized this dynamic group of asanas including T 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 surya namaskar as one complete sadhana for the whole body is emphasized.

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1. 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.

2. 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*

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Peer review under responsibility of Transdisciplinary University, Bangalore.

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 body-building 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.

2.1. 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].

2.2. *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.

3. *Suryanamaskar* from other schools of *Yoga*

3.1. 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.

3.2. 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 swanasana* 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].

3.3. 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*

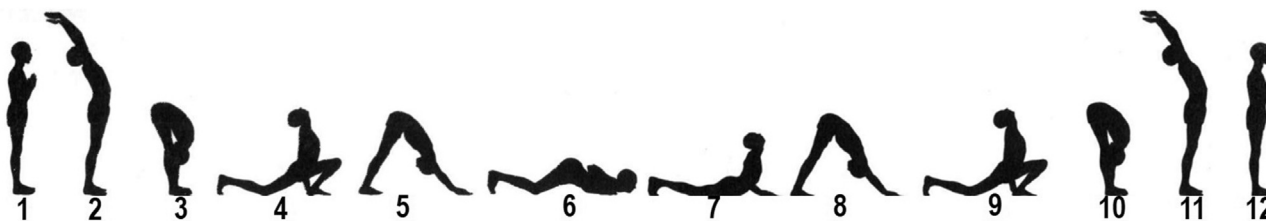


Fig. 1. Pictorial representation of *Suryanamaskar* postures (Bihar School of *Yoga* tradition): Final position of each step of *Suryanamaskar* of Bihar school of *yoga* tradition. Numbers (1–12) represents the number of each step as given in Table 1. Picture obtained and modified from Swami Satyananda Saraswathi, *Asana Pranayama Mudra Bandha* [7].

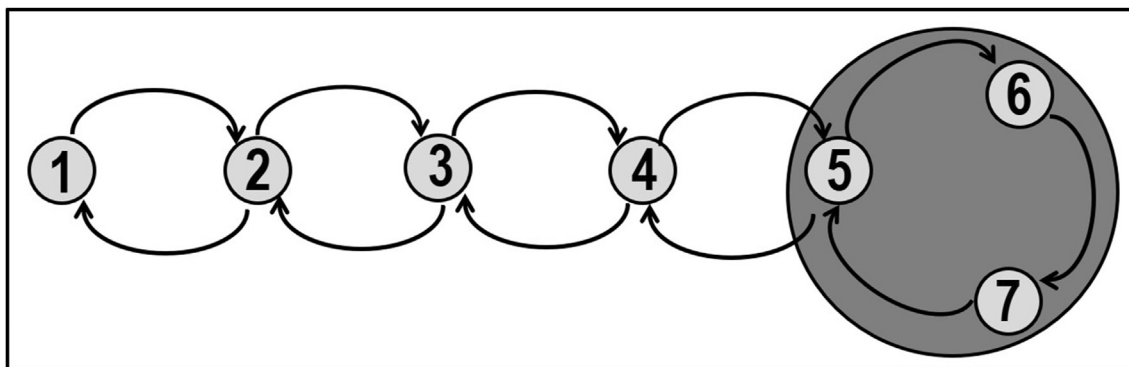


Fig. 2. Schematic representation of surya namaskar postures (Bihar School of Yoga tradition): Schematic of steps of Suryanamaskar of Bihar school of Yoga tradition numbered as per the sequence. Arrow indicates the flow of steps in the respective direction. 1. *Pranamasana*; 2. *Hasta utthanasana*; 3.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

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).

4. Benefits of Suryanamaskar

4.1. 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 1

Name of the postures in Suryanamaskar, respective Beeja Mantras/Mantras to be chanted, and corresponding Chakras to be concentrated [7].

| Steps | Name of the Posture | Beeja Mantra/Mantra | Associated Chakra |
|-------|---|--|-------------------|
| 1 | <i>Pranamasana</i> (prayer pose) | <i>Om Hraam/Om Mitraya Namah</i> | Anahata |
| 2 | <i>Hasta Utthanasana</i> (raised arms pose) | <i>Om Hreem/Om Ravaye Namah</i> | Vishuddhi |
| 3 | <i>Padahasthasana</i> (hand to foot pose) | <i>Om Hroom/Om Suryaya Namah</i> | Swadhisthana |
| 4 | <i>Ashwa Sanchalanasana</i> (equestrian pose) | <i>Om Hraim/Om Bhanave Namah</i> | Ajna |
| 5 | <i>Parvatasana</i> (mountain pose) | <i>Om Hraum/Om Khagaya Namah</i> | Vishuddhi |
| 6 | <i>Ashtanga Namaskara</i> (salute with eight parts or points) | <i>Om Hrah/Om Pushne Namah</i> | Manipura |
| 7 | <i>Bhujangasana</i> (cobra pose) | <i>Om Hraam/Om Hiranyagarbhaya Namah</i> | Swadhisthana |
| 8 | <i>Parvatasana</i> (mountain pose) | <i>Om Hreem/Om Marichaye Namah</i> | Vishuddhi |
| 9 | <i>Ashwa Sanchalanasana</i> (equestrian pose) | <i>Om Hroom/Om Adityaya Namah</i> | Ajna |
| 10 | <i>Padahasthasana</i> (hand to foot pose) | <i>Om Hraim/Om Savitre Namah</i> | Swadhisthana |
| 11 | <i>Hasta Utthanasana</i> (raised arms pose) | <i>Om Hraum/Om Arkaya Namah</i> | Vishuddhi |
| 12 | <i>Pranamasana</i> (prayer pose) | <i>Om Hrah/Om Bhaskaraya Namah</i> | 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/pranamasana 2. Tadasana/hasta uthanasana, 3. Uttanasana/pada hasthasana, 4. Utkatasana (hip stretch pose), 5. Chaturanga dandasana. 6. Danda samarpna, 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 *Hastha uthanasana* (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.

4.2. 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

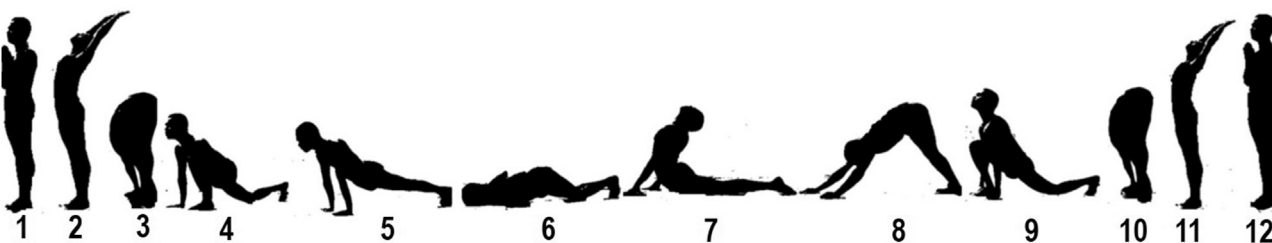


Fig. 4. Pictorial representation of Suryanamaskar (Sivananda Yoga Vedanta Centre tradition): Pictorial representation of the flow of postures of *Surya namaskar* as per Sivananda Yoga Vedanta Centre tradition. 1. Pranamasana; 2. Hasta utthanasana; 3. Pada hasthasana; 4. Ashwasanchalanasana; 5. Phalakasana;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

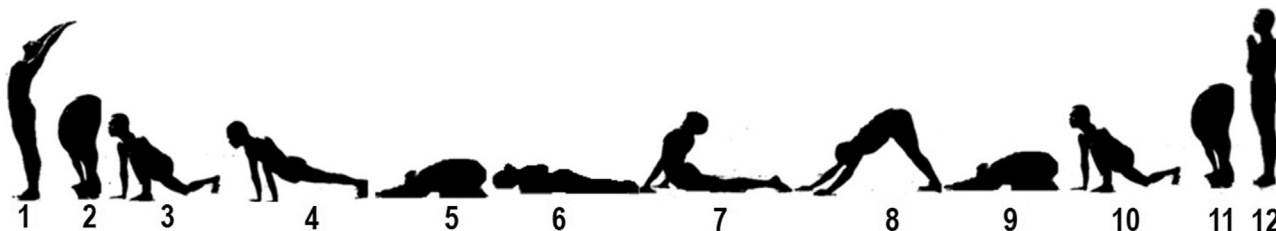


Fig. 5. Pictorial representation of Suryanamaskar (Swami Vivekananda Kendra tradition): Pictorial representation of the flow of postures of Suryanamaskar as per Swami Vivekananda Kendra tradition. 1. Hastha uthanasana; 2. Padahasthasana; 3. Ashwasanchalanasana; 4. Phalakasana or Dandasana; 5. Shashankasana;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

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 *Suryanamaskar* and the glands concerned.

5. 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 6–12 rounds of *Suryanamaskar* followed by *Yoganidra*, *Pranayama*, and meditation. Old age people who are below 70 years can practice *Suryanamaskar* 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 |

6. 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 (3–7 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 *Padhahasthasana* (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 cardio-respiratory 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.

7. 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
Disease management with Suryanamaskar [11–13,16–24,26,28,29,31–41].

| Study | Study design | Population type, size (n) | Intervention | Comparator | Outcomes | Conclusion |
|---------------------------|---|--|---|--|---|--|
| Srinivasan TM, 1990 | Cohort (Observational) study | Healthy male volunteers, 5 | <i>Bhujangasana, Sirsasana, Sarvangasana, Halasana, Pascimatanasana; Kavalayananda Tradition</i> | Pre-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 systolic time interval studies during asana practice. |
| Sinha B et al., 2004 | Comparative controlled study | Male volunteers from Indian Army, 21 | <i>Hatha yogic asanas: (28 min: kapal bhati & yoga mudra for 2 min each, Surya namaskar 3 min 40sec), pranayama (10 min), meditation (5 min) for 3 months</i> | 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. |
| Taneja I et al., 2004 | Randomised controlled trial | Diarrhea-predominant irritable bowel syndrome patients, 22 | <i>Vajrasana, Shashankasana, Ushtrasana, Marjarisana, Padhastasana, Dhanurasana, Trikonasana in two variations, (Pawanmuktasana, and Paschimottanasana), Surya Nadi pranayama (right-nostril breathing) two times a day for 2 months.</i> | At 0, 1, & 2 months of practice compared with conventional group treated with loperamide 2–6 mg/day for 2 months | Significant decrease of bowel symptoms and state anxiety in both groups. Enhanced parasympathetic activity in yogic group. Enhanced gastric activity in conventional treatment group. | Beneficial effects of yogic intervention over conventional treatment in Diarrhea-predominant irritable bowel syndrome |
| Chaya MS et al., 2006 | Controlled Clinical Trial | Healthy yoga practitioners, 104 | Mixed set of <i>Asanas</i> , meditation and <i>pranayama</i> for 6 months; SVYASA tradition | Yoga and non-yoga group comparison | Significant reduction in BMR compared to non-yoga group | Long term yoga practice leads to decline in BMR in both men and women |
| Bhutkar PM et al., 2008 | Pilot (Observational) study | MBBS students, 78 | <i>Surya namaskar</i> | Pre- and post- practice comparison | Increases cardio respiratory efficiency and lung capacity | Suggested as a practice for improving cardiovascular efficiency. |
| Bhavanani AB et al., 2011 | Comparative controlled study | School children, 42 | <i>Suryanamaskar</i> – 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 cardiovascular 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. |
| Bhutkar MV et al., 2011 | Sequential self control study | Healthy individuals, 79 | <i>Omkar chanting, Suryanamaskar, shavasana; 24 weeks Yoga Vidya Dham Tradition</i> | 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. |
| Pal A et al., 2011 | Randomized Controlled Trial | Subjects with coronary artery disease, 170 | <i>Jala neti, Shavasana, Bhujangasana, Shashankasana, Vajrasana, Ushtrasana, siddhasana, Hastha utthanasana, Nadi shodhan pranayama</i> for 6 months | Intervention group compared with non yogic 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. |
| Mody BS., 2011 | Pilot (Observational) study | Healthy Asian Indian Men and Women, 6 | <i>Suryanamaskar</i> for 30 min | Heart rate and oxygen consumption were measured while performing 4 rounds of <i>Surya namaskar</i> in 30 min | Average Intensity was 80% HRmax, oxygen consumption was 26 ml/kg/min, energy expenditure 230 kcals | Regular practice helps improve cardio respiratory fitness and promote weight management. |
| Nidhi R et al., 2012 | Prospective, randomized interventional controlled trial | Adolescent females, 90 | <i>Suryanamaskara, asanas, pranayama</i> , and meditation for 1hr/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. |

Table 3 (continued)

| Study | Study design | Population type, size (n) | Intervention | Comparator | Outcomes | Conclusion |
|-------------------------------|--|---|--|--|--|--|
| Bhavanani AB et al., 2013 | Cohort (Observational) study | Female volunteers from yoga class, 21 | <i>Suryanamaskar</i> – 3 rounds and 5 min of quiet sitting in both groups | External controls not participating in <i>Yoga</i> were compared to <i>Yoga</i> training group | Significant increase in Heart rate following the practice compared with both external and self-control. | <i>Surya Namaskar</i> is suggested as an effective means to improve neuromuscular abilities |
| Chatterjee S & Mondal S, 2014 | Randomized controlled trial | Untrained volunteers, 45 | <i>Suryanamaskar</i> , <i>Sthithilikaranas</i> , <i>Kriyas</i> , <i>Asanas</i> , <i>pranayama</i> , meditation for 12 weeks. Three combinations comprising of above practices were used. | Practice group compared with control group for 12 weeks | Significant increase in basal levels of GH and DHEAS in blood. | <i>Surya namaskar</i> stimulates all glands and contributes to promote healthy aging. |
| Sinha B & Sinha TD, 2014 | Prospective longitudinal cohort study | Army soldiers, 9 | <i>Suryanamaskar</i> , <i>pranayama</i> , 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 M et al., 2014 | Mixed repeated-measures descriptive study | Trained healthy <i>Yoga</i> practitioner, 36 | <i>Suryanamaskar</i> A & B | 11 poses of <i>suryanamaskar</i> 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 programs. |
| Jakhotia KA et al., 2015 | Comparative controlled study | Obese females, 119 | <i>Suryanamaskar</i> | Comparison of circuit training (CT), treadmill walking and modified <i>Suryanamaskar</i> (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 <i>Surya Namaskar</i> showed better results in all parameters analysed such as weight management, cardio respiratory fitness and body flexibility. |
| Paikkatt B et al., 2015 | Randomized controlled trial | Individuals with Chronic schizophrenia, 30 | <i>Suryanamaskara</i> , <i>asanas</i> , <i>pranayama</i> for 90 min/day for 1 month | Comparison of <i>yoga</i> therapy with pharmacotherapy | After 1 month <i>yogic</i> intervention group showed better rating in Positive and Negative Syndrome Scale (PANSS) variables than pharmacotherapy group. | <i>Yoga</i> practice improves psychopathology resulting in better quality of life. |
| Godse AS et al., 2015 | Randomized controlled trial | College students, 419 | <i>Suryanamaskar</i> for 14 days | Experimental compared to control group (non <i>yoga</i> group) | <i>Suryanamaskar</i> can be applied as a relaxation strategy for high stress college students with high R disposition levels and to reduce stress at a dispositional level as | <i>Surya Namaskar</i> is effective in leading to R – Dispositions like physical relaxation, mental quiet etc and negative emotions at a dispositional level |
| Dhawan V et al., 2018 | Controlled trial | Men volunteers, 42 | Loosening practices, <i>Suryanamaskara</i> , <i>asanas</i> , <i>pranayama</i> , and meditation for 120 min for 21 days. | Comparison between start and end of <i>yoga</i> 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 <i>yoga</i> sessions. | <i>Yoga</i> based lifestyle intervention improves pregnancy outcomes and improves health trajectory of the offspring. |
| Mullerpatan RP et al., 2019 | Cross sectional study | Trained healthy <i>yoga</i> practitioners, 10 | <i>Suryanamaskar</i> , 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 | <i>Suryanamaskar</i> 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 | <i>Kriya</i> , <i>surya namaskar</i> , <i>asana</i> , <i>pranayama</i> , and <i>dhyana</i> daily in the morning, 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 | <i>Yogic</i> intervention has promising 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* 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 near-normal 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].

8. 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.

Source of Funding

None.

Conflict of Interest

The authors declare that there are conflicts of interest.

Author contributions

L. Prasanna Venkatesh: Conceptualization, Methodology, Reviewing and Editing;

S. Vandhana: Data curation, Writing- Original draft preparation, Reviewing and Editing.

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