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Review Article

The Concept of Alignment, Stability and Proficiency in Yoga Asanas-Collating Eastern and Western Perspectives

Mohan Kishore D[1], Kousthubha J[2], Basavaraj Angadi[3] and Manjunath NK[4]*

[1]Deputy Director, Swami Vivekananda Yoga Anusandha Samsthana (S-VYASA University), India

[2]Assistant Professor, Swami Vivekananda Yoga Anusandha Samsthana (S-VYASA University), India

[3]Research Assistant, Swami Vivekananda Yoga Anusandha Samsthana (S-VYASA University), India

[4]Professor, Swami Vivekananda Yoga Anusandha Samsthana (S-VYASA University), India

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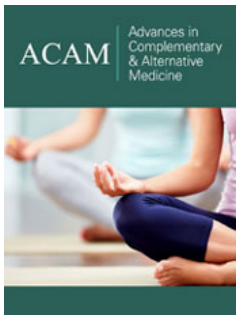

***Corresponding author:** Manjunath NK, Professor, Swami Vivekananda Yoga Anusandha Samsthana (S-VYASA University), Bengaluru, India

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Abstract

Yoga is an ancient Indian practice involving the physical, mental, and spiritual planes of being. Asana is a part of Yoga which is widely practiced for its physical benefits. Several scriptures such as Patanjali Yoga Sutras & Hatha Yoga discuss in detail about various asanas and its benefits. Human biomechanics evolved through the field of mechanics. The use of biomechanics is extensive in the field of medicine and sports. Biomechanical models have given us the insight into the mechanics of the musculoskeletal system. Understanding the mechanics of the body helps in optimizing the performance and preventing injuries. This study aims to collectively compare information available on traditional practices of Yoga and Modern Biomechanics. The studies of Yogasanas and biomechanics have suggested the practice of asanas improve the functional mobility and range of motion. Asanas aim to improve alignment and stability, which was demonstrated in some studies. Considering all the studies on asana and biomechanics, most of them are focused on the joints and muscles parameters. No studies have been conducted on the biomechanics of asanas in detail. The studies reviewed under this study concluded that the similarities between the understanding of traditional Yogasanas in the scriptures and the modern biomechanics. The conceptualization of asanas or physical postures are similar between the East and the West perspectives. Further studies on asanas and its biomechanical models are necessary.

Keywords: Yoga; Asana; Biomechanics; Surya namaskara

Introduction

Yoga is an ancient Indian tradition, which involves self-discipline at physical, mental and spiritual planes of being. Asanas (Physical postures) have become synonymous with Yoga in recent times because of its closer connection with fitness, associated health benefits at physical level, attractive nature of the practices, and increased global acceptance. The variety in style, methods and applications have made Asanas as the most sought Yoga techniques other than meditation. The use of the principles of Kinesiology including bio-mechanics has enhanced the process of understanding individual postures in a scientific manner. Mathematical modeling has given a new direction for developing the most accurate method of understanding and doing an Asana perfectly and proficiently [1].

Yoga Asanas-Eastern Perspectives

Asanas (physical postures) play an important role not only in promoting physical health but also preparing an individual for advanced Yoga practice. Asana also acts as a steppingstone for progressing to Pranayama (regulated breathing), and Pratyahara (modulating sensory inputs) before taking initiation into meditative practices. Sage Patanjali defines an Asana as "Sthiram Sukham Asanam" [2], the posture which is steady and comfortable. The concept of stability, comfort and minimal effort have been the cardinal principles on which asanas

are developed. Sage Patanjali also describes the process and methodology to attain proficiency in performing an Asana as Abhyasa (practice). The process is described as "sa tu dirghakala nairantarya satkarasevito dridha-bhoomih" [2], meaning practice, becomes firmly grounded when continued regularly with devotion for an extended period (Patanjali yoga sutra).

Understanding a Posture through Biomechanics-Western Perspective

Human Biomechanics is the study of structure and function and the effects of force on the body using various concepts derived from mechanics. All life forms are subject to external and internal environmental forces like gravity and forces generated from within the body. Bio-mechanics aids in understanding the mechanical interaction between these two forces within the musculoskeletal system. Understanding the biomechanics of the human body using motion analysis helps explore the interactions of the bone, muscles, and ligaments and the forces they generate and experience while performing any motion. Several complex biochemical, neural, and mechanical pathways and processes occur in the body to facilitate muscle contraction and joint movement [3].

The Principles of Yoga Postures and Bio-Mechanics

The concept of "Sthiram Sukham Asanam"[2], "sthira", firm and "sukha" comfort is an essential component of biomechanics for maintaining a posture. The weight-bearing joint is firm since they, along with muscles, are part of kinetics. The plane of motion will be smooth and comfortable once the firmness is established. Other biomechanics concepts of centre of gravity and line of gravity will aid in performing a well-coordinated posture. Performing an asana should become effortless, derived from Patanjali Yoga Sutras chapter 2, verse 46, "Prayatna shaithilya Ananta samapattibhyam"[2]. A posture in its final state should become natural and effortless to establish a state of infinite expansion. This is a process of transient acclimatisation into the posture itself. Following this, Patanjali says, "Tato dvandva anabhighatah" [2] chapter 2-verse 48, which translates to "once the practitioner is seated in the final posture effortlessly, he/she will be unafflicted by the dualities. The dualities are opposites: up/down, hot/cold, good/bad, and success/failure. The opposites working in the body are the agonists/antagonists muscles, sympathetic/parasympathetic nervous system, joints and other physiological processes. The attainment of balance between these systems will result in homeostasis. Hence it is said 'Samatvam Yogamuchyate' [4], practicing yoga helps an individual to attain balance.

Biomechanics of Yoga Postures

Biomechanics can shed light on understanding the mechanics of the human musculoskeletal system during yoga practice. Since yogic postures (asanas) can, by default, direct the person performing the postures into their natural skeletal alignment, studying the mechanics is crucial. Physiologically, practising Yoga stimulates the central balance and coordination between all the joints and increases range of motion and dynamic stability. Biomechanically designed yoga modules have significantly improved physical function and muscle-specific strength enhancements, [5] they are also known to add profound value to clinical practice. When used in joint and muscle-related pathologies such as knee osteoarthritis, such modules effectively produced the desired results in strength training and rehabilitation. These biomechanical insights can be used by therapists, clinicians, and instructors in selecting and administering yoga modules. [3,6-10]. Therefore, biomechanics can help prevent injury, provide an understanding of optimal posture and alignment, enhance recovery, and aid rehabilitation [11]. This perspective review attempts to collate the traditional concepts of Yoga postures and their probable correlation with the existing scientific literature.

Biomechanics of Yoga Postures (Asanas)

Bhujangasana (cobra posture)

"Bhujangasana" is a Sanskrit word translating into bhujanga "snake" or "cobra" and asana "posture." This terminology is because the posture resembles a cobra with its hood raised and was described in the hatha yoga text Gheranda Samhit [12]. When performing the cobra pose, the spine is arched while the chest is expanded, resembling the raised hood of a cobra. This posture allows the thoracic cage to expand and stretch the anterior muscles. The cobra pose initiates intervertebral joints, hip joint, and knee extension, while the ankle joint undergoes plantar flexion and external rotation of the glenohumeral joint. The spinal column extension is the most critical part of the movement while performing the cobra pose. The spinal extension can be further subdivided into an extension of the cervical, thoracic, and lumbar vertebral regions. This posture helps stretch the anterior longitudinal ligaments and relax the posterior longitudinal ligaments. During this posture, the hip joint is extended, assisted by the erector spinal muscle group and the contraction of the hamstring muscles. This pose helps increase the range of motion, aided by the anterior tilting of the pelvis. Hatha yoga has described the three muscle groups involved in the cobra pose: neck, shoulder, and back. The predominant muscle group involved in facilitating the posture is the back muscles. These muscles produce a concentric tension which creates spinal extension. The hip and thigh muscles play a synergistic role in maintaining the pose [13] (Figure 1).

Figure 1: Bhujangasana (cobra posture).

Warrior pose (virabhadrasana)

"Virabhadrasana" is a Sanskrit word derived from an ancient mythical warrior ", Virabhadra", and asana "posture" or "pose".

The warrior pose has three variations ranging from beginners to advance, where the beginning is a simple posture performed with both feet on the ground, contrary to the advanced pose, where one must balance on one leg where the leg and hands are outstretched. Virabhadrasana is one of the most widely practised yogic postures and is easily recognised. The biomechanical analysis of the warrior poses produced high muscle activation of vastus lateralis in the warrior two poses and vastus medialis in the warrior one variation. All three poses have been shown to activate Quadriceps, which can be used as a therapeutic intervention for strengthening. Warrior 1 pose can also reduce excessive lateral overload on the patella. Although warrior pose 2 produced a high joint moment force in the knee adductor across the medial condyles. Whereas in warrior three, the training effect and activation of the hamstrings are significant. The warrior pose can be used as an excellent rehabilitation and strength training yoga pose due to its high activation of the quadriceps and hamstring muscles [8] (Figure 2).

Figure 2: Virabhadrasana (Warriror pose).

Tree pose (vrikshasana)

Figure 3: Tree pose (vrikshasana).

"Vrikshasana" is a Sanskrit word meaning Vriksha "Tree" and asana "pose" [12]. This pose is one of the few standing poses in yogasana. The tree pose is a simple posture which combines balance, core stability, strength, and concentration. Although The practice of Vrikshasana induces low Joint moment force and low levels of quadricep activation, this posture can act as a training mode for developing balance, strength and core stability in yoga beginners [8]. The tree pose induces large ankle eversion and inversion of the joint moment of force. The forces will strengthen the ligaments and tendons, helping to retain the health of the ankle joint [7]. (The biomechanical demands of standing yoga pose in seniors: the Yoga empower senior study YESS) Vrikshasana practised regularly will increase dynamic and static balance, which is crucial in day-to-day activities, according to this study [13] (Figure 3).

Chair pose (utkatasana)

"Utkatasana" is a Sanskrit word meaning Utkata "Fierce Seat" and asana "pose" [12]. This pose is similar to a squat and resembles sitting on an imaginary chair, therefore called a Chair pose. The practice of chair pose produces high hip and knee flexion, followed by moderate ankle dorsiflexion. Knee extensor moment force is the highest while performing the chair pose, followed by hip extensor moment, hip abductors, and ankle plantar flexor moment, respectively. During the static hold of this pose, the highest muscle activation is seen in the antigravity muscles and the thigh muscles to maintain the posture [14]. The Chair pose generates many support moments with the recruitment of gluteal muscles, hamstrings, Quadriceps, vastus lateralis and strengthening longissimus thoracic [15] (Figure 4).

Figure 4: Chair pose (utkatasana).

Crescent pose (ashta chandrasana)

Ashta Chandrasana is a Sanskrit word Ashta meaning "Eight", Chandra meaning moon and asana "pose". The Crescent pose is a deep lunge that resembles a crescent moon. The practice of this pose induces moderate extension in the hip joint, knee flexion, ankle inversion and dorsiflexion angles. Tremendous joint moment forces are produced in the hip flexors and moderately in the knee extensors and ankle plantar flexors. The highest muscle activity is observed in the Rectus abdominis, Erector spinae, and Quadriceps and moderate activity in hamstrings, Gluteus medius and

Gastrocnemius muscles [14]. Regular practice and maintaining this pose can promote endurance and reduce fatigue [15] (Figure 5).

Figure 5: Crescent pose (ashta chandrasana).

Downward dog pose (adho mukha svanasana)

The downward-facing dog pose is a widely recognised conventional yoga pose. "Adho Mukha Svanasana" is a Sanskrit word meaning "Adho Mukha" downward facing, "Svanasana" Dog pose. Adho Mukha Svanasana produces the highest flexion angles in the hip joint, moderate flexion angle in the knee joint, and minimal dorsiflexion angle in the ankle joint. The hip extensors and ankle plantar flexors produce the highest joint moment force during this pose. The Erector spinae, Rectus abdominis, and Hamstrings are activated the most. While Quadriceps, Gastrocnemius and Gluteus Medius are moderately activated [14]. The activation of External oblique abdominis and Gluteus maximus are higher than other rectus abdominis muscles. This pose is a recovery pose that strengthens the core and gluteal muscles. Maintaining this pose provides an excellent stretch to the Erector spinae, the hamstrings and calf muscles [15] (Figure 6).

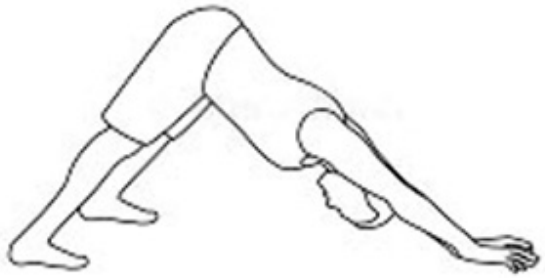

Figure 6: Downward dog pose (adho mukha svanasana).

Forward fold pose (uttanasana)

This pose is one of the first poses one learns in yoga asana practice. The Sanskrit word Uttanasana is made of "ut", meaning "intense" or "deliberate", and "tan", translating to "stretch" or "lengthen." This pose stretches and lengthens the entirety of the back musculature. The stretch is felt from the calf muscle and hamstrings and follows the low, mid and upper back to the neck muscles. This pose provides a good stretch to the posterior chain of muscles, which can benefit muscle health. The external oblique abdominis and gluteus medius are most activated in the forward fold pose. The Upper and lower fibres of the rectus abdominis are moderately activated [15] (Figure 7).

Figure 7: Forward fold pose (uttanasana).

One-leg balance pose (utthita hasta padangustasana)

The name is derived from the Sanskrit words Utthita meaning "extended", Hasta meaning "hand", Pada meaning "foot", Angusta meaning "thumb" or "toe", and asana meaning "posture." The biomechanical profiles show average ankle, knee and hip joint angles and joint moment force. The practice induces increased hip abductors joint moment of force and gluteus medius activity. Prolonged pose practice also targets the core muscles, erector spinae and rectus abdominis. The pose will help develop strength and balance [14]. The one-leg balance pose produced plantar flexion and external rotation moment at the ankle joint and joint loading. Thus, promoting ankle strength and joint health [16] (Figure 8).

Figure 8: One-leg balance pose (utthita hasta padangustasana).

Biomechanics of Sun Salutation (Surya Namaskara)

The word Surya Namaskara is a Sanskrit word translating to Surya "sun" and namaskara "greeting" or "salutation". Surya namaskara is a widespread yogic practice inculcating both static

and dynamic hold during the practice. It is a sequence of 12 yogic postures performed continues preceding one after another. The postures balance flexion and extension while performing it with synchronised breathing and awareness. The set of asanas is arranged ingeniously, combining forward-bending and backwards-bending asana to complement and balance each other. These postures produce varying structural loads on all the joints and the muscles. To understand these structural loads, studying the geometry and support conditions of the musculoskeletal system is crucial. Mathematical and biomechanical studies on Surya Namaskara show exciting patterns in the variation of moment force experienced by the upper body. Shoulder joint experiences a greater moment force than the elbow and wrist joints. The ankle and wrist joints were primary in transmitting the ground reaction force. Hip joints experienced the highest joint moment during the practice (Figure 9).

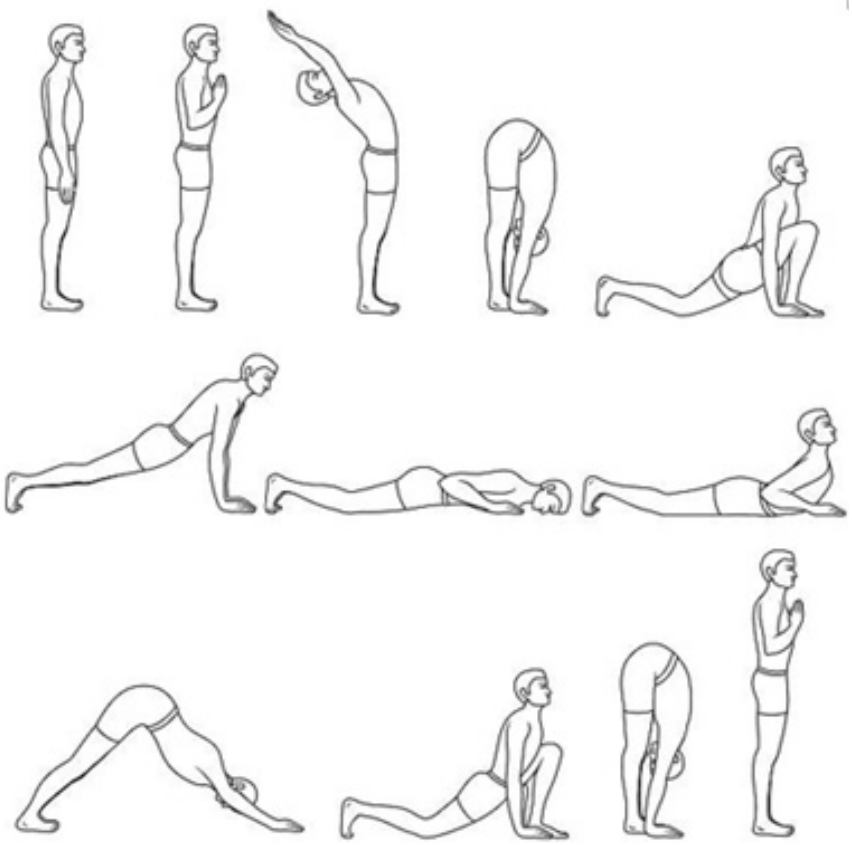

Figure 9: Biomechanics of Sun salutation (surya namaskara).

The biomechanical model of Surya Namaskara would aid in understanding the forces experienced by the various joints and muscles. This knowledge will help decide the indications and contraindications that may apply to the practitioner. Although the Surya Namaskara postures have a submaximal load on the musculoskeletal system, the energy expenditure is comparable to high-impact load movements, proving effective in bone remodelling and osteogenesis scenarios. The clinical implications can be applied in several fields like exercise and sports medicine, geriatric, and rehabilitation [1]. Regular practice of Surya namaskara can enhance mobility of all the joints of the body, induce stretch in the anterior and posterior chain of tissues and develop strength, balance and conditioning [17].

Adverse Effects Associated with the Practice of Yoga Asanas

Yoga practice as a beginner should be performed under an expert's supervision to avoid mistakes in form and techniques and, crucially, prevent injuries. Studies indicate that beginners should avoid extreme and complicated yogic practices. Yoga practitioners with pre-existing health conditions should be cautious while performing certain contra-indicated practices under the guidance of the teacher [18]. Adverse effects associated with the wrong practice of yoga asanas are well documented. Although Yoga helps to develop strength [19], proper care must be taken when practising extreme flexion and extension of joints. People with pre-existing comorbidities should be cautious while practising Yoga and avoid extreme practices [20]. Yoga practitioners and therapists should take a biomechanical approach when designing and advising yoga practices for at-risk and beginners. This way, injuries can be prevented, and we can achieve better outcomes. [21].

Applications of Biomechanics

Biomechanics and its principles have been adopted and applied in Other clinical fields, and multispecialty areas in biomechanics are cardiovascular biomechanics, cell biomechanics and sports

biomechanics. Biomechanics can be divided into three major categories. Clinical biomechanics: This branch deals with the clinical applications of biomechanics in areas such as gait, neuro-muscular processes, tissue and fluid mechanics, and motion and movement evaluation to develop diagnosis methodology, treatment modalities and rehabilitation for injury or disease. Occupational biomechanics: this typically deals with the research and application of ergonomics, human growth and how they influence movement. As the words denote, occupational biomechanical analysis is used to understand the influence and interaction of the environment with the mechanics of workers in various fields of work.

Clinical biomechanics

Clinical biomechanics investigates all facets of the human body. Clinical biomechanics aims to develop efficient treatment modalities and optimise the quality of life and functioning in multiple planes of the human body. It bridges the gap between research and clinical application of biomechanics. The disciplines described under clinical biomechanics are mechanobiology, biophysics, medical robotics, ergonomics, physical and occupational therapeutics and rehabilitation. With insight into the interaction of internal and external forces with the body and applying the laws of biomechanics, an athlete's performance can be enhanced and prevent injuries. The methodologies of clinical biomechanics are used by various healthcare professionals ranging from physicians, surgeons, physical therapists, occupational therapists, physical trainers and orthotic engineers [22].

Surgical Biomechanics

Biomechanics is extensively used to understand fluid body mechanics to plan and perform surgery. Biomechanical approaches are used extensively during amputations of limbs at various joints and perform corrective surgeries. Orthopaedic surgeries require a significant understanding of the human biomechanics principles to operate and administer the treatment modalities. Knowing joining kinetic and kinematics is essential in promoting optimal fracture healing modalities and rehabilitation. The choice and design of an implant are influenced by the skeletal mechanics of the patient [23]. Corneal diseases are a considerable burden on the ophthalmic industry. Recent studies and clinical assessments use corneal biomechanics to optimise diagnosis and surgical treatment [24].

Sports science and sports medicine

The principles of motion, force and other principles are used in sports and exercise, known as sports biomechanics. Sports biomechanics incorporates a detailed analysis of various sports and exercise movements. The mechanics involved in sports is studied, and biomechanics models are developed to minimise the risk of injury and promote optimal performance and efficient rehabilitation of sports injuries.

Rehabilitation

Kinetic chain, one of many biomechanics concepts, has helped us understand human movement. This concept has helped in many clinical applications, including sports medicine, musculoskeletal medicine, neurorehabilitation and more. With advances in technology and biomechanics, its importance in rehabilitation is significant [25].

Conclusion

Static and dynamic postures are needed to develop strength, including endurance and stamina. Knowing specific actions of muscles would facilitate designing personalised yoga training modules for a beginner to progress further to advanced levels. Biomechanics can also help supplement and compliment the regular movements an individual is engaged with daily through various yoga postures. Complimenting flexion with extension-based practices, Adduction with abduction, and other complimenting postures will increase the range of motion to facilitate enhanced mobility and performance. Prevention and management of physical health problems will become more efficient with better understanding biomechanics of Yoga. Therapeutic Yoga uses postures as one of the techniques to influence human physiology. The principles of biomechanics can facilitate an individual to practice yoga postures with confidence and achieve optimal efficiency to derive the best benefits of Yoga. Most of the injuries associated with the practice of Yogasanas can be attributed to a lack of strength and endurance to maintain balance, improper alignment and stretching beyond one's capacity. Hence, it is essential to apply the knowledge of biomechanics in training individuals to prevent injuries and manage various health problems.

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Conflict of Interest

All the authors declared no conflict of interest.

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