Biomechanics of Spine and Effect of Yogic Postures in Back pain

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***Abstract*— Back pain is a devastating lifestyle disease that affects a large proportion of the world's population at some point in their life. Absence from work due to this has a huge economic impact on the patient, their employer, and the healthcare providers who seek support for their recovery. Unfortunately, back pain is often resistant to treatment and intervention; therefore, alternate therapies such as Yoga are being explored. Within the literature, certain Yoga postures were identified to be associated with reduced back pain in patients suffering from chronic lower back pain. This study has revealed the interrelationship between the anatomical structure of the back and the effect of yoga postures.**

***Index Terms*— Yoga, Anatomy, Back pain**

INTRODUCTION

When Yoga is practiced as a science of health and healing, its techniques, and methods, which are meant for spiritual experiences, are automatically geared to do the job for the promotion of health and for bringing the healing touch to the body and mind suffering from illnesses. Yoga postures involve the increased awareness of various physical and physiological processes influenced by controlled stretching, contraction, and relaxation of various muscles, their coordination in balancing and during maintenance of posture, etc.

The skeletal system and the muscular system are the principal systems of the Human body responsible for the movements of the body. Muscular tissue is specialized for contraction and is, therefore, able to move. Muscle cells are called muscle fibers and each muscle is a bundle of lengthwise small thread-like fibers known as myofibrils. Each of the myofibrils has three main qualities, it can contract and shorten its length when stimulated. It can get lengthy whenever required and it has the elasticity to come back to its original shape system etc when no action. This contractibility, extensibility, and elasticity bestow the muscles its unique function. Movement, which is a function of voluntary muscle, is caused due to specific contraction, and relaxation of muscles. Contraction could be of two types isotonic and isometric. Isotonic contraction results when the muscle fiber shortens and causes the joints to move through some range of motion against constant resistance Low back pain is one of the most frequent medical causes of absence from work, and disability arising from chronic back pain is now major welfare and economic problem. Of course, back pain can be referred to as a convenient excuse for malingering, but there can be little doubt that many people have real and severe problems. Mechanical influences must be important because specific types of mechanical loading constitute the greatest known risk factors for acute disc prolapse and low back pain in general. However, there is growing evidence that back pain is a phenomenon that affects both the mind and body.

ANATOMY OF THE LOW BACK

The spinal column is made up of circular bones called vertebrae and between each vertebra is a disc made up of a strong fibrous outer layer and a softer, gel-like center. The discs act as shock absorbers and allow the flexibility of the spinal column. The structures in the lumbar area which may be responsible for low back pain are the lumbar vertebra, vertebral discs, ligaments around the spine and discs, spinal cord and nerves, muscles of the low back, internal organs of the pelvis and abdomen, and the skin covering the lumbar area. The nerves that provide sensory and stimulate the muscles of the lower lumbar region, the thighs, legs, feet, and toes all come out of the lumbar spinal column through bony openings known as the foramen. The group of muscles that are responsible for flexion, extension, and rotation of the back and movement of the lower limbs is attached to the lumbar spine through tendons.[01]

Lumbar vertebrae consist of a short weight-bearing vertebral body and a neural arch that encircles the spinal cord in a ring of bone. Vertebral bodies resist most of the compressive force acting down the long axis of the spine, whereas the neural arch safeguards the spinal cord and provides attachment points for muscles and ligaments. Adjacent vertebral bodies are separated by intervertebral discs, which comprise a soft deformable nucleus pulposus surrounded by the tough concentric layers (lamellae) of the annulus fibrosus. Intervertebral discs allow small movements between vertebrae and distribute compressive loading evenly onto the vertebral bodies. The nucleus behaves like a pressurized fluid and generates tensile hoop stresses on the annulus so that excessive compressive loading of the spine can lead to tensile failure in the annulus. Spinal stability is aided by the apophyseal joints which join adjacent neural arches, and which have cartilage-covered articular surfaces orientated more vertically than horizontally. These joints resist horizontal forces acting on the spine and protect the lumbar discs from excessive clasp and torsion. In lordotic postures, the neural arches can resist more than half of the compressive force acting on the spine, chiefly following sustained loading at constant force or disc degeneration, both of which narrow the discs and bring the neural arches closer together. Various intervertebral ligaments span neighboring vertebrae and mostly serve to limit indirect movements of the

spine. Fibers of the interspinous and capsular ligaments vary in length and orientation and appear to be deployed specifically to resist flexion movements.[02]

BIOMECHANICS OF SPINE

Bones, disks, and ligaments contribute by playing a structural role and by acting as transducers through their mechanoreceptors. Mechanoreceptors send proprioceptive impulses to the central nervous system which coordinates muscle tone, movement, and reflexes. Damage to any spinal structure gives rise to some degree of instability.

The movements in the spine are flexion, extension, rotation, and lateral flexion. These movements occur as a combination of rotation and translation in the following three planes of motion: sagittal, coronal, and horizontal. These movements result in various forces acting on the lumbar spine and sacrum: compressive force, tensile force, shear force, bending moment and torsional moment. For example, with lumbar flexion, a compressive force is applied to the anterior aspect of the disc and a distractive force is applied to the posterior aspect of the disc. The opposite forces occur with lumbar extension.[03]

The lumbar spine forms an effective load-bearing system. When a load is applied externally to the vertebral column, it produces stresses to the stiff vertebral body and the relatively elastic disc, causing strains to be produced more easily in the disc. Pressure within the nucleus pulposus is greater than zero, providing a preload mechanism allowing for greater resistance to applied forces. Hydrostatic pressure increases within the intervertebral disc resulting in an outward pressure towards the vertebral endplates resulting in bulging of the annulus fibrosis and tensile forces within the concentric annular fibers. This transmission of forces effectively slows the application of pressure onto the adjacent vertebra, acting as a shock absorber. The intervertebral discs are therefore an essential biomechanical feature, effectively acting as a fibrocartilage cushion transmitting force between adjacent vertebrae during spinal movement. The lumbar disc is more liable to injury compared with other spinal regions due to the annular fibers being in a more parallel arrangement and thinner posteriorly compared with anteriorly, the nucleus being located more posteriorly, and the holes in the cartilaginous endplates.

When a load is applied along the spine, shear forces occur similar to the intervertebral disc as the firmness of the nucleus results in a lateral bulging of the annulus. Shear forces also occur as one vertebra moves, for example, forwards or backward regarding an adjacent vertebra with flexion and extension. Torsional tensions result from the external forces about the axis of rotation and occur in the intervertebral disc with activity such as twisting of the spine. The zygapophysial or facet joints provide stability to the intervertebral joint concerning shear forces, whilst allowing primarily flexion and extension movement.[04]

Yoga for healthy psychosomatic activities

There are 8 components of yoga on which most styles are based: These are as follows yamas (moral restraints), niyamas (moral observations), asana (posture), pranayama (controlled breathing), pratyahara (sensory withdrawal), dharana (concentration), dhyana (meditation), and samadhi (self-actualization).

In yoga practice, just as the bare feet develop a new relationship with the ground through the practice of standing asana, the hip, pelvic joints, and lower spine develop a new relationship with the earth when we bear weight directly on them in sitting postures.

In yoga kneeling postures are often used to help open the hip and knee joints. When the body's weight is taken off the feet and legs, the pelvic muscle attachments can be strained because they no longer steady the body weight high off the ground. Kneeling also provides a stable base from which the center of gravity can be raised so the spine can fully extend most beautifully expressed in poses such as camel (ustrasana) and pigeon (kapotasana).[05] A position that's frequently used to counter pose strong spinal extensions is the child's pose, the kneeling position that produces mild, even spinal flexion and lowers the center of gravity. Supine poses mean lying in a face up position. It is the opposite of prone, a face down position. Similarly, supination means to turn a hand, foot, or limb upward, whereas pronation refers to turning them downward. Prone poses mean lying horizontally so that the ventral aspects of the body face downwards. Moving into postures from a prone position engages the posterior musculature of the body, which is why many back-strengthening workouts start in this position.[06]

Yogasana performing individuals seem to be much more flexible and active than others. Yoga not only helps to alleviate physical ailments but also act on psyche, changes the attitudes, distresses. Improve tolerance and stamina.

Yoga Postures for Backpain

Yoga can be a helpful form of exercise to improve muscle strength and flexibility in the lower back. It is important to start slow and not push into positions that increase pain in the lower back.

Following Yoga postures are helpful for alleviation of back pain:

Uttanasana (Standing forward bend)

A standing forward bend posture aided by gravity involves flexion and extension of the trunk. Erector Spinae muscle Stretch and lengthen during this posture and it helps for the stability of the spine and posture (Mild spinal flexion). Hip joint, legs, and spine act in this pose. Hip flexion, knee extension, mild spinal flexion (the tighter the hamstrings, the more the spinal flexion).

Fig.01

Bhujangasana(Cobra posture)

A basic prone back-bending posture lifting the chest against gravity, with the palms placed directly under the shoulders. Erector spinae and transversus spinalis act in this posture. Powerful contraction and strengthening of above muscles and, Chest expansion due to Serratus posterior superior help in this posture. Internal arm rotation, thoracic back flexion, stability of posture done by Latissimus dorsi muscle. Spine extension, sacrum counternutation, hip extension, internal rotation, adduction, knee extension, ankle plantar flexion, scapula neutral (possibly upward rotation), glenohumeral joint external rotation, elbow extension, and forearm pronation happen in this posture.

Fig.02 **Fig. 03**

Shalabhasana (Locust posture)

A prone back-bending position, arms extended at about shoulder level with legs straight together. Legs and head kept as high as possible. Intermediate deep muscles and erector spinae give powerful contraction. Middle Trapezius do Lateral rotation in prone arm raise. Latissimus and rhomboids are lengthening the arm and upper back and stability of the spine. Spine extension; sacrum counternutation; hip extension, medial rotation, adduction; knee extension; ankle plantar flexion; scapula upward rotation, elevation, abduction; glenohumeral joint external rotation, flexion; elbow extension; forearm neutral; wrist neutral happens in this posture.

Fig. 4 **Fig.5**

Balasana (Child's posture)

A resting forward bend posture position, where the body settles into deep full spinal flexion and a slight cervical extension, aided by gravity. Middle Trapezius causes shoulder abduction at a 120-degree angle. Erector spinae stretch, lengthen (Neutral alignment

due to simultaneous full spinal flexion and hip flexion/abduction). Full spinal flexion (maybe a slight cervical extension, depending on the head position or the length of the neck); hip flexion, neutral rotation, adduction; knee flexion; ankle plantar flexion; scapula abduction and downward rotation; glenohumeral internal rotation and elbow extension are seen.

Fig.6

Sethubandhasana (Bridge lumbar stretch posture)

A supine inversion/ backbend posture where gravity plays a key role. The scapulae are elevated to place the shoulders on the floor, allowing the chest to be lifted off the floor. Erector spinae (longissimus thoracis) give powerful contraction. Intrinsic deep muscles do stability. Rhomboids are adductors of the scapulae. Levator scapulae press the scapulae into the floor. Trapezius adduct, elevate, and medially rotate the scapulae. Spine cervical and upper thoracic flexion; lower thoracic and lumbar extension; sacrum counternutation; hip extension, adduction, and internal rotation; knee flexion; ankle dorsiflexion; scapular adduction, downward rotation, elevation; glenohumeral joint external rotation, extension, adduction; elbow flexion; forearm supination; wrist extension (dorsiflexion).

Fig. 07

Tadasana (Mountain Pose)

Intrinsic and extrinsic foot muscles, quadriceps, iliopsoas, piriformis, abdominal wall, and diaphragm take part in this posture. It increases strength, power and mobility in feet, legs, thigh, back, and hips. It tones abdomen and buttocks, muscles, relieves tension, aches, sciatica pain, and pain in the body. It encourages healthy digestion and elimination of waste products.

Fig.08

Parsvakonasana (Extended Side Angle Pose)

The spinal muscles are toned up by this posture. It helps to revitalize the whole body. This posture improves the blood circulation to the whole body, so long-time sitting professional's people are benefitted. It is helpful to reduce fat from the hip region. Spine flexion (mild); rotation in the anterior aspect of leg; counter rotation in the posterior aspect leg. Anteriorly deep hip flexion, knee extension, ankle dorsiflexion. posteriorly hip flexion, medial rotation; knee extension; deep plantarflexion in the ankle.

Fig.09

Marjarasana(Cat Pose)

Increases the mobility of the vertebral column. Relieves tension of cervical, thoracic, and lumbar spine. Strengthens and tones the muscles of the arms and abdomen. Improves circulation and supports the abdominal organs by increasing muscle tone of muscles of anterior abdominal wall.

Fig.10

Purvottanasana (Upward Plank Pose)

Strengthens muscles of hand, wrist, back and legs. Stretches shoulder, chest and front of ankles. Spine flexed (mild); nutation in the front leg; counternutation in the back leg. Front leg: deep hip flexion, knee extension, ankle dorsiflexion. Back leg: hip flexion, medial rotation; knee extension; deep dorsiflexion in the ankle.

Fig.11

Gomukhasana (Cow stretch)

Stretches the muscles and relieves the pain in the back, hips, thighs, ankles, chest, shoulders, and arms. It helps to make the spine straight and improves body posture. It is beneficial for respiratory problems as it gives exercise to the lungs.

Fig.12 **Fig.13**

Uttkatasana(Chair pose)

Shoulder girdle, spine, quadriceps, and hamstrings to balance each other, knees (adductors and medial rotators) take part in this pose. Strengthens ankle, thigh, calve, back, neck, and muscles of chest and arms. Helps to get rid of buttock fat and relieves the pain of joints. Shoulder flexion, elbow extension, forearm supination, axial extension in the spine, hip and knee flexion, and ankle dorsiflexion are seen.

Fig .14

Adhomukha Swanasana (Downward Dog Pose)

Increases blood flow to the head and shoulder stand can help improve brain function and memory. Reduce anxiety and depression. Takes pressure off the heart, which must work less to get the blood flowing to the brain. Strengthens and tones the muscles of arms and legs. Helps to relieve pain in the upper, middle, and lower back.

Fig.15

Paschimottanasana (Seated Forward Bend)

Reduces fat from abdomen, stretches the spinal muscles and brings flexibility. Relieves constipation and digestive disorder. Tones the abdominal pelvic organs. Balance the menstrual cycles, this asana is recommended especially for women after delivery to tone up the abdominal muscles. Spinal flexion (moving toward extension); sacrum nutation; hip flexion, adduction, internal rotation;

knee extension; ankle slight dorsiflexion; scapula abduction, upward rotation; glenohumeral joint flexion, slight external rotation, adduction; elbow extension; forearm slight pronation.

Fig.16

Ardhamatsyendrasana (Baradvaja's Twist)

Rhomboids, serratus anterior, erector spinae, pectoralis major and psoas muscles work on this posture. This is the best of the twisting postures as it rotates the spine around its axis besides giving two side-twists to the spine throughout its length. Stretches and increases the flexibility of the spine, shoulders, neck, and hips. Stimulates function of abdominal organs and improves digestion and elimination of wastes. Relieves symptoms of backache, fatigue, menstrual discomfort, and sciatica. Spinal rotation toward raised (top)leg, neutral extension. Top leg: deep hip flexion, adduction, internal rotation; knee flexion. Bottom leg: moderate hip flexion, adduction, external rotation; knee flexion. Front arm (contralateral arm rests on the top leg): scapula in neutral, glenohumeral external rotation, slight abduction, and flexion moving toward extension; elbow flexion; wrist neutral extension. Back arm: scapula neutral; glenohumeral external rotation, extension; elbow extension; wrist dorsiflexion.

Fig.17

Katichakrasana (Standing Spinal Twist Pose)

Improves flexibility of the neck, back and spinal muscle, tones the abdominal visceral organs. Makes waist thin and flexible by decreasing fat in the abdomen.

Fig.18

DISCUSSION

Poor posture resulting lower back pain is becoming increasingly prevalent today, due to the sedentary nature of a modern lifestyle. The physical postures of yoga are a form of therapeutic exercise that integrates balance, coordination, strength, and flexibility. Based on the findings of various research-works on the impact of yoga on containing health problems, it has been

established beyond doubt that regular and guided practice of yoga can certainly help to manage psychosomatic disorders positively.

Biomechanics call it a kinetic chain (connected chain of moving parts), designed for both movement and stability. Stability is created by tripod stool in each vertebra (Intervertebral disc and two facet joints). The range of movement of each vertebral segment is determined by intervertebral discs. The direction of movement is determined by the angle of facet joints.

Significant movements allowed in this region are flexion and extension. 50% of all the movements of flexion allowed in the entire vertebral column are created in the lumbar spine. Out of that, 75% were created in the L5-S1 joint. Abdominal muscles and organs are highly responsible for the limitation of extension in the lumbar spine. The facets in this region allow for an almost completely free range of extension. Rotation of the lumbar spine is quite limited (10 degrees).

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