

**CHAPTER 1**  
**INTRODUCTION**

## **1.0 INTRODUCTION**

### **1.1 BIOMECHANICS**

The myriad forms of life on earth are subjected to a primordial phenomenon termed “gravity”. The form, function and motion of these biological systems are influenced directly or indirectly by gravity which has been a subject of scientific study over centuries (Klette, & Tee, 2008).

The study of biomechanics comprises of the study of loads, motion, stress, and strain of solids and fluids of biological systems and the mechanical effects on the body’s movement, size, shape and structure. These influences can be found at various levels, from inner workings of a cell, the mechanical properties of soft and hard tissues, to the development and movement of the neuro-musculoskeletal system of the body (Lu, & Chang, 2012).

The form of the musculoskeletal system is influenced by many mechanical factors. Various human motion results from the complex interplay of biomechanical and neurological factors. The biomechanical factors involve the kinematics and dynamics of the musculoskeletal system while the neurological factors involve the sensory motor integration performed by the central nervous system (CNS). Thus, human movement is achieved by a complex and highly coordinated mechanical interaction between bones, muscles, ligaments and joints within the musculoskeletal system under the control of the nervous system. The forces that act on living things create motion. However, a healthy stimulus creates growth and development whereas overloaded tissues could cause an injury (Knudson, 2007). Muscles generate tensile forces and apply movements at joints with short lever arms to provide static and dynamic stability of the body under gravitational and other loads while regularly performing precise limb control. Any injury or lesion of any of the individual elements of the musculoskeletal system will change the mechanical interaction and cause degradation, instability or disability of movement. Effective modification, manipulation and control of the mechanical environment aids in preventing injury, correct abnormality and in rehabilitation (Lu, & Chang, 2012). Thus the applications of the knowledge of biomechanics of human movement can help in improvement of performance and in the reduction or treatment of injury.

## 1.2 YOGA BIOMECHANICS

*Yoga* biomechanics is an emerging area within the field of biomechanical research. It is the study of the effect of *yoga* on the interaction of forces and their effects on the body, the form, function and motion of our biological body in enhancing quality of life, performance, balance, stability, co-ordination, flexibility and range of motion, muscle strength and endurance.

The key principles of *yoga* biomechanics are:

1. Joint Action - Structurally, the joints can be classified by the tissue that connects the two bones such as cartilage, fibrous tissue, synovial fluid, or some combination of the three. But functionally, the joints can also be classified by the degree of movement possible and biomechanically by the number of bones involved and the complexity of the joint. Also, the fibre length has a significant influence on the magnitude of the joint motion that results from a muscle contraction. The fundamental behaviour of muscle is shortening, and it is this shortening that produces joint motion. However, in the practice of *āsana*s, the movement is observed in the synovial joints which are the most mobile joints in the body (Kaminoff et.al., 2012).
2. Skeletal joint action and muscular joint actions - Skeletal joint actions: The main joints that are involved in the process of moving into the *āsana* are identified according to their actions (flexion, extension, adduction, abduction, rotation, etc.).

Muscular joint actions: Muscles that create the joint actions are identified by the kind of muscle action such as concentric action (where the muscle fibres contract and generate *more* force than the resistance that is present so that the ends of the muscle slide toward each other and the muscle shortens), eccentric action (where the muscle fibres contract and generate less force than the resistance that is present so that the ends of the muscle slide apart and the muscle lengthens) and isometric action (where the muscle fibres contract and generate the same amount of force as the resistance that is present so that the ends of the muscle neither move apart nor move together and the length of the muscle does not change). In concentric contraction, the pulling power of the muscle is greater than the resistance. In eccentric contraction, the pulling power of the muscle is less than the resistance, whereas, in isometric contraction, the pulling power of the muscle is exactly the same as the resistance (Kaminoff et.al., 2012). The practice of *āsana*s, involves initiating all the skeletal and muscular actions sequenced to provide a variety of movement. The starting position of an *āsana* is defined from which various skeletal and muscular actions lead to the actual position of an *āsana*.

3. Physiology of stretching - This involves the three methods of stretching:
  - Ballistic stretching - Resetting the muscle length to that which has been attained due to previous practice.
  - Passive stretching - A stretch is held for a longer duration for the stretch receptor to acclimate.
  - Facilitated stretching - Involves briefly contracting the muscle targeted for the stretch (Long, 2008). The progression of *āsana*s, involves all these three methods amalgamated depending on the requirement of the person performing the practice.
4. Reciprocal inhibition - Reciprocal inhibition is an automatic antagonist alpha motor neurone inhibition which is evoked by contraction of the agonist muscle (Crone, 1993). As and when a particular pair of muscles acts the other muscle gets a message to respond and modulate accordingly. Some pairs of agonists-antagonists muscles act in relationship at the level of the spinal cord while others other repeated movement patterns occur from the higher levels in the brain (Kaminoff et.al., 2012). This reciprocal relationship is systematically performed in various *āsana*s through flexion-extension, abduction-adduction and so on.
5. Breath Awareness - In an *āsana*, the breathing pattern is illustrated at three levels:
  - Stage 1 - Inhaling while drawing oneself into an *āsana*.
  - Stage 2 - Performing deep diaphragmatic breathing while holding an *āsana*
  - Stage 3 - Exhaling as drawing oneself out of an *āsana*.

In the practice of *prāṇāyāma*, the breathing is classified and describe according to the purpose of breathing evenly, diaphragmatically, for the purpose of hyperventilating or for the suspension of breath at will.

These aspects of *yoga* biomechanics have been incorporated in this study while designing the *yoga* module. The *yoga* intervention was given with utmost care and awareness on the body and breath. The changes thereby were measured using various tests of core stability, flexibility, range of motion, balance and proprioception.

### **1.3 CRICKET IN INDIA**

From being a popular game of the 19<sup>th</sup> century to the national summer game in many countries of the old British Commonwealth (Hardcastle et al., 1992), cricket is India's most popular sport. Cricket is the most prominent and celebrated sport in India. In 1932, India joined the "elite club" along with England, Australia, South Africa, West Indies and New Zealand. The first Cricket club was established in the year 1792 in Calcutta. The national team played its first ever test match on 25<sup>th</sup> June

1932 at the Lord's, to become the sixth team to be given the privilege of Test Cricket status (Bose, 1986). India has won the Cricket world cup twice in the year 1983 and in 2011. By winning the 2011 world cup, India became the first cricket team to have won the World Cup at home and the third team to have won the World Cup more than once.

Since the year 2005, with the introduction of T20 cricket into the international and domestic schedules, the physical preparedness of elite cricket players has become complex (McNamara et al., 2016). Depending on the hours of daylight and temperature, a season in cricket generally coincides with the driest months of a year. Unlike the temperate countries, cricket is generally played all year round in the tropical countries.

Currently, considering the ever growing popularity of the game in the Indian subcontinent, a lack of substantial injury data of the cricket players at the elite level is an extreme cause for concern. While the game has emerged to be extremely competitive with an increased intensity of training, it has become not just financially lucrative for players but also physically and emotionally burdening to perform. In such a scenario, injury surveillance is essential in taking a step towards management and prevention of possible health problems among players (Alonso et al., 2010). As the consequences of sustaining an injury may prove to be catastrophic for the career of a cricket player (Barlett et al., 1996), it becomes imperative to identify the injuries and the risk factors involved so that the preventative measures can be identified, assessed and integrated.

#### **1.4 INJURIES AMONG CRICKET PLAYERS**

Cricket is a major international sport played in about 105 countries. It demands competence that is physically and mentally vigorous due to the length and pace of the game. Being a multi-dimensional sport, a cricket player undertakes varied roles of a batsman, bowler, wicket keeper. Although it is a non-contact sport, injuries in cricket occur in varied ways. Cricket injuries are chiefly categorized into two – repetitive/overuse and impact. Overuse injuries occur predominantly among bowlers and fielders who throw the ball frequently while training and during the matches (Finch et al., 1999). The impact or collision injuries occur in varied ways on field as a result of a direct contact with a ball, another player, the ground or the boundary. The prevalence of injuries is higher in particular sports, specifically cricket, in which the prevalence for stress lesions in bowlers is higher than most other sports (Bartlett et al., 1996).

The injury data from other countries reveal an elite international level cohort or club level injury incidences that are match or season specific. Due to an absence of off-season and inclusion of newer designs of tournaments such as Twenty20, the players in India are exposed to unique playing conditions and game formats throughout the year. Premier league designs have exposed the players to unique playing conditions, game formats and an increased intensity across player positions (Petersen et al., 2010). With the emergence of Twenty20 tournaments there has been no concurrent reduction in the amount of first class or one day cricket and this has resulted in an escalated workload (Orchard et al., 2010).

Previous studies have postulated the bowling technique as being a contributing factor in injuries among fast-bowlers (Ferdinands et al., 2009; Always et al., 2019). Studies have derived a significant connection between lumbar spine injuries and transverse plane counter-rotation of shoulder alignment (line joining acromion processes) of greater than 40 degrees (Foster et al., 1989). Studies have shown that a possible dysfunction in the shoulder rotators, combined with a front-on bowling action and external rotation hypermobility are possible predisposing factors for chronic shoulder injuries in cricket among the fast bowlers (Aginsky et al., 2004). The shoulder injuries are common and can become chronic or recurrent among cricket players, wherein, although being injured the players would not want to miss a match and end up compromising on performance by changing position in the field to avoid throwing from the outfield (Ranson, & Peter, 2008).

## **1.5 MINDFULNESS AMONG SPORTSPERSONS**

Elite athletes are consistently confronted with obstacles in their pursuit of optimising their own potential and achieving sporting excellence. It appears that today's highly competitive sporting world is well known for its unpredictable nature because the gap between athletes' physical skills as well as the margin of victory seems to be narrowing. One of the most important aspects of sports performance is the player's ability to train the mind to put themselves in the best situation to compete with an optimum athletic ability and focus, where there is little room for error. Expectations to be perfect and fear of defeat can hinder any player's performance during intense competition. The pursuit of excellence in sport encompasses four significant components, namely physical, technical, tactical and mental skills (Coulter et al., 2010). The facilitative role mental skills play in high level sports participation has been strongly emphasised in the last few decades. Mental factors such as self-confidence, commitment, concentration, coping skills, imagery and visualisation goals have emerged

as key antecedents to achieving athletic success at the highest level of sports participation (Devonport et al., 2006; Mahoney et al., 1987).

Mindfulness techniques have been widely utilized in clinical psychology, often as an adjunct to cognitive or behavioural interventions (Cash, & Wittingham, 2010). It has become relevant in sport considering the fact that the practice inculcates a present moment awareness that is crucial in athletic performance (Birrer et al., 2010). An early study integrating mindfulness in sport was conducted by Jon Kabat-Zinn, who designed mindfulness-based stress reduction (Zinn, 2003). Mindfulness, defined as the non-judgmental focus of one's attention on the experience that occurs in the present moment (Zinn, 1994), aids in addressing issues related to tendencies of present moment focus. Current moment awareness, a crucial component of peak sport performance also helps in generating a state of 'flow', or a state of complete focus (Kee & Wang 2008). Mindfulness-based interventions for sports are efficient in minimizing external distractions (Gardner, & Moore, 2012). Mindfulness training allows the individual to channelize on being non-judgmental rather than restricting negative thoughts. With the present moment acceptance of internal experience, an athlete can focus on the positives and learn to cope through challenging times (Gardner, & Moore, 2004).

## **1.6 YOGA**

*Yoga* is a polyvalent *samskr̥ta* word, which in ordinary usage signifies joining or attaching (an individual consciousness with the supreme consciousness). Being one of the six orthodox systems of Indian philosophy, it was systematized by Sage Patañjali. In opposition to the idea of *yoga* as union, Sage Patañjali defines *yoga* as a state of disjunction, a separation of spiritual principle from the material principle (Mallinson, & Singleton, 2017). It is the oldest system of personal development in the world, encompassing body, mind and spirit. Sages of the past had a profound understanding of man's essential nature and of the need to live in harmony with himself and his environment (Lidell, 1983). Thus, *yoga* is as much a living art and as a science. It is an art as it enhances one's quality of life and it is a science as it consists of acquiring knowledge through observation and experiment. *Yoga* as a science, deals with the body and mind, whereby the rhythm of the mind is conquered by controlling the body through disciplined practice (Iyengar, 1993).

## 1.7 INFLUENCE OF *YOGA* ON MUSCULOSKELETAL FUNCTIONING

The physical practice of *yoga* employs whole body positions with the intent of enhancing segment and joint range of motion (ROM). It is unique in the sense that it employs actions in a multi-planar manner and it combines many different types of stretching, such as active, static, passive and dynamic, into a unified systematic practice (Hart, & Tracy, 2008). With regard to the influence of *yoga* on injury prevention, a study on a group of Kripalu *yoga* practitioners, found that a single bout of *yoga* training significantly attenuated the symptoms of induced Delayed Onset Muscle Soreness (DOMS) (Boyle et al., 2004).

Hamstring muscle injuries was managed successfully with a seven-point programme-biomechanical assessment and correction, neuro-dynamics, core stability, eccentric strengthening, an overload running programme, injection therapies and stretching/relaxation in a professional footballer (Brukner et al., 2012). Another study that examined the effects of Bikram *yoga* on strength, balance, and steadiness among a younger population found substantial improvements in one-legged balance and modest improvements in strength among their participants (Brian et al., 2013). *Yoga* intervention on the postural skills of the Italian short track speed skating team showed improvements in eleven of the fourteen angles measured when comparing pre and post postural tests. This study also suggested that *yoga* could be inserted into out-of-season training cycles (Brunelle et al., 2015). An eight week of *yoga* training on female hockey players showed significant improvement in muscular strength, muscular endurance, flexibility and agility (Singh et al., 2015).

Several studies that have applied *Yoga* for therapeutic purposes have shown positive influences on the musculoskeletal system. It has also exerted a positive influence on the activation of core muscles (Omkar, 2012), may contribute to enhance health status and wellness (Gaurav, 2011), minimise fear of falling and improve balance (Schmid, 2010), cardio-vascular fitness (Cowen, & Adams 2007), muscular strength, agility (Singh et al., 2015), muscular endurance (McClean, 2009; Brynzak, & Burko, 2013), flexibility (Brynzak, & Burko, 2013; Polsgrove et al., 2015; Zannotti et al., 2002) and cardiovascular endurance (Brynzak, & Burko, 2013), shoulder flexibility and decline in lower and upper extremity injuries (McClean, 2009), flexibility, balance and preparedness (Brynzak, & Burko, 2013), range of motion of the shoulder and hip (Sager, & Grenier, 2014), flexibility and balance as well as whole-body measures (Polsgrove et al., 2015), strength, balance, and steadiness in one-legged balance and modest improvements in strength (Tracy, & Hart, 2013).



Currently, studies that apply *yoga* intervention in the cricket arena are scarce. A longitudinal effect of the practice of *yoga* with respect to injury prevention and also finding a preventive training modality for non-contact injuries through practical and safe methods of body-mind training among elite athletic populations is of crucial importance.

## 1.8 YOGA AND MINDFULNESS

Historically, mindfulness has its origins in Eastern contemplative spiritual traditions and has been considered the core of Buddhist meditation (Zinn, 2003). Dhyansky explains that, based on the so-called ‘Proto-Siva’ from Mohenjodaro, discovered by Marshall and Mackay, reveal that the five ‘Proto-Siva’ seals, clearly indicates that *yoga* was known and practiced by the people of the Indus Valley civilization in the North Western part of India about five thousand years ago. Further, *yoga* maintained the oral tradition till Patañjali systematized it in his *Yogasūtrās* (Dhyansky, 1987) Patañjali discusses the human mind and its bondage, and gives a detailed prescription for it accordingly, in his multi-component process of *Rāja yoga* (Krishnananda, 2006). The *yogic* technology of *Rāja yoga* overlaps with meditative traditions such as Buddhism (Feuerstein, 2002). Eventually, as the discipline of *yoga* became a common property of humanity, it was applied as a therapeutic intervention in the twentieth century yielding various psychophysiological benefits. Each component of *yoga* such as – physical postures (*āsana*s), breathing techniques (*prāṇāyāma*), deep relaxation, and meditation comprise of its own distinct emphasis cultivating an awareness and ultimately more profound states of consciousness (Büssing, 2012). *Yoga* prescribes to reach a state of meditation through breath and it introduces syncing of breath with purposeful movement as its foundation. Likewise, breathing technique is also the crux of mindfulness skills as described by Kabat-Zinn (Zinn, 1990).

*Yoga* focuses on systematically directing awareness towards internal sensations emanating during *yoga* movement sequences that are performed slowly and gently without being physically taxing, thereby facilitating mindful awareness (Salmon, 2009). A study that investigated the relationship between home practice of mindfulness meditation exercises and levels of mindfulness, medical and psychological symptoms, perceived stress, and psychological well-being on adults in a clinical Mindfulness-Based Stress Reduction (MBSR) program found *yoga* practice to be more strongly correlated with self-reported improvements in mindfulness, perceived stress, anxiety, and psychological well-being than formal sitting meditation time (Carmody, & Baer, 2008). Another

study that explored the utility, feasibility, and potential efficacy of a comprehensive mindfulness intervention for student athletes with modified MAC (Mindfulness-Acceptance-Commitment) intervention sessions immediately followed by 1-hr *haṭha yoga* session, reported greater mindfulness, greater goal-directed energy, and less perceived stress than before the intervention (Goodman et al., 2014). The *yogic* techniques, thus, aim at bringing focus by incorporating body movement to quieten the mind (Gordon, 2013). Recent lines of evidence suggest that *yoga* training can have a positive impact on a range of physiological, cognitive, and performance aspects that include facets of mindfulness and flow (Briegel et al., 2013).

To date, there has been no attempt to carry out an experimental study on the effects of *yoga* on mindfulness on a large group of cricket players. The current study is thus an attempt to fill this major gap in this field.

The current study has brought to light a detailed pattern of cricket injuries across multiple first class State Cricket Associations in India along with their current approach towards the injuries. The fundamental rationale of the study was to survey the annual prevalence, nature and mechanism of the musculoskeletal injuries among injured male cricket players. Based on this survey report (Rao et al., 2020) a comprehensive *yoga* biomechanics module was designed and validated by the experts from the field of *yoga*, *āyurveda*, sports medicine and physiotherapy, addressing the various anatomical regions that are prone to injuries. Further, this validated *yoga* module was employed in the *yoga* intervention study that aimed at assessing the changes in muscular recruitment, joint angles and mindfulness among the cricket players. In the next section, we present texts from ancient literature to highlight mindful awareness and its importance in any action, followed by scientific studies on the aspect of *yoga* and mindfulness among sports persons