# CHAPTER – 1

## INTRODUCTION

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CHAPTER 1:
INTRODUCTION

1.1 LOW BACK PAIN [LBP]:

1.1.1 GLOBAL TO LOCAL SCENARIO:

A good aligned, flexible spine is important for an active, healthy life. In vertical bipeds like the modern skyscraper, the spine openly resists the gravity. Spine acts like a crane to lift the objects as well as a crankshaft during walking. The anatomical arrangement of the vertebra acts like a biological machine which attaches the kinetic chain to transfer the biomechanical forces to well-coordinated functional activities of daily life.

Spinal pain is multifaceted which involves structural, biomechanical, biochemical, physiological, medical and sometime psychological also; this leads to complex treatment which may be ineffective and difficult to manage [1].

Low back pain (LBP) is a common medical problem. Low-back pain (LBP), usually has pain or discomfort in the area between the lower rib and the gluteal folds and is coined commonly as a potentially disabling condition [2]. Prevalence rate of low back pain in 3 months duration is estimated to be around 25%, where it is as high as 84% in lifetime [3, 4, 5]. In addition to pain and disability, LBP is also associated with loss of work productivity, poor quality of life, and high health care costs, and thus an economic burden on society [3, 6]. Though LBP sometimes has an associated etiology like radiculopathy or spinal stenosis, but most of the time the cause is unknown and is termed as non-specific low back pain that is there is no identifiable anatomic source for their pain [7]. International Association for the Study of Pain [IASP] classifies LBP as acute (less than 6 weeks), subacute (between 6 weeks and 12 weeks) and chronic (more than 12 weeks) [8, 9]. Low back pain is usually mild in nature [10] and limitation of activities is rare [11]. In most of the patients, the pain and discomfort reduces in the first 6 weeks [12, 13]. Few patients with chronic and severe pain end with disability and causing economic burden to the community [14]. LBP is an intermittent and recurring condition. Among individuals with a resolved episode of low-back pain, it is estimated that between 24% and 74% will have a recurrent episode within one year [15, 16].
Chronic Low Back Pain [cLBP] is defined as the low back pain which lasts for more than 3 months duration, as most of the connective tissue around the spine heals usually in 6-12 weeks, unless if there is any pathomechanical instability, however about 10% of the LBP may not resolve in this period. Chronic low back pain is a common musculoskeletal disorder affecting 80% of people at some point in their lives. Although negative social interaction (for example, dissatisfaction at work) has been found to relate to chronic LBP, a significant portion of the problem is of mechanical origin. It is often referred to as clinical spinal instability [17].

One of the research articles clearly states that the vast literature available about LBP is not only heterogeneous but also contradictory [18]. World Health Organisation [WHO] in its report clearly stated that LBP is ranked first among the diseases caused as a result of work complication and it is the foremost occupational risk factor with 37% among the whole. This high prevalence of complications at global levels has made WHO to name the first decade of the third millennium as the “decade of campaign against musculoskeletal disorders which is considered to be the silent epidemic” (WHO, 2005).

In United States of America USA, back pain is considered to be a leading cause of disability and it is to have a prevalence of 10-56% in one year, whereas 15% is the point prevalence of chronic LBP [18]. It was thought that the low-income countries has low prevalence rate of LBP, especially in rural population, compared with the developed western countries [19]. But the recent research reports from the developing nation such as Turkey [20, 21], Tibet [22], China [23] and Africa [24] disproved this with the one year prevalence rate between 36% and 64%. Thus LBP is an alarming health problem throughout the world.

Prevalence of LBP in the general population in our country varies from 6.2% to 34.7%. Recent study in the general population of the eastern part of India shows 32.98% [25] of prevalence rate, whereas in Jammu it is bit higher than this value 34.21% [26]. Among the rural people in the western India, 17.3% of them got low back pain [27]. In a large population study of general population in Jodhpur, it had been found only 6.2% of prevalence rate [28]. In a study done in Pimpri, Pune of Maharashtra state it has been found that the prevalence of back pain is about 34.21% in general population [29]. This prevalence of LBP is related to the occupation in which they are engaged. Duration of the occupational exposure, working position such as sitting, occupation involves heavy weight lifting,
demand of work such as driving, twisting of the trunk are considered to be the risk factor for LBP [30,31,32]. In a study among the bus drivers of Latur in Maharashtra state, it has been found that 64% of the bus drivers in the state transport company had LBP [33].

1.2 CORE STABILIZERS:
Akuthota 2008 described core as a muscular box surrounded with the group of muscles. Anteriorly it has abdominal muscles, posteriorly the paraspinal muscles, proximally the diaphragm and distally the pelvic floor and hip girdle musculature [34]. There are totally 29 pairs of muscles within this box which stabilizes the spine, pelvis, and kinetic chain during functional movements.

1.2.1 ANATOMY:

Core consists of a complex system of muscles, ligaments and fascia which provides spinal stability needed for the activities of daily living. Spinal stability by core is by activating the thoracolumbar fascia [nature’s back belt]. Transverse Abdominis muscle has wide attachments to the middle and posterior layers of the thoracolumbar fascia [35]. In addition, the deep lamina fibers of the posterior layer attaches to the lumbar spinous processes. Thoracolumbar fascia connects the lower and the upper limb [36] by its barrel like structure around the trunk [37]. Bergmark (1989) divided core muscle into 2 types as local muscle system and global muscle system. Core muscle has both slow-twitch and fast-twitch muscle fibers. Local muscle system [deep muscle layer] is made primarily with slow-twitch fibers, usually shorter in length and responsible for inter-segmental movement and acts during change in posture and extrinsic loads. Transversus Abdominus [TrA], Lumbar Multifidi [LM], internal oblique, deep transversospinalis, and the pelvic floor muscles are the local muscles. Global muscle system otherwise known as the superficial muscle layer has fast-twitch fibers and these muscle fibers are long and have large lever arms, thus producing large amounts of torque and gross movements [38]. The main global muscles [major stabilizers] include erector spinae, external oblique, rectus abdominis muscles, and quadratus lumborum [39]. TrA by its stabilizing effect is considered to be the very important muscle in the core. TrA acts like a belt around the abdomen by the arrangement of its muscle fiber, which run horizontally except for the most inferior fibers, which run parallel to the internal oblique muscle. Isolated activation of TrA occurs during the ‘‘Hollowing in / drawing in’’ maneuver. TrA along with internal oblique muscle contracts together to increase the intra-abdominal pressure which in turn impart stiffness to the spine [37]. External oblique muscle, the most superficial and largest abdominal muscle, acts as a check of anterior pelvic tilt. Minimal activation [5 – 10%] of TrA and Multifidus is enough
to stiffen the spine segments [40]. Hip musculature is important for all ambulatory activities as well as it play a key role in stabilizing the trunk and pelvis during locomotion [41]. Psoas muscle flexes the lumbar spine [35]. Diaphragm which forms the roof of the muscular box contracts to increase the intra-abdominal pressure, thereby adding spinal stability. Pelvic floor musculature is activated along with TrA muscle activation [42]. TrA and LM muscles have been documented to get contracted in 30 ms before movement of the shoulder and 110 ms before movement of the leg in healthy people, thus theoretically proved to be the prime stabilizers of the lumbar spine [43, 44]. Recently researches give importance to the deep core muscles, especially the transversus abdominis and multifidi, for core stability [45]. However, McGill and other biomechanists gives importance to the large prime mover muscles, namely abdominal obliques and quadratus lumborum, in providing stability [37]. For optimal spinal stabilization, contraction of both deep and superficial core muscles is needed [46].

Though these musculature attached to the spine contributes greatly to its functional stability, it is not possible without the passive subsystem like ligaments. The anterior and posterior longitudinal ligaments run continuously from the cervical vertebrae to the sacrum. In this the anterior longitudinal ligament [ALL] is broad and strong ligament which attaches to the front of the vertebrae and its disc, and is resistant to hyperextension of the spinal column. Posterior longitudinal ligament [PLL] is thin and relatively weak compared to its anterior counterpart and has its attachment only to the posterior element of intervertebral discs, its primary function is to resist hyperflexion. The ligamentum flavum connecting the lamina of individual vertebrae however is very strong as it contains elastic connective tissue that stretches and recoils during flexion activities [47].

1.2.2 CORE STABILITY THEORY:

In the 1970s, researchers began to describe the concept of spinal stability. It became transparent that spinal stability is a dynamic process which includes both static position as well as controlled movements. This model describes the biomechanics of the spine as similar to the biomechanics of other systems. Core stability is defined as the ability to control the position and movement of the central portion of the body. It is vital for proper load balance within the spine, pelvis, and kinetic chain.
Panjabi’s (1992a) article is the first theoretical perspective to all the researchers using the term core stability [48]. He divides core through three subsystems, namely

1. Passive subsystem,
2. Active subsystem and
3. Neural control subsystem.

Passive subsystem has the bones and the ligaments that contribute to the stability of the spine. This subsystem provides most of its stability by passive restraint toward the end of the range of motion. When the spine is in neutral position, this does not provide as much support to the spine. A cadaver study by Crisco JJ 1992, explained that the spine will buckle even with 20 pounds weight if the muscles are removed with intact bones and ligaments [49]. Muscles provide the support and stiffness at the intervertebral level to sustain forces commonly encountered in life. Therefore, the second subsystem is the active subsystem formed by the muscles surrounding the spine. The greater the stiffness at each segment, the greater the stability. Even a small amount of muscle contraction is enough to make the joint stable and stiff. In normal situation, about 10% of the maximum contraction is sufficient to provide segmental stability of the spine. If there is any segment damaged by ligamentous laxity or disk disease, slightly more force is needed. Thus endurance is much more needed than muscle strength in most patients. The third component of spinal stability is the neural control subsystem that coordinates muscle activity to respond to both expected and unexpected forces. This system helps in activating the correct muscles at the right time by the right amount to protect the spine from injury and also allow the desired movement. Stiffness is achieved with specific patterns of muscle activity, which differ depending on the position of the joint and the load on the spine. Panjabi saw these three components as interdependent, and one system could compensate for deficits in another. These subsystems are highly integrated and optimization of all three was necessary for normal biomechanics of the spine. Impairment of any one of these subsystem will lead to instability in the spine and thus the individual is prone to injury, pain and dysfunction. This impairment over a period of time ends in gradual degeneration of joints and soft tissue from repetitive microtrauma, caused by poor control of spinal structures. In other words, stability of the spine is not only dependent on muscular strength, but also proper sensory input that alerts
the central nervous system about interaction between the body and the environment, providing constant feedback and allowing refinement of movement [50].

1.3 CLINICAL SPINAL INSTABILITY & ALTERED PULMONARY FUNCTION IN LOW BACK PAIN:
1.3.1 CLINICAL SPINAL INSTABILITY:

Clinical spinal instability is a controversial topic and is not well understood. White and Panjabi defines clinical instability of the spine as the loss of the spine’s ability to maintain its patterns of displacement under physiologic loads so there is no initial or additional neurologic deficit, no major deformity, and no incapacitating pain [51].

Researchers found loss of the tonic activation of transverse abdominis muscle in low back pain patients during walking [52]. Most importantly in patients with LBA, this inactivity of the TrA is during the ipsilateral foot strike. Thus the data shows that the function of this muscle includes inter-segmental control of the spine and pelvis, support of the abdominal viscera and respiratory efficiency. There is a strong association between low back pain and respiratory disorder as well as incontinence [53]. Though there is no evidence that whether motor control impairment or pain come first, previous researcher found that the altered active support system leads to poor control of the joints which return leads to the repeated microtrauma of the structures around and ends with pain in the patients [54]. Many researchers later supported these concepts and concluded that LBA leads to the instability of the spine. Later Ferreira found that the patients with LBA have poor automatic control of the transverse Abdominal (TrA) [55]. This was in support with the previous research finding of delayed onset of the TrA contraction in LBA as well as other stabilizer muscles of the lower back and absence of its tonic and pre-adjusting function [44, 56]. Though many different muscles depending on the task contribute to the stabilization of the spine, TrA is widely accepted to be the main anterior stabilizer. TrA controls the intra-abdominal pressure during vocalization, respiration, defecation, vomiting etc. [57]. It is assumed that the TrA, which is connected to the lumber fascia, controls the spinal stability [58]. Postural reflexes are well
organised for anticipatory movement as well as during perturbation in balance. TrA is considered to be one main muscle takes part in this anticipatory reaction [59] as it is the first muscle to fire in this event [60]. Research study suggested that this early activation of TrA is to compensate the long elastic anterior fascia [61].

Studies of the multifidus the prime core muscle show several abnormalities in patients with LBP. Repeated imaging of the multifidus shows atrophy of the muscle in cLBP [62]. The muscle wastage is very common with the dysfunctional lumbar level in patients with unilateral acute LBP [63]. Researcher found that multifidus muscle remains week at least for 10 weeks’ time if the patients with acute LBP don’t exercise, but recovers to normal size in patients who receives stabilization exercise program which stressed deep abdominal and isolated LM muscle contractions [63].

### 1.3.2 PULMONARY FUNCTION IMPAIRMENT IN LBP:

Respiration is the process in which an organism exchanges carbon dioxide with oxygen in the blood and it has two phases namely inspiration and expiration. Inspiration is an active process in which diaphragm along with the intercostal muscle works. Primary muscles for inspiration are diaphragm and external intercostal, whereas the auxiliary inspiratory muscles are the sternocleidomastoid, scalene, serratus anterior, pectoralis major, pectoralis minor, trapezius and erector spinae. Expiration is a passive process by recoiling of the thorax back to the original state. It is been found that any muscle attached to the rib cage can alter the mechanism of breathing to some extent. For example, if there is weakness of upper back erector spinae and middle and lower trapezius muscle, it interferes with the ability to straighten the upper back, and therefore the upward movement and expansion of the chest is affected and ends in reducing the lung capacity [64]. Neurological study shows that the efferent impulses to the motor unit of a skeletal muscle play an important role in various motor function such as respiration, locomotion and postural control [65].
Pulmonary function is most commonly measured by Spirometry, which helps in identifying the pulmonary dysfunction namely obstructive or restrictive disease [66]. Pulmonary restriction is a termed as a group of respiratory disorders related to an impaired filling of the lungs with air [67]. Though this dysfunction shows reduced lung volumes, respiratory flow as well as maximal voluntary ventilation [MVV] may be also gets affected [67-69]. In neuromuscular weakness, the respiratory muscles have a reduced ability to generate the optimal lung volumes and pressure, thus shows a restrictive dysfunction pattern [68]. Though neuromuscular weakness is the most common physical sign of musculoskeletal pain, we in our clinical practice rarely consider this musculoskeletal pain and pulmonary function together. In respiration, both pulmonary function and the respiratory muscles along with the intact neural pathway is responsible for adequate ventilation [70, 71]. Therefore respiratory muscle weakness can reduce the pulmonary function.

Spinal stability as well as respiration uses some muscles [core muscles] in common. For example, the diaphragm, which is considered to be the primary respiratory muscle, is also responsible for stabilizing the spine. Similarly spinal stabilizers are also activated to increase the respiratory capacity [72-75]. Spinal stability provided by these muscles is derived from their co-contraction which increases intra-abdominal pressure [69]. These muscles function as respiratory muscles, when respiratory demand increases, by increasing their activities [66-68 & 70-72]. Hagins and Lamberg recently found that in patients with chronic low back pain over a period of time, tend to develop a dysfunction in their respiratory ability due to weakness of low back and abdominal muscles [76].

Diaphragm is human’s main respiratory muscle. Abdominal muscle is activated in both quiet as well as forceful breathing. It is believed that strengthening of abdominal muscle will help in ventilatory process. It is documented that abdominal muscle strengthening can assist prolonged and forced expiration [68]. The main inspiratory muscle, diaphragm along with the trunk muscle helps in trunk stability and postural control [71]. Abdominal muscle fibres pull the ribs and costo-cartilage proximally during expiration. This increases the intra-abdominal pressure, and these muscles push the diaphragm proximally, thus increases the speed of expiration as well as the lung volume [72]. Recruitment of the expiratory muscle lengthens the diaphragm, thus helps in inhalation also [77]. Expiratory
muscle weakness results in decreased peak expiratory flow rate [PEFR], forced expiratory volume in 1 s [FEV₁] and forced vital capacity (FVC) [66]. Similarly it is documented that the weakness of expiratory muscle drastically lowers the capacity to cough and sputum drainage [78]. Researchers found that respiratory muscles strengthening exercise improves the ability to cough and sputum expectoration. Abdominal muscles are considered as strong and play a vital role in activities like coughing and deep respiration [79].

Abdominal muscles especially contraction of the upper and lower fibres of TrA are the most crucial muscles in respiration. Diaphragm continuously contributes to respiration and posture adjustment, along with the abdominal muscles [72]. Forced expiratory volume in 1 second (FEV₁) means the capacity of air that is blown out after maximal inspiration in one second and a normal adult can exhale 80% of their total capacity in 1 second during expiration [80]. In respiratory muscle training (RMT), FVC and FEV₁ are usually measured to evaluate the pulmonary function [81].
1.4 CORE STABILIZATION EXERCISE:

In the recent time, many non-invasive modalities are used by physiotherapists to treat CLBP which includes transcutaneous electrical nerve stimulation, hot packs, ice packs, medications and massage, proved to provide temporary relief [82]. Orthoses commonly braces may provide short-term external support for the back, but will weaken the back muscle with prolonged use and the spine becomes vulnerable to injury [83]. Chiropractic adjustments of the involved spine may provide temporary relief, but need self-adjustment of the posture by patients for prolonged benefits as well as repeated session is needed [84].

In the rehabilitation of patients with acute and chronic LBP, Exercise therapy is used extensively by physical therapists. Literature reviews as well as treatment guidelines for the treatment of LBP commands exercise therapy as an ineffective treatment for acute LBP where as it has positive effects in chronic LBP [85-87]. Low back exercises and flexibility can be the best treatment option for almost all types of back problems as it is likely to help restore balance in the spine. Low back exercises concentrate on strengthening with the abdominal muscles, to be able to give stabilization of the spine. Rehabilitation programs or preventative rehabilitation programs that focus on strengthening lumbar muscles combined with core stability and proprioception will reduce the risk of low back pain if exercises are done correctly, and on a regular basis. The factors that affect lumbar stability have been an area of extensive research. The clinical application of this research in the form of lumbar stabilization exercise programs has become a common treatment of low back pain and is also increasingly used by athletes to improve performance and by the general public for health and the prevention of injury. There is no evidence that one exercise program is better than another for the rehabilitation of patients with LBP. Therefore, a wide variety of exercises have been utilized for progressive strengthening of the low back.

Core stability is defined as the ability to control the position and movement of the central portion of the body. Core stability training targets the deep abdominal muscles that connect the spine, pelvis and shoulders, and assist in the maintenance of good posture and also provides the foundation for both arm and leg movements. Spinal control is maintained by two main factors namely the modulation of the IAP and tensioning the thoracolumbar fascia. It was found that the TrA muscle associated closely with the control of IAP [60, 88] and recent research confirmed that the increase in IAP leads to stability of spine [89, 90].
Fascial tension directly restricts the intervertebral movement and indirectly compresses the vertebral segment through the posterior layer of thoracolumbar fascia [91].

Core strengthening, usually called lumbar stabilization has a theoretical basis in treatment and prevention of various musculoskeletal conditions and also popularly used therapeutic exercise treatment regimen for low back pain conditions. Clinically core acts as a muscular corset which acts together to stabilize the body and spine [46]. Strength training of these muscles around the spine and abdomen helps in maintaining the spinal stability and pelvic control [92]. Weakness of these core muscle leads to spinal instability and leave the lower back vulnerable to injury. Core stabilization exercise by effective abdominal training increases the strength, stability, balance and stamina. Thus the trunk or spinal stabilizers muscle strengthening helps to improve the endurance of trunk extensors muscles as well as the mobilizers, ends in preventing reoccurrence of backaches in future [93].

1.4.1 Core Stabilization Exercise and Pulmonary Function:

Abdominal muscle training should be done with correct breathing pattern with the appropriate respiratory muscles because respiratory muscles are directly involved during common core stability exercises [94-96]. De Palo et al. stated that strength training exercises like sit-ups, directly recruits the primary respiratory muscle, diaphragm [95]. Many research findings states that the respiratory muscles are contracted in a variety of activities in which respiration is not primarily factor [94-97]. Abdominal muscle contributes about 20% of breathing, thus alters the pulmonary function. During inspiration, it acts as a fulcrum for the diaphragm to act as well as provides anterior stability to abdomen to help with lateral chest wall expansion. On expiration, it pulls the rib margin and increases the intra-abdominal pressure [IAP] [98]. Thus it is believed that the strengthening of the abdominal muscles could assist in ventilatory process [99].

It is well known that strenuous non-respiratory activities involving the skeletal muscle like trunk, extremities and abdominals can strengthen theses muscles, but the question arises is that whether non-respiratory activities or exercise program will strengthen the respiratory muscles. Research findings demonstrated that during such non respiratory maneuvers, the IAP increased as the abdominal muscles are recruited. This increased IAP stimulates the diaphragm to activate inorder to minimize the transmission of intra-
abdominal pressure to the thorax. Thus the difference in the trans-diaphragmatic pressure (Pdi) is developed. Al-Bilbesi F and McCool FD [2000] found this recruitment of diaphragm as well as increased Pdi during sit-ups and weightlifting exercises [100]. These repeated contraction of diaphragm will obviously results in strength-training effect on the diaphragm. In a study done with muscle autopsy, it has been found that the muscle mass of diaphragm was greater in people those who were engaged in manual labour, thus proved that individuals who engaged in physical labour with repetitive activities tends to strengthen the respiratory muscles [101]. This made us to guess that the trunk muscle activities can recruit the diaphragm. In a comparative study between the weightlifters and normal subject, after 1 year of experiment, it was found that the diaphragm thickness [Tdi] measured with ultrasound as well as maximal inspiratory pressure [PImax] were high with weight lifters. This study also demonstrated that individuals with more muscle had greater diaphragm mass and inspiratory muscle strength [102]. Similarly it was found that the trunk flexors strength has a strong positive correlation with PImax among normal healthy subjects [103].

Ventilatory capacity can be increased by endurance training of the respiratory muscles. Airway resistance is one of the factors which alter the forced expiratory volume. Thus, increasing the endurance of respiratory muscles rather than decreasing the airway resistance tends to increase FEV₁ [104]. Hypertrophy of the diaphragm though long duration strength training can improve the PFT values [105]. In an experimental study it was documented that the adolescents involved in high level of physical activity had on an average greater lung volume than their age and body size matched sedentary counterparts, which was attributed to reduce resistance to expiration in respiratory muscles [106]. Research evidences reported relatively high values of FVC, FEV₁, and PEFR in sportsmen [football, hockey, basketball, volleyball, and swimmers] as compared to controls, confirming that the exercise facilitates pulmonary function, reflected as increased lung volumes and capacities [107-110].
1.4.2 Efficacy of Core Stabilization Exercises:

Recently more number of clinical studies evaluated the clinical efficacy of core stabilization exercise in the management of CLBP. Though researches done in the past evaluated the clinical outcome of CSE on CLBP [111], nowadays a well-designed high quality randomized control trails are done to rule out the efficacy of CSE over other treatment modalities in CLBP. First clinical study about core stabilization started with the motor control perspective, in spondylolisthesis patients with CLBP [112]. Subjects underwent motor relearning program for 10 weeks duration showed significant reduction of pain and disability, whereas there was no change in the control group with no intervention. Hides JA et al studied the effect of motor relearning focusing mainly on multifidus and TrA muscles for 4 weeks duration in acute LBP patients and found the size of multifidus recovered in the experimental group [113]. Long term [3 year follow up] study of the same patients showed that the control group subjects had 12.4 times more likely to get back pain compared with the experimental group [114]. Though these studies were done in acute LBP, it is important to consider here as the recurrence of LBP is a major factor in CLBP.

Evidences shows that the strength training and neuromuscular re-education of the core musculature plays a significant role in restoring spinal stability and in turn this minimizes the pain associated instability [115]. Core strengthening mainly focuses on muscular stabilization of abdominal, paraspinal and gluteal musculature [116]. Though the specific role of individual muscles in relation to spinal stability is still widely unknown, but optimal firing and synchronization of all core muscles is proposed to be necessary for the greatest amount of spinal stability. Stability initially requires maintenance of a neutral spine but it should progress beyond the neutral zone in a controlled manner. Thus the training program should start with exercises that concentrate on specific core muscles but it should also progress to complex movements with other training principles. Thus, there is increasing evidence to prove the positive effect of core stability exercise in CLBP, particularly from a motor-control perspective.
1.4.3 SUMMARY:

Core stability exercise (CSE) is an evolving process, and refinement of the clinical rehabilitation strategies is on-going. CSE arrived in the late 1990’s and become popular in LBP management, due to observed changes in abdominal muscle activation patterns as well as improvement in the trunk stability. It was largely derived from studies that demonstrated a change in onset timing of the trunk muscles in back injury of CLBP patients [88]. CSE, consisting of low-load exercises emphasizing voluntary and isolated control of deep trunk muscles, are assumed to help restore trunk muscle deficits in LBP [84, 85]. Similarly in CSE, importance is given to the strength training of TrA or low velocity exercise performed laying or kneeling on all fours [86]. It is believed that such exercise would help normalise motor control which would include timing dysfunction. To overcome the timing problem, the proponents of CS came up with a solution – teach everyone to continuously contract the TrA or to tense/brace the core muscle [117, 118].
1.5 YOGA FOR LOW BACK PAIN:

Yoga was originated in India 5,000 years ago. Now a day it is becoming increasingly popular Western world as an exercise program for different diseases [119]. Yoga is considered to be derived from Ayurveda, an ancient knowledge which aims to discover the true sense of human life and to find remedies for diseases [120]. Yoga is a holistic approach to health and focus on mind-body medicine within complementary and alternative medicine [120]. Physiotherapists started using yoga as an adjuvant to treat musculoskeletal and cardiorespiratory conditions [121-125]. Though there are several types of Yoga, hatha yoga is the most practiced one in western world [119]. Hatha yoga has three main elements namely the body, the mind and the breath [126]. It aims to promote the inner balance between the 3 elements by its two main components namely asanas - proper use of body posture and pranayama - isometric muscle contractions combined with breathing techniques [127]. Yoga postures are designed to strengthen the muscle of the body and increase flexibility [119]. Breathing techniques such as inhalation and exhalation practiced along with postural adaptations helps in strengthening the respiratory muscles [127].

Yoga not only includes physical movements, but it also has complex intervention which involves other components such as specialized use of the breath and relaxation along with the maintenance of posture [122]. Yoga helps in improving the physical functioning thereby increases the spinal flexibility [120,121], and increased strength [124]. Psychological factor like cognitive appraisal could include fear avoidance [125], improvements in self-efficacy [126,127] and improvements in body awareness [128,129]. Yoga also reduces the anxiety and depression thus improving the mood and well-being in the patients [122, 130].

Recently Yoga is used for the treatment of LBP. It is a form of complementary and alternative medicine which includes various practices such as Asanas [Adopting physical postures], Pranayama [Breathing exercises] and meditation [131]. Current studies show that yoga helps in relieving back pain and also in reducing functional disability in LBP [132]. Yoga aims to correct postural alignment, thereby reduces the pain, by selectively stretching the short, tight muscles and strengthening the weak, lengthened [133]. Though there are several types of yoga, hatha yoga is practiced widely [121]. Hatha yoga has three main elements: the body, the mind and the breath [134]. Breathing techniques [pranayama],
practiced during yoga in the form of inhalation, exhalation and suspension, connects the postural correction with strengthening of respiratory muscles which results in improved ventilation [122]. The American Pain Society’s guidelines recommend that clinicians consider offering yoga to patients with chronic LBP.

1.5.1 YOGA and PULMONARY FUNCTION:

Research reviews about the effect of yoga on pulmonary function shows a range of study done between the 8th grade school students and male medical students and the research revealed improvements in respiratory muscular strength following 3–6 months of regular yoga training [135,136]. In the study done among medical students, they practiced a yoga technique namely nouli [135] and this produced a better neuromuscular control than any other yoga technique. This technique also helps in improving the strength and stability of rectus abdominal and transverse abdominal muscles [135, 137]. On the other hand the school students practiced bhasrika, is a powerful pranayama technique, aimed to strengthen both inspiratory and expiratory muscles by its forceful and rapid breathing [138]. Another comparative study between the yoga and physically active control group documented an increase in FVC, FEV1, and PEFR by 33%, 18.75%, and 6%, respectively, in yoga group whereas no marked changes in the control group [139].

Yadav and Das studied the effects of yoga using a shorter, more-realistic training duration. For their study they included sixty women and the subjects were instructed to practice yoga for 5 days per week. Each yoga session was for about 1hour and it consisted of 15 minutes of pranayama and 45 minutes of prayer, asanas, and meditation. The total duration of the study was 12 weeks. The parameters assessed were FVC, FEV1 and PEFR. First post-test evaluation was done at the end of 6 weeks and it showed 13% improvement in both FVC and FEV1 whereas there was no change in PEFR. Final evaluation was done at the end of 12 weeks of yoga training, which showed a significant improvement in all three pulmonary function tests parameters assessed. To be specific, FVC and FEV1 each increased by 26%, and PEFR increased by 10%. Authors commanded that the positive effect of yoga on pulmonary function tests, such as FVC and VC, may be due to various physiological adaptation of the pulmonary system [139,140]. To point out, the specific yoga asanas may
help in increasing the flexibility of the shoulders, rib cage, and back [141]. In addition by focusing on one’s breath during pranayama, one consciously overrides the stimulus to the respiratory centers, leading to more conscious control over respiration [135]. It has been found that during focused breathing, the lungs are emptied and thus it filled more completely, and this suggested being the cause for improvement in FVC and VC [140]. Thus we can conclude that if the filling and emptying of the lung is more, we can expect a greater improvement in FVC and VC. Some yoga technique provides cleansing action by cleaning the nasal and sinus passages, thus improving the pulmonary function [140]. Yogic exercise especially the kapalbhati activates the abdominal and diaphragmatic muscle, results in powerful stroke of exhalation producing quick improvement in the pulmonary function. We can suggest that this modulate the airway caliber and reduces airway resistance as well as strength training of respiratory muscles helps in increasing the respiratory parameters. Practicing yoga for 6 to 12 weeks will help in improving the pulmonary function [138]. Yogic breathing exercise train the practitioner to use diaphragmatic and abdominal muscles more efficiently.

1.5.2 EFFICACY OF YOGA:

Though yoga has a long tradition and practiced for many years in India, till date we don’t have many high quality scientific trails to support the administration of yoga for low back pain. One of the highly influencing clinical trials is a randomized control trail comparing the effects of yoga with conventional back exercises and self-care booklet in patients with low back pain [142]. This study showed that the patients treated with yoga has both clinical and statistical improvement than the self-care booklet group in their functional status measured with the Rolland Morris disability questionnaire but yoga is not better than the conventional back exercise group. All three group has significant reduction of pain intensity measured in a 11 point numeric scale at 12 weeks, but long term follow up after 26 weeks showed improvement of symptoms continued only in the yoga group [143].

Iyengar yoga, a popular style of hatha yoga that frequently uses properties was compared with a back education group in a controlled trail in patients with CLBP. It was found that yoga had significant reduction of patients’ pain, disability and medication usage
than the back education group after 16 weeks [144]. In the recent study, Williams et al compared the Iyengar yoga against the standard medical care in the management of CLBP. Patients in yoga group received 90 minutes of yoga classes two times a week for 24 weeks, standard medical care was purely patients’ self-directed and authors didn’t regulate it. Results showed that the subjects in the yoga group had significant improvement in functional disability, pain intensity and depression [145]. A cross sectional study to find the use of alternative and complementary medicine, about 50% of the Physiotherapists in the United Kingdom and Ireland reported the use of these alternative modalities in the management of pain. Most of them selected yoga as their choice for low back pain especially in the management of CLBP. Yoga was ranked three out of the ten commonly used complementary and alternative medicine techniques for low back pain followed by acupuncture and massage [146]. Thus yoga can be used as an adjuvant in the management of pain and it can give promising results in mobile patients whose CLBP didn’t respond to the conventional therapies.

1.5.3 SUMMARY:

In our society with modern lifestyle people adopts sedentary lifestyle and this leads to poor posture and weakness of the trunk muscles, ends in higher prevalence of low back pain [147]. Various studies claimed the benefits of yoga in these conditions [143-148]. Asanas, physical postures of yoga can be considered as a form of therapeutic exercise that integrates balance, co-ordination, strength and flexibility. Nowadays yoga is prescribed as an adjuvant with other interventions such as lifestyle modification, exercises, ergonomics, massage, mobilization and manipulations and provides promising results by reducing the pain and disability in patients with LBP [148]. Thus, Yoga can be a choice of treatment for physiotherapists if practiced in a safe and strategic manner [146].
1.6: NEED FOR THE STUDY:

- Segmental instability of the lumbar spine may cause functional disorders and strain as well as pain. It is supposed that paraspinal and abdominal muscles have the greatest capacity for enhancing the stabilisation of the spine.

- In the literature and in clinical practice reduced endurance of back extensor muscles and abdominal muscles has been associated with back pain. In the past decades several investigators made to test these muscles’s endurance with pain, functional and motivational factors. However, there is limited literature which studied the effect of the weak core muscles on pulmonary function in patients with cLBP. Weak abdominal muscle and the lumbar spine instability may alter the forced expiration.

- Literature review shows that there is a great need of non-invasive measures to analyse the chronic low back pain so the selected pulmonary function parameters such as FEV$_1$ and PEFR is tried in this study.
1.7: AIMS:

1. To find whether pulmonary function - FEV₁ and PEFR is altered in patients with chronic low back pain.

2. To find the effect of Core Stabilisation Exercises and Yoga exercises [Asanas] on pain, disability and pulmonary function - FEV₁ and PEFR in patients with chronic low back pain.
1.8: OBJECTIVES:

1.8.1: Primary:

1. To compare the effect of Core Stabilisation Exercises and Yoga Exercises [Asanas] on Pulmonary Function - FEV₁ & PEFR, pain intensity and disability in patients with chronic low back pain.

1.8.2: Secondary:

2. To record the pulmonary function - FEV₁ & PEFR in patients with chronic low back pain.

3. To estimate the Pain intensity and Disability in patients with chronic low back pain.

4. To find the effect of Core Stabilisation Exercises on Pulmonary Function - FEV₁ & PEFR, pain intensity and disability in patients with chronic low back pain.