https://doi.org/10.33472/AFJBS.6.10.2024.4048-4075

AFJBS

African Journal of Biological Sciences

Effectiveness Of Core Stability Exercise Programme Using Swiss Ball, Theraband And Floor Exercises In Cricketers With Low Back Pain

Dr. M. Raja Srinivas, MPT Sports, (Ph.D.)[1*]. Dr. Pavan kumar Talupuru MSPT ,DPT(USA), Ph.D[2], Dr. Harikumar.Tadi MPT ortho[3], Dr. J. Kishore Babu[4],

[1*]Prinicipal & professor Grace cop under knr university of Health sciences warangal
[2]Dean of Ahs Chaitanya Deemed to be university Hyd
[3]principal & professor Care cop under knr university of health sciences
[4]MPT Musculoskeletal & Sports,ph.D Professor Navodaya cop Raichur under Ragiv Gandhi University of health sciences Bangalore
***Corresponding author:-** Dr. M. Raja Srinivas, MPT Sports, (Ph.D.)
[*]Prinicipal & professor Grace cop under knr university of Health sciences warangal

Article History
Volume 6,Issue 10, 2024
Received: 2-05-2024
Accepted : 20-05-2024
Doi:-
10.33472/AFJBS.6.10.2024.4048-4075

ABSTRACT

INTRODUCTION : Low back pain (LBP) is one of the most common complaints seen in primary care, with 60-85% of adults experiencing it at some time in their lives. Athletes are no exception, with the added strain of long training contributing to the problem. Current studies have done to see the effect of core strengthening exercises using Swiss ball, theraband and floor exercises in general population with low back pain, but there are no studies which have compared the effectiveness of Swiss ball, theraband and floor exercises in core strengthening in cricketers with low back pain.

Objective: study and compare the effectiveness of Swiss ball exercises, theraband exercises and floor exercises in cricketers with low back ache in terms of pain and back strength.

Methods:

Study Design: Randomized Clinical Trial

Sample: Male and Female cricketers with low back ache.

Sixty competitive cricket players between the ages 18 to 35 years were randomly assigned to 1 of 3 groups. Swiss ball (n=30), theraband (n=30) and floor exercises

Baseline pain and back strength was taken pre treatment i.e. 1st day and post

Treatment. VAS was used to assess pain. Comparison of data within group and between groups of the pre and post values was done.

Results: The results revealed that within group analysis in all the three groups showed statistically significant improvement in terms of pain and back strength ($p<0.005$). Whereas when between groups was analysed, Group B (theraband and floor exercise) showed significant improvement when compared to Group A (Swiss ball and floor exercise) and Group B (floor) showed significant improvement

Conclusion: Although the study showed beneficial results in all the 2 groups, but the results reflected that theraband group had better improvement than the other two groups which was measured in terms of strength improvement and pain reduction.

Key words: Swiss ball, TheraBand, cricketer

INTRODUCTION

Phylogenetically, the spine, a system of articulated segments superimposed one on another has developed in such a way as to support man's ability to move with an upright posture. It has three main functions: Support, mobility and protection. As a support, the spine functions as a framework for the attachment of internal organs and also supports the upper and lower extremities, the trunk, the head, and any external loads. If its functional requirement were limited to support, the spine could be a rigid rod, greatly simplifying its structure. However, the required mobility complicates the spine structure. Thus, instead of a single rigid column, the spine is a stack of rigid blocks (vertebral bodies) with flexible soft tissue (discs) in between. In addition, intervertebral joints (facet joints) control the motion pattern. These joints and the disc are often referred to as the three joint complex. The third function of the spine is to protect the spinal cord, cauda equina and nerve roots. This is accomplished successfully by the bone surrounding the neural tissue almost completely.

The lumbar spine functions as a complex interplay of musculoskeletal and neurovascular structures creating a mobile yet stable transition between the thorax and pelvis. Lumbar region repeatedly sustains enormous loads throughout one"s life time still providing the mobility necessary to allow a person to perform myriad tasks associated with daily living. Considering the magnitude and complexity of the functional demands it is not surprising that low back is a common site for dysfunction.

Back pain was once known as an ancient curse and is now known as a modern international epidemic. Low back pain is neither a disease nor a diagnostic entity of any sort. The term low back pain refers to pain of variable duration in an area of the anatomy afflicted so often that it has become a paradigm of responses to external and internal stimuli.

LBP is defined as pain experienced between the twelfth rib and the inferior gluteal folds, with or without associated leg pain. Low back pain (LBP) is one of the most common complaints seen in primary care, with 60–85% of adults experiencing it at some time in their lives. Athletes are no exception, with the added strain of long training period contributing to the problem, especially in adolescents. In addition, athletes are at high risk of back pain both from trauma and from overuse injuries, especially in sports requiring hyperextension, flexion and rotation. There are enormous causes of low back ache with or without radiating pain. These constitute idiopathic, degenerative, traumatic, inflammatory, congenital, neoplastic, metabolic, postural and gynecological, renal or rectal systemic causes.

Up to 75% of elite athletes experience back pain. In young adults, intervertebral discs are so strong that it first damages the adjacent bone after a traumatic injury. It is impossible to damage a healthy disc except by forcible flexion. After the second decade however degenerative changes in discs may result in necrosis, sequestration of the nucleus pulposus, softening and weakening of the annulus fibrosis. Then comparatively minor strains may cause internal derangement with eccentric displacement of the nucleus pulposus or external derangement, the nucleus pulposus then bulges or bursts through the annulus fibrosis, usually posterolaterally. In the former, unequal tension in the joint causes muscle spasm and sudden severe pain as seen in acute lumbago and in the latter herniated nucleus pulposus may compress on adjacent nerve roots resulting in radiating pain or sciatica.

Fast bowlers have a far higher incidence of spondylolysis (11–55%) than the general population (5%). Other lumbar pathology found commonly in cricketers include pedicle sclerosis, spondylolisthesis, accelerated disc degeneration and muscular soft tissue injury. There is a clear association between bowling with a mixed side/front-on action and stress fractures of the pars inter-articularis. Correction of technique results in a reduction of injury within one year of its implementation. Other factors that have been shown to be associated with stress fractures are landing on an extended knee; an excessive workload of bowling (overs per match and games per season); and poor foot structure, (collapsed longitudinal arches). Unfortunately, studies are not available to directly link the correction of these factors to a reduced incidence . As stated in Cricket Australia Injury Report 2003 on Australian cricketers, it was shown that the incidence of LBP was 8%, and as high as 14% among fast bowlers.

The conservative treatment for low back pain is presently going through rapid changes. In the past, patients diagnosed with low back pain were advised to take medication, rest in bed for two weeks, "live with the pain", or change occupations. Now they are being treated with mobilization, therapeutic exercises, back stabilization programs, back care classes, myofascial release, strain/counterstain techniques, and many other active forms of treatment. Physical therapists are at the forefront of this change in the management of patients who suffer with low back pain.

Despite the prevalence of low back pain in athletes, there are several interventions and indications for which there is a lack of evidence regarding efficacy for commonly used physiotherapeutic exercises such as swiss ball, core stability exercises, theraband, medicine ball, flexi rings, thera tubes, special frames like cadillac, reformer, neuromuscular education and combined rehabilitation interventions.

The core has been referred to as the "powerhouse," the foundation or engine of all limb movement. A comprehensive strengthening or facilitation of these core muscles has been advocated as a way to prevent and rehabilitate various lumbar spine and musculoskeletal disorders and as a way to enhance athletic performance. The vertebral column is supported by global and local stabilizing system which was given by Queensland research group.

„Core stability" is defined as the ability to control the position and motion of the trunk over the pelvis to allow optimum production, transfer and control of force and motion to the terminal segment in integrated athletic activities. Core muscle activity is best understood as the pre-programmed integration of local, single-joint muscles and multi-joint muscles to provide stability and produce motion.

The importance of function of the central core of the body for stabilization and force generation in all sports activities is being increasingly recognized. „Core stability" is

seen as being pivotal for efficient biomechanical function to maximize force generation and minimize joint loads in all types of activities ranging from running to throwing, there is less clarity about what exactly constitutes „the core", either anatomically or physiologically, and physical evaluation of core function is also variable.

The core musculature consists of multifidus with its superficial and deep fibres, erector spinae acting as a postural muscle, longissimus thoracis acting in an extensor function during lifting. Transverse abdominis (TrA) originates at the internal surface of the 7th-12th costal cartilages, the thoraco lumbar fascia, iliac crest and lateral third of the inguinal ligament and inserts on linea alba, the pubic crest and pectin pubis through the conjoint tendon. As it runs horizontally around the abdomen, it forms a corset/rigid cylinder around the spine which serves to stabilize both the spine and the sacroiliac joints. Rectus abdominis acts to flex the trunk by flexing the lumbar vertebra. It originates on the pubic symphysis and inserts on the xiphoid process and 5-7th costal cartilages.

Stability is achieved through the co activation of trunk muscles; therefore, endurance training has been postulated to be beneficial in training trunk muscles to provide stability. It is possible that performing upper body strengthening exercises on a swiss ball can increase trunk muscle activity to a sufficient extent to adequately stress the spinal stabilizing musculature to achieve beneficial endurance training effects. This may render conventional trunk resistance exercises superfluous and increase the efficiency of rehabilitation and prophylactic exercise programs. Contrarily, an elevated muscle activation level may be contraindicated in subjects with low back injury or unstable spines. Co-activation of the trunk muscles has a compressive loading cost that may outweigh the benefits of trunk muscle training. Safe exercises on stable ground have been advocated and thoroughly investigated with a detailed biomechanical model.

In a previous study which addressed on the influence of core strengthening program on low back pain occurrence and hip strength differences was studied from 1998 - 2000 and after incorporation of core strengthening, there was no statistically significant change in occurrence of low back pain but this study did not include athletes who had presently symptoms of low back pain.

The ball has been used in physical therapy in neurodevelopmental treatment for about 40 years[16] .Until 1990 very little literature was available on swiss ball, in 1993 several articles appeared in publications dealing with physical therapy in which Carriere described the use of swiss ball in hospital and Marcks the use of physio roll for the facilitation of motor skills.

The swiss ball has become an accepted therapeutic tool not only in physical therapy departments but also among sports medicine personals and those seeking to promote healthy life style. Swiss balls have been incorporated into strength training regimes thought to be a more effective means in training the muscular skeleton system. Performing strength exercises on swiss balls has been advocated on the belief that a labile surface will provide a greater challenge to the trunk musculature, increase the dynamic balance of the user and possibly train users to stabilize their spines to prevent and treat injury.

The short term study conducted by Stanton R. Reaburn with swiss ball training on core stability concluded that swiss ball training may positively affect core stability. Theraband and floor exercises are crucial programmes used in core strengthening as adopted by the concept of Pilates, but to the best of our knowledge comparison between the individual modes of strengthening of these muscles is scarce.

The use of elastic resistance products in therapeutic exercise programs has become widespread in rehabilitation and has been shown to be an effective method of providing resistance and improving muscle strength. Studies have suggested that effective use of elastic products for resistance training requires not only the application of biomechanical principles but also an understanding of the physical properties of elastic resistance material.

Elastic resistance products, specifically designed for use during exercise, fall into 2 broad categories: elastic bands and elastic tubing. Elastic bands and tubing are produced by several manufactures under different product names, the most familiar of which is Thera-band, Elastic Resistance Bands and Tubing. Elastic bands are available in an assortment of grades or thicknesses. Tubing comes in graduated diameters and wall thickness that provide progressive levels of resistance. Colour coding denotes the thickness of the products and grades of resistance.

Recognized as the original system of progressive resistance for over 25 years, and endorsed by the American Physical Therapy Association (APTA), theraband elastic resistance has been proven to increase strength, mobility and function, as well as reduce joint pain. Evidence-based exercise programs utilizing theraband and tubing rehabilitate injuries, improve the functional ability in adults and improve athletic performance.

Exercise therapy was more effective than usual care by the general practitioner and equally as effective as conventional physiotherapy for chronic low back pain and may be helpful for chronic low back pain patients to increase return to normal daily activities and work. The evidence review included all types of exercises such as specific back exercises, abdominal exercises, flexion, extension, static, dynamic, strengthening, stretching or aerobic exercises. The key aim is to optimise the performance of muscles acting on the lumbar spine to prevent harmful movement. A review of the evidence suggests that those with greater ranges of spine motion have increased risk of future troubles and that endurance, not strength, is related to reduced symptoms.

In a previous study which addressed on the influence of core strengthening program on low back pain occurrence and hip strength differences was studied from 1998 - 2000 and after incorporation of core strengthening, there was no statistically significant change in occurrence of low back pain but this study did not include athletes who had presently symptoms of low back pain.

The second study involved training in acute first-episode unilateral LBP . This group was selected because they have a reduced cross-sectional area of multifidus ipsilateral to their symptoms . The intervention involved a 4-week program of motor relearning focused on multifidus in conjunction with TrA. After 4 weeks all pain and disability measures had recovered in all**OBJECTIVES**

1. To find out the efficacy of Swiss ball exercises on core stabilization in cricketers with low back pain in terms of pain and strength.
2. To find out the efficacy of theraband exercises on core stabilization in cricketers with low back pain in terms of pain and strength.
3. To compare the effects of Swiss ball, theraband and floor exercises are common in cricketers with low back ache in terms of pain and strength.

REVIEW OF LITERATURE

Back pain has plagued humans for many thousands of years. There are descriptions of lumbago and sciatica in the Bible and in the writings of Hippocrates. These terms were familiar to Shakespeare and presumably to his public. Despite the long history of awareness of this problem, a reasonable and scientific explanation of the source of low back and leg pain did not emerge until the 20th century. Research of the 19th and 20th centuries has yielded the detailed description of the anatomy and pathology of most of the potential sources of back pain, including the intervertebral discs, the facet joints, the sacroiliac joints and the spinal ligaments.

The term low back pain refers to pain in the lumbosacral area of the spine encompassing the distance from the 1st lumbar vertebra to the 1st sacral vertebra. This is the area of the spine where the lordotic curve forms. The most frequent site of low back pain is in the 4th and 5th lumbar segment.Low back pain is defined as pain experienced between the 12th rib and the inferior gluteal folds, with or without associated leg pain.

While no mortality is associated with LBP, significant morbidity is associated with chronic low back pain syndromes. A significant number of athletes are unable to return to their normal daily sports routines or function in a productive sports environment secondary to low back pain. There are athletes, who after certain activities develop a dull, nagging lumbar pain that slows them down. Marked modification of both recreational as well as work activities becomes essential. Pain often is not sufficiently severe to stop athletes from getting on with their practice, but
"bugs" them.

The incidence of low back pain (LBP) has been estimated between 4%-56% of the general population per year. Between 60% and 80% of the population will experience LBP during their lives and up to 15% become chronic. LBP is the most frequent cause of disability in individuals less than 45 years and the third leading cause in those 45 years and older. LBP is most common between 35-55 years of age, but affects people of all ages. In jobs that require an extensive amount of physical effort, 2-5% of the working population is compensated each year for work- related LBP. LBP is second only to the common cold in missed work days in the United States affecting as much as 20% of the work force annually. Annual prevalence rate estimates for LBP range from 41%6 to 65% while point prevalence rates approximate 30%. Variability in the statistics reported reflect the challenge of performing epidemiology studies with consistent design or variability in the definition of terms.

Overuse injuries of the spine are commonly seen in clinical practice. It is estimated that 10-15% of the athletic population experiences back injuries. Athletes who participate in sporting events that require repeated hyperextention or flexion of the spine, such as cricket pace bowlers, may be particularly at risk. Of the six pace bowlers used by New Zealand national team last season, three sustain injuries which kept them out of pace bowling for at least two months, and others have had significant spinal injury problems but have managed to continue bowling.

In a study that investigated the prevalence of injury in Australian first class cricketers over six seasons and found that any time during the season, 16% of the pace bowlers were likely to be injured compared 4% of the spin bowlers, 4% of the batsmen and

1 % of the wicket keepers. The highest injury prevalence was stress fracture to the lumbar spine at 2.4% of all players. The next most prevalent injury was ankle and foot sprains at 1.4%. Another study showed that the lumbar spine accounted for the largest number of injuries (14%) , with the stress fracture being more common (2% of all injuries), but nearly 11% of all days lost, these studies also highlight the cost in terms of time out of the sport associated with such injury, with back injury accounting 24% of all missed days and 19% of missed 1st team matches.

It has been stated that most low back pain is of unknown etiology. There are multiple reasons for this statement including a lack of sensitivity of special testing used to assess low back pain, a high rate of anatomical anomalies noted on diagnostic imaging, a failure to demonstrate a high correlation between anatomic abnormality with clinical symptomatology and a failure of clinical examination to predict symptom reports and disability rates. Even so, it can be stated that a considerable number of cases of low back pain are the result of mechanical factors since the symptoms can be altered either positively or negatively with movement of the spine during a mechanical examination.

There are multiple proposed causes for both acute and chronic low back pain. Authors have proposed muscular involvement, facet joint, intervertebral discs (IVD), scoliosis, sacroiliac involvement, muscular imbalances, and instability; yet reliable identification of that specific pathological agent remains elusive. The ability to identify a specific painful tissue is hampered by the innervations of potential pain generating structures. It has been identified that the dura, outer annulus and the posterior longitudinal ligament are all innervated by the sinuvertebral nerve, the zygoapophyseal joint and the local muscles are innervated by the medial branch of the posterior primary rami. Since multiple structures are located in a small area and are innervated by nociceptors from the same nerves, pain referencing patterns from various structures are similar, thus making accurate identification of a specific structure unlikely. It must also be considered that in inflammatory conditions or in circumstances where a localized trauma has occurred, multiple pain generating structures may be involved so the problem is multifactorial in nature.

Authors have identified pathological conditions by proportion. Bogduk reports that 39% of back pain is from the IVD, 33% is unidentified, 15% from the

zygoapophyseal joint and 13% from the sacroiliac joint. Laslett et al has reported that from 15-40% of back pain may be from the zygoapophyseal joint. Dontigny has stated that up to 95% of all low back pain may originate from a subluxed S3 facet of the SI joint. However, no scientific based study using a diagnostic gold standard was used to validate his claim. Bernard"s estimation of SIJ contribution is a more modest 22.6% retrospectively examining 1293 cases of LBP over a 12 year period. These varying percentages of pathoanatomic causation for LBP may suggest that the populations studied are not homogenous, causation may be unpredictable, or diagnostic standards may be inherently unreliable.

Numerous studies have been performed to determine different factors that may be predictive of low back pain. Many of these studies have been of cross sectional design and lacking in sufficient statistical power to draw strong conclusions.[39] With regard to age, a range from approximately 40-60 seems to incur the highest prevalence rates but the relationship to incidence isn"t as clear. Psychosocial factors including depression, self-esteem, job satisfaction and feelings of distress are more strongly related. Studies have also demonstrated that job related factors other than psychosocial factors could also be involved.

The physical demands of the job were also predictors with positive odds ratios for injury including: peak sagittal trunk velocity, maximum low back moment, peak lumbar shear forces, lumbar disc compression, and work related twisting. Personal characteristics including cigarette smoking, obesity, 70 trunk strength and flexibility, exercise history, familial history and general health have all been implicated.Factors related to body build, nutritional status and general constitution cannot reliably predict incidence of back pain. In addition to pathoanatomical causation, one must consider the interaction of risk factors with anatomical causation. This approach is featured in the biopsychosocial model of causation. This model explains a portion of the unpredictability of low back pain exclusively on anatomical or physiological factors and validates the results of numerous studies performed on psychosocial factors reported in the literature.

It is imperative to identify the natural progression of LBP to better understand the effects of treatment. False conclusions about interventions will result if we cannot identify how the disorder behaves naturally. Hestbaek"s systematic review of 36 studies published between 1981 and 1999 revealed that LBP does not evolve in a predictable pattern. Studies use differing methods of determining progression of the disorder making comparisons difficult. Cross sectional and longitudinal studies use cohorts of those with LBP at different stages of the disorder creating inequities during comparisons.

LBP does not feature true recovery but changes over time with the progression of the Disorder and the progression is nonlinear in fashion so basing classification of LBP as acute, sub acute or chronic on duration of symptoms alone is invalid. There may be significant variations between the short-term and long-term prognoses altering the results of a given study though it does appears that in CLBP, as age increases so does the disability. Short-term effects may view a problem as being cured; however, LBP is frequently characterized by recurrent bouts of pain and disability suggesting that chronicity can be determined by either duration or recurrence of symptoms.

For the purpose of this paper, the segmental dysfunction model will be used to describe the deficits associated with LBP and will be centred around Panjabi"s model of stabilization.85, 86 Stability has been described as a balance between passive structures, active structures and their neuromuscular control. Panjabi described the subsystems of stability as interdependent meaning that deficits in one component could be compensated for by enhanced activity in another component. If a passive structure was damaged or a muscle lacked strength or endurance, greater muscular effort could maintain the needed level of stabilization through altered neural control to prevent further damage. The actual ability of the system to compensate for structural changes should be questioned since damage to passive structures seems to be quickly followed by detrimental changes in the muscular component further challenging or because of neural control changes.

Number of systems and subsystems work accordingly to maintain the functional joint stability of the back. Any alteration such as ligamentous injury leads to proprioceptive deficits. These pathomechanic sensory deficits progresses at decreased neuromuscular control leading to functional instability. Also it is noted that ligamentous injury causes gross mechanical instability leading to functional instability. All these changes and factors leading to functional instability causes repetitive injury and abnormal stress on the structures leading to ligamentous injury thus continuing the vicious chain of events leading to pain and instability.

Segmental instability refers to the state where normal control of a particular movement is temporarily lost during function. This particular condition can be due to losses in the integrity of passive structures that assist in stability, a loss of muscular stiffness due to atrophy or injury, or a loss of neuromuscular control because of compromised proprioceptive input. Using this model of instability, it is easier to appreciate how abnormal movements at a single segment can occur at any particular range of motion resulting in abnormal force to be placed on the segment or structures surrounding the segment leading to nociceptive afferent input.

It is apparent that at least one of these subsystems fails to heal effectively following an acute episode of LBP leaving the individual susceptible to subsequent episodes. Ultimately, it appears that neuromuscular control is primarily responsible for prolonged pain and loss of function and this finding is consistent with conclusions drawn from peripheral joints.

The athlete's core is composed of the trunk, and the pelvic and shoulder girdles. The core operates as an integrated functional unit enabling the entire kinetic chain to work synergistically to reduce force load, dynamically stabilize, and generate force against abnormal forces. An efficient core allows for the maintenance of optimal length- tension relationships of functional agonists and antagonists, which makes it possible for the body to maintain optimum force-couple relationships. Athletes who participate in high-impact sports that require great physical strength need strong core musculature in order to generate sufficient force to play their position safely and absorb the impact of collisions. Football players and hockey players must be able to generate force quickly, while being able to perform highly coordinated movements. This is not possible without a strong base musculature, trained in a Sport-specific manner. Throwing or racquet athletes require strength and neuromuscular coordination throughout their trunk, pelvic and shoulder girdles, and lower extremities to generate the needed force from their proximal to distal upper extremity. Golfers generate most of their power through the trunk and pelvic girdle, even though the successful golf swing is mediated through the upper extremities.

The core maintains postural alignment and dynamic postural equilibrium during functional activities, and relies on an efficient neuromuscular system. A strong and stable core can improve optimum neuromuscular efficiency by improving dynamic postural control. As the efficiency of the neuromuscular system decreases, the ability of the kinetic chain to maintain appropriate forces and dynamic stabilization decreases significantly. Decreased neuromuscular efficiency leads to compensation and substitution patterns, as well as poor posture during functional activities. These altered patterns lead to increased mechanical stress on the contractile and noncontractile tissue, and lead to repetitive micro trauma, abnormal biomechanics, and injury. Research has demonstrated that people with low back pain have an abnormal neuromotor response of the trunk stabilizers accompanying limb movement, as well as greater postural sway and decreased limits of stability.

Bergmark classified the lumbar muscles as either local or global, while Lee refers to these muscles as the inner unit and the outer unit.

The Local Stabilizers

- Local stabilizing muscles tend to produce little movement due to their positioning, and their overall length changes very little during contraction. The main local spinal stabilizers are considered to be the following:

 Lumbar spine: transversus abdominis and multifidus
 Thoracic spine: sternocostalis and rotators

 Cervical spine: multififus, rotators, longus capitis, longus colli and semispinalis cervicis.
 Pelvic floor: levator ani, puborectalis, iliococcygeus, ischiococcygeus.

The Global Stabilizers
Global stabilizers are larger muscles that function primarily in an agonistic manner, providing for movement of larger joints and functional units. Excessive contraction of the global muscles may occur in patients with poor ability to activate the local stabilizers. The result can be low back pain or symptoms elsewhere in the body, depending on the activity of the athlete.
The global musculature includes:
 Longissimus thoracis
 Iliocostalis lumborum thoracis
 Quadratus lumborum
 Rectus abdominis
 Internal obliques
 External obliques
 Erector spinae

Core stabilization is a concept that considers the integrated relationship between the legs, pelvis, trunk and upper extremities.
The aims stabilization is as follows:
1. Achieve localized segmental neuromuscular control
2. Ability of the athlete to achieve and hold, isometrically, the position power
(neutral pelvis) or optimal stability
3. Improve neuromuscular coordination between the trunk, pelvic and shoulder girdles during changing movement patterns.
4. Improve the athlete‟s musculoskeletal and cardiovascular fitness and endurance.
5. Educate the athlete about what he or she can and cannot do, with regard to the particular injury or condition, if present.

The physical object known as a "Swiss Ball" was developed in 1963 by Aquilino Casani, an Italian plastics manufacturer. He perfected a process for moulding large puncture-resistant plastic balls. Those balls, then known as "Pezzi balls", were first used in treatment programs for newborns and infants by Mary Quinton, a British physiotherapist working in Switzerland. Later, Dr. Susanne Klein-Vogelbach, the director at the Physical Therapy School in Basel, Switzerland, integrated the use of ball exercise as physical therapy for neuro-developmental treatment. Based on the concept of "functional kinetics" Klein-Vogelbach advocated the use of ball techniques to treat adults with orthopedic or medical problems. The term "Swiss Ball" was used when American physical therapists began to use those techniques in North America after witnessing their benefits in Switzerland. From their development as physical therapy in a clinical setting, those exercises are now used in athletic training, as part of a general fitness routine and incorporation in alternative exercises such as yoga and Pilates.
The swiss ball is an extremely popular apparatus used for core stability training in populations as varied as spinal disorders to elite athletes. It is therefore surprising to discover just how little

evidenced based research has been conducted in this area and unfortunately the results of this research is conflicting. The majority of the research in this area involves abdominal muscles exercises comparing them to the traditional mat (stable surface) styles, however the benefits of Swiss ball exercises appear to have been equivocally applied to all whole body exercises.

The earliest research into this topic is by Vera-Garcia, F.J., Greinier, S., & McGill,

S.M. (2000) into abdominal muscles response during curl ups on stable and labile surfaces analyzing electromyographic signals. They concluded that performing curl ups on a swiss ball changes both the level of muscle activity and the way that the muscles co-activate to stabilize the spine suggesting a higher demand on the motor control system which they concluded may be desirable for specific stages in the rehabilitation process. They showed that greater muscle activation and cocontraction of trunk flexor and extensor muscles were elicited if the curl up exercise was performed on the swiss ball. There were only 8 participants in this study of which none reported acute or chronic lower back pain history. It was this research that lead to a boom in the use of swiss balls in physiotherapy and poor core strength rehabilitation.

The next investigations into the swiss ball were conducted in 2004 by Stanton, R., Reaburn, P.R. & Humphries, B who looked at the effect of a short-term (6-weeks) swiss ball training program on core stability and running economy with 10 participants in their control group and 8 in their experimental group. They found no significant differences for myoelectric activity of the abdominal and back muscles on running economy or posture between both groups; however, they did find a significant difference on core stability. This research appears to support the earlier work of Vera-Garcia et al.

The first empirical study into the use of the swiss ball with lower back pain patients was conducted in 2005, by Marshal, P.W.M., and Murphy, B.A. They took 20 LBP patients and conducted a 12-week swiss ball core training exercise program. They found evidence that this modality of exercise may successfully improve the functional capacity of patients with chronic non-specific lower back pain and attribute the reduction in disability to the improvement in the flexion relaxation response of the erector spinae. However, this study did not include a control group so it is difficult to conclude that performing exercises on the swiss ball would be more effective than performing those exercises on a stable surface.

Cosio-Lima LM in 2003 studied the effects of physioball and conventional floor exercises on early phase adaptations in back and abdominal core stability and balance in women, concluded that early adaptations in a short-term core exercise program using the physioball resulted in greater gains in torso balance and EMG neuronal activity in previously untrained women when compared to performing exercises on the floor.

Thera-Band elastic resistance devices have increased in popularity in the rehabilitation setting. There are six different colours of the band produced, each one varying from the others in the level of resistance offered. The least resistive band is yellow, and the next five colours gradually increase in resistive properties. The colours of the bands, from lowest to highest resistance are yellow, red, green, blue, black, and silver. Hughes et al (1999) showed the benefits to using Thera-Band for strengthening include its ease of use, safety for all populations of people to employ, low cost, and portability. Its use can translate into increased functional performance by those who use it correctly. Anderson, Rush, Shearer, and Hughes (1992) reported a ten percent increase in the strength of the internal rotators of the shoulder of young subjects after six weeks of training with Thera-Band.[116] Ward, Paolizzi, Maloon, Stanard, and Bell (1997) compared the use of free weights and Thera-Band on the external rotators of the shoulder for four weeks. Both methods were equally effective in producing gains in strength in the muscles that were exercised.

The amount of resistance provided by a piece of elastic material is dependent on its stiffness (which is coded by colour), its length, its initial deformation, and its final deformation. As the material is stretched more 7 and more, the resistance increases, therefore the initial length will govern how much more stretch the material can undergo. Another characteristic of elastic resistance is that over time the material begins to fatigue; upon being stretched countless times the elastic material will no longer be able to provide the same tension. A patient may be able to recognize the decrease in resistance of the material, but this dilemma can be avoided altogether by continually changing the material used after it has been stretched so many times.

According to Simoneau et al. (2001) when the elastic bands were stretched to 100% of their initial length for 501 cycles, there was a decrease in tension of approximately 9-12% between the first and last cycle. They also found that the most fatigue will occur within the first 50 stretch cycles. They concluded that the tension in the material decreases slowly with repeated stretching, and would continue to decrease with an increased number of stretches.

Due to the fact that the resistance level is determined by the stretch and the resting length of the material, some questions as to just how much resistance the patient is receiving have arisen. Studies have quantified the amount of resistance provided by different colors of TheraBand Results of these studies give a rough estimate as to how much work is actually being performed by a patient.

There is a growing popularity of stabilization exercises proposed to enhance athletic performance and to develop muscles of the trunk. Core strengthening is becoming a major trend. Since sports activity involves movement in three cardinal planes. Core musculature must be assessed and trained in these planes. However, clinical outcomes of core strengthening programs are lacking in the research, even though core stabilization programs are increasing.

Traditional rehabilitation focuses on isolated absolute strength gains, isolated muscles, and single planes of motion. Clark, et al proposes that all functional activities are triplanar and require acceleration, deceleration, and dynamic stability. One plane being used leads to other planes requiring dynamic stabilization to allow for optimal neuromuscular efficiency. One needs to train dynamic stability to occur efficiently during all kinetic chain activities, since there are a wide variety of movements associated with athletics, athletes need to strengthen hip and trunk muscles that provide stability in all three planes of motion.

Boonstra et. Al. (2008) did a cross-sectional study on the reliability and concurrent validity of a visual analogue scale (VAS) for disability as a single-item instrument measuring disability in chronic pain patients. Fifty-two patients and three hundred forty four patients above age of 18 years were included in reliability and validity group respectively. Reliability study: Spearman"s correlation coefficients of the test and retest data of the VAS for disability; validity study: values of the VAS disability scores with the scores on four domains of the Short-Form Health Survey (SF-36) and VAS pain scores, and with Roland-Morris Disability Questionnaire scores in chronic low back pain patients. Thus they concluded that the reliability of the VAS for disability is moderate to good.

METHODOLOGY

The main advantage of VAS has been claimed to be a high degree of „sensitivity" i.e., a discriminating capacity superior to that of other scales. The visual analogue has been found to be easy to administer and highly reliable and valid and is a very useful tool in the clinical measurement of both acute as well as chronic pain.

Review on reliability of rating low back pain with a visual analogue scale (VAS). Measuring pain on a visual analogue scale is one of the WHO recommended outcome measure for low back pain.

Source of Data:
Primary data was collected from OPD of Tirumala college of physiotherapy, Nizamabad .

Duration of study:
Study duration was one year

Methods of Data Collection:
Study design:
The study design was a Randomized Clinical Trial
Sampling Design:
The sampling design was a random sampling design. A simple random method was used for assigning participants in to two groups.
Participants:
Male and Female cricketers with complaints of low back ache and willing to take treatment were recruited for the study.
Sampling Method:
Envelope method was used for assigning participants in to two groups.
Sample Size:
The sample size for this research study was sixty (60).
Study Sample:
The study sample included male and Female cricketers with low back ache.
Inclusion Criteria:
Male and Female cricketers with complaints of low back ache.
- Age group between 18-35 years.
- Low back pain which is classified as non specific without any underlied patho- mechanic changes.
- Visual Analogue Scale >6
- Athletes willing to participate in the study.

Exclusion Criteria:
- Those who were unable to perform the exercises because of one or the reason.
- Associated Neurological symptoms
- Injuries to lower limb
- Those on physiotherapeutic treatment for low back pain
- Those taking analgesic or antispasmodic or any other medicine for any painful condition of the body.

Materials:
- Data collection sheet

APPARATUS AND EQUIPMENTS:
1. Measuring Tape:
A non stretchable measuring tape with total length of 60 inches / 152 centimeters was used to measure the height of each participant. The participant stood against the wall with head and heel touching the wall and a mark was made on wall at vertex of the head. The distance from the ground to the vertex was measured as height of participant.

2. Weighing Machine:
A standard bathroom weighing machine with 1 kg increment was used to measure the weight of each participant in kilograms.

OUTCOME MEASURES:

1. Pain Intensity:
Pain score of the patients involved in this study were recorded by using the Visual analogue scale (VAS). The visual analogue scale is a 10 cm straight line drawn on a paper marked with numbers 0 to 10, where 0 symbolized no pain and 10 symbolized the worst thinkable / untolerable pain and participants were asked to mark a point on this line as per the severity of his/her pain which indicates present pain level.

2. Core strength:
Core strength was measured using standard technique of measuring range with the help of pressure biofeedback.

PROCEDURE:
Prior to the commencement of the procedure, informed written consent was taken from the participants. Only those willing to take treatment intervention for four times a week were recruited for the study. The sixty (60) subjects were randomly allocated to two groups of thirty (30) each. Envelope method was used for the purpose of allocation of the subjects to the two groups.
All the participants with low back ache who reported the complaints on field were screened for inclusion and exclusion criteria and then they were requested to participate in the study. Those willing to participate in the study were given a brief idea about the nature of the study and the intervention. The demographic data including age, height, weight, side of affection and duration of symptom were collected through data collection sheet. Initial evaluation of pain intensity was done using visual analogue scale (VAS).
Then participants were randomly allocated into 2 groups:
Group A: Swiss ball exercises and pelvic floor exercises
Group B: Theraband exercises and pelvic floor exercises
The two groups received the selected treatment for four times a week

INTERVENTIONS:

Group A:
Group A received swiss ball exercises. Ten repetitions of each exercise were performed with 10 seconds hold of three sets.

Abdominal curl exercise on swiss ball :

- Position of the athlete: The athlete was lying supine on the ball with both the arm crossed over the shoulder.
- Position of the therapist: The therapist stood besides the athlete, observed and then corrected the faulty movements.
- Position of the ball: The ball is placed under the hips of the athlete.
- Procedure: The therapist commanded the athlete to lift his back off the ball , pulling the bottom of his rib cage down towards hips as he curls up keeping the ball stable and the position was maintained.

Back extension exercise with swiss ball :

- Position of the athlete: The athlete was lying with head facing downwards with both hands interlocked behind the head.
- Position of the ball: The swiss ball was positioned beneath the lower abdomen.
- Position of the therapist: The therapist stood besides the athlete, observed and then corrected the faulty movements.
- Procedure: The therapist commanded the athlete to lift his body upward as much as possible and look in front and the position was maintained.

Pelvic bridge with swiss ball:

- Position of the athlete: The athlete was lying supine with knees extended and feet on the ball and arm were at the side.
- Position of the therapist: The therapist stood besides the athlete, observed and then corrected the faulty movements.
- Position of the ball: The ball is placed under the foot.
- Procedure: The therapist commanded the athlete to lift his pelvis off the floor and the position was maintained.

Side bridge with swiss ball :

- Position of the athlete: The athlete was positioned on the ball in side lying; resting the elbow on the ball and elbow was placed directly below the shoulder.
- Position of the therapist: The therapist stood besides the athlete stabilising the ball with his legs, observes, correct faulty movements and commands.
- Position of the ball: The ball is placed under elbow.
- Procedure: The athlete raises his hips until his torso gets straight from shoulder to ankle and the position was maintained.

Dosage:

The swiss ball exercises were given for ten repetitions of three sets. The above procedure was given for four times a week for four weeks. At the end of week the athlete"s pain and back strength was reassessed and recorded on data collection sheet.

Group B:

Group B received theraband exercises. Ten repetitions of each exercise were performed with 10 seconds hold of three sets.

Theraband-loop abdominal crunch exercise :

- Position of the athlete: The athlete was lying supine on firm surface with hip knee flexed and foot supported on ground.
- Position of the therapist: The therapist stood in front of athlete stabilizing athlete"s ankle and knee with foot.
- Position of the theraband: The theraband was placed just below the inferior angle of scapula. Athlete held the ends of theraband in his hand with elbow in full extension.
- Procedure: The therapist commanded the athlete to move his shoulders towards his knees by stretching the ends of theraband and the position was maintained.

Theraband-loop abdominal oblique crunch exercise :

- Position of the athlete: The athlete was lying supine on firm surface with his hip knee flexed and foot supported on ground.
- Position of the therapist: The therapist stood in front of Athlete stabilizing athlete"s ankle and knee with foot and hand of therapist.
- Position of the theraband: The theraband was placed just below the inferior angle of scapula. Athlete held the ends of theraband in his hand with elbow in full extension.
- Procedure: The therapist commanded the athlete to perform movement of lifting his one shoulder and take it over his opposite knee clearing off the ground and the position was then maintained.

Theraband-loop back extension exercise :

- Position of the athlete: The athlete sat in long sitting position on a firm surface.
- Position of the therapist: The therapist supervised the athlete by standing besides him.
- Position of theraband: The theraband was placed below the fore foot of the athlete. Athlete held the ends of theraband in his hand with elbow in full extension.
- Procedure: The therapist commanded the athlete to hold the theraband and stretch its end by extending the back to go in supine and the position was then maintained.

Theraband-loop trunk side bending exercise :

- Position of the athlete: The athlete stood erect on a firm surface.
- Position of the therapist: The therapist supervised the athlete by standing besides him.
- Position of the theraband: The theraband was placed below the foot of the athlete. Athlete held the ends of theraband in his hand with elbow in full extension.
- Procedure: The therapist commanded the athlete to hold the theraband and stretch it by side flexing to opposite side and was asked to repeat it for other side by stretching the other end and the position was then maintained.

Dosage:

The theraband exercises were given for ten repetitions of three sets. The above procedure was given for four times a week for four weeks. At the end of week the athlete"s pain and back strength was reassessed and recorded on data collection sheet.

Group C

Group C received floor exercises. Ten repetitions of each exercise were performed with 10 seconds hold of three sets.

Abdominal crunches:

- Position of the athlete: Supine lying with knee flexed position and both the arms were crossed over his shoulders.
- Position of the therapist: The therapist Stood in front of athlete and stabilized the ankle of the athlete.
- Procedure: The therapist then commanded the athlete to move his shoulders towards his knees and the position was maintained. The therapist stabilized the knees and tried to avoid trick movement such as hip hiking.

Back extension exercise

- Position of the athlete: The athlete was in prone lying with both his arms crossed over his shoulders.
- Position of the therapist: The therapist supported athlete‟s pelvis and both lower limbs.
- Procedure: The therapist commanded the athlete to perform back extension by lifting his upper chest off the plinth and the position was then maintained.

Side bridge

- Position of the athlete: The athlete was in side lying with right/ left forearm on the ground in midprone position with elbow under the shoulder.
- Position of the therapist: The therapist supervised and corrected any faulty posture.
- Procedure: The therapist commanded the athlete to raise his hip until his torso gets straight from shoulder to ankle and the position was then maintained. The exercise was repeated on other side.

Oblique crunches

- Position of the athlete: The athlete supine lying with Knee semi flexed position and both the arms crossed over his shoulders.
- Position of the therapist: The therapist stood in front of athlete and stabilized the ankle of athlete.
- Procedure: The therapist commanded the athlete to move his shoulder towards his opposite knee in oblique direction and the position was the maintained. The Therapist stabilized the knee in order to avoid trick movement such as hip hiking.

Dosage:

The floor exercises were given for ten repetitions of three sets. The above procedure was given for four times a week . At the end of week the athlete‟s pain and back strength was reassessed and recorded on data collection sheet.

The post-interventional responses were recorded on 16^{th} session of treatment in the form of visual analogue scale (VAS) and back strength.

The pain intensity was recorded using visual analogue scale (VAS). The participants were asked to mark the intensity of pain on a 10 cm long line marked with numbers 0 to 10 where 0 represents no pain and 10 maximum pain.

DISCUSSION

The present study showed improvement in all the experimental groups when compared to their baseline values. However, theraband group was statistically significant when compared to swiss ball and floor exercise groups whereas swiss ball group had better improvement than floor exercise group in terms of pain and strength of core musculature as compared by VAS.

The improvement seen in the Swiss ball group is in consent with the study done by Vera-Garcia, F.J et al (2000) who studied abdominal muscles response during curl ups on stable and labile surfaces analyzing electromyographic signals concluded that performing curl ups on a swiss ball changes both the level of muscle activity and the way that the muscles co-activate to stabilize the spine suggesting a higher demand on the motor control system which they concluded may be desirable for specific stages in the rehabilitation process. They showed that greater muscle activation and co-contraction of trunk flexor and extensor muscles were elicited if the curl up exercise was performed on the swiss ball. There were only 8 participants in this study of which none of the participants reported acute or chronic lower back pain history and at the same time there was no difference in mean age, height, weight.

An experimental study in 2004 by Stanton, R., Reaburn, P.R. & Humphries, B studied the effect of a short-term (6-weeks) swiss ball training program on core stability and running economy with 10 participants in their control group and 8 in their experimental group. They found no significant differences for myoelectric activity of the abdominal and back muscles on running economy or posture between both groups; however, they did find a significant difference on core stability. The present research is in agreement to the conclusion of the cited study with only difference in the duration of the present study which is of week. The present study differed in the study duration, objectives and the outcome measures with intervention being similar as that of swiss ball for core stability.

An empirical study by Marshal and Murphy in 2005 who used Swiss ball as a mode of intervention in low back pain patients for a duration of 12-weeks. Researchers found evidence that this modality of exercise may successfully improve the functional capacity of patients with chronic non-specific lower back pain and attribute the reduction in disability to the improvement in the flexion relaxation response of the erector spinae. However, the study did not include a control group to conclude that swiss ball exercises would be more effective than performing those exercises on a stable surface. The present study also found that swiss ball exercises are better than floor exercises for LBA for pain relief and core strengthening is consistent with the above study.[130]

A research by Richard A. Ekstrom et al in 2007 who analysed the electromyographic signals of core trunk, hip, and thigh muscles during 9 rehabilitation exercises suggested that the exercises used in the study could be used for a core rehabilitation or performance enhancement program, whereas the similar exercises were used for the purpose of rehabilitation of cricketers with low back ache. Investigators have reported both linear and nonlinear relationships between EMG signal amplitude and increasing force production during isometric contractions. Marras and Davis found positive linear relationships for the erector spinae, rectus abdominis, and external and internal oblique abdominis muscles during isometric flexion and extension exertions. This linear relationship of muscles stated can be associated with the present study in terms of strength gain Thus, individuals with poor endurance of the abdominal and back muscles will benefit from appropriate use of bridging, unilateral bridging, sidebridging, prone bridging on elbows and toes, and the quadruped arm/lower extremity lift exercises. All the above exercises demonstrated coactivation of muscle groups and should be beneficial for stabilization or endurance training.[132]

A study by Cosio-Lima LM in 2003 studied the effects of physioball and conventional floor exercises on early phase adaptations in back and abdominal core stability and balance in women, concluded that early adaptations in a short-term core exercise program using the physioball resulted in greater gains in torso balance and EMG neuronal activity in previously untrained women when compared to performing exercises on the floor. The difference seen in the two groups in the present study and the previous study is in the gender targeted as previous study incorporated female but the present study had male participants and who were trained for athletic performance.[131]

Hughes et al (1999) in his study showed the benefits of using theraband for strengthening of shoulder musculature because it is easy to use, safe for all population to employ, low cost and portability and hence the present study also agrees with the previous researches as the participants in theraband group were more comfortable and clearly compliant.[115]

Anderson, Rush, Shearer, and Hughes in 1992, reported a ten percent increase in the strength of the internal rotators of the shoulder of young subjects after six weeks of training with Thera-Band. The results of the present study of the theraband group also demonstrated improved strength

Triber FA et al (1998) made a study to determine the effect of a 4- week isotonic resistance training program using theraband elastic tubing and light weighted dumbbells on concentric shoulder rotator strength or velocity of serve or both in a group of elite-level tennis players. 22 male and female varsity college tennis players were randomly assigned to control group and experimental group for 4 week training. The experimental group exhibited significant gains in internal rotation torque at both slow and fast speeds & also in external rotation torque at fast speed. Thereby, they concluded that resistance training using theraband and lightweight dumbbells have beneficial effects on strength and functional performance in college level tennis players, the results of the present study was consistent with the results of Triber FA in increased strength of core muscles by use of therabands.[133]

Another benefit provided by the fact that elastic resistance does not rely on gravity and that it provides continuous tension to the muscles being trained. When you lift a free weight like a dumbbell in any direction other than straight up and down, the tension on the muscle can actually be removed at certain points in the range of motion. Another unique benefit of elastic resistance is that free weight resistance does not offer is linear variable resistance. What this means is that, as the range of motion of the exercise increases, the resistance provided by the elastic equipment increases. One of the benefits of this is that as the range of motion increases and the resistance increases, the number of muscle fibers that are being used in the exercising muscle increase. More the muscle fibers used, the greater the adaptations in muscle strength that can be achieved with the training program. These changes can be presumably associated with the strength gains and benefits in pain reduction in the present study.

The researches performed on elastic resistance suggest that not only does elastic resistance offer similar benefits to free-weight resistance as implied in the present study, but it actually has several benefits that outweigh those of free weights. This means that a program using elastic tubing resistance can provide similar benefits to a program that uses free-weight resistance, such as increased muscle strength, increase muscle tone and size and decreased body fat. In addition, a program that uses elastic tubing resistance can also provide benefits that are not offered by free-weight resistance programs, such as more functional strength, better injury prevention, greater ability to change muscle emphasis during exercises, greater muscle power development and easier use.[134]

Axler, Craig T, Mcgill, Stuart M proposed a study which investigated various abdominal exercises that optimize the challenge to the abdominal muscles (rectus abdominis, external oblique, internal oblique) but would impose minimal load penalty at the lumbar spine and concluded that no single exercise was found that would optimally train all of the abdominal muscles while at the same time incurring minimal intervertebral joint loads. It also concluded that a variety of abdominal exercises are required to sufficiently challenge all of the abdominal muscles and that these exercises will differ to best meet the different training objectives of individuals.[135]

CONCLUSION

The present study is in consensus in terms of pain of athletes with non specific low back pain of meta analysis in systematic review by Edwin Choon Wyn Lim et al who concluded that pilates-based exercises are superior to minimal intervention for re- duction of pain in individuals with nonspecific low back pain. The individuals with nonspecific chronic low back pain in most of the studies received 8 to 12 of Pilates- based exercises at a frequency of 1 to 2 times per week over a span of 6 to 8 weeks. Since the study closely resemble Pilates exercise approach of rehabilitation with a frequency of 4 sessions per week , the improvement can be credited to pilates-based exercises.

SUMMARY

- This research study was done to compare the effectiveness of Swiss ball, theraband and floor exercises in cricketers with low back ache. 60 participants with complaints of low back ache were randomly allocated into two groups i.e. group A, group B each group comprising of 30 participants. Group A was treated with Swiss ball and pelvic floor exercises, group B was treated with theraband and pelvic floor exercises . Outcome was measured in terms of visual analogue scale for pain and strength. Comparison of Groups in terms of Age, Height, Weight and ANOVA was applied for the analysis. Comparison of pain scores as on VAS within group, Paired t-test was applied. Comparison of differences between means obtained for VAS of groups, ANOVA were done for statistical analysis.In present study intra group comparison results showed pain relief and improved strength was statistically significant in two groups. Whereas inter group comparison results showed that group B i.e. theraband and pelvic floor exercises was statistically significant in reducing pain and strength than group A in cricketers with low back ache and group A i.e. Swiss ball and pelvic floor exercises was statistically significant in reducing pain and strength than group A in cricketers with low back ache.·

- Hence based on the results of the present study it can be concluded that all the two groups showed significant decrease in visual analogue score and improved strength whereas group B showed more significant improvement than the other two groups which was measured in terms of strength improvement and pain reduction.·

RESULTS

The present study titled “Effectiveness of core stability exercise program using swiss ball, theraband and floor exercises in cricketers with low back pain”: included 60 participants, out of which 30 participants were allocated to Group A who received Swiss ball and pelvic floor exercises, 30 subjects in Group B who received theraband and pelvic floor exercises 30 subjects The two groups were compared based on outcome measures VAS

Statistical Analysis:

Statistical analysis for the present study was done manually as well as using statistical package of social sciences (SPSS) version 14 so as to verify the results obtained .For this purpose data was entered into an excel spread sheet, tabulated and subjected to statistical analysis . Various statistical measures such as mean, standard deviation, and test of significance such as paired and unpaired t -test were used. Nominal data from patient"s demographic data i.e. age, sex, Ht, Wt distribution were analyzed using ANOVA t-test. Comparison of the pre intervention and post intervention outcome measures within the group was done by using Paired t-test, Wilcoxon matched-pairs test was applied whereas ANOVA, Kruskal-Wallis test was utilized to measure the difference between two groups (Intergroup comparison) in terms of decrease in Visual Analogue Scale (VAS). Probability values less than 0.05 were considered statistically significant and probability values less than 0.001 were considered highly significant.

DEMOGRAPHIC PROFILE:

Age Distribution

Age of the participants in the study was between 18 to 35 years. The mean age of the participants in group A was 21.1 years ±1.92, the mean age of participants in group B was 21.2years ±2.07. The difference in mean age of twogroups was statistically not significant (p= 0.405). (Table No.1)

ANTHROPOMETRIC MEASUREMENT:

Body Weight

The mean Body weight of the participants in Group A was 62.2kgs ±5.62 , the mean weight of the participants in Group B was 64.45kgs ± 5.75 where as the mean weight of the participants in group C was 61.45 ± 3.59. The difference in mean body weight of two groups was statistically not significant (p= 0.161). (Table No.1)

Body Height

Mean height of group A was 171.3±6.03cm, mean height of group B was 173.9 ± 3.64 cm. The difference in mean height of two groups was statistically not significant (p= 0.106). (Table No.1)

OUTCOME MEASUREMENTS:

i) Visual Analogue Scale Score:

In the Group A, the mean VAS score on pre session as on first session was 6.4 ± 0.8, which was reduced to a mean of 3.6 ± 1.2 after 16 sessions of treatment. The p value by paired t test was found to be < 0.1772 which is highly significant. (Table No. 2, Graph No.2)

In Group B, the mean VAS score on pre session as on first session was 6.3 ± 1.0, which was reduced to a mean of 2.9 ± 1.3 after 1month of treatment. The p value by paired t test was found to be < 0.1772 which is highly significant.

On comparing the pain scores as on VAS in all the groups, which was 2.8 ± 1.08 reduction of pain in group A, 3.34 ± 1.11 in group B. The results between the two groups using ANOVA showed that there is highly significant difference between group A, group B at 5 % level of significance. Therefore, we conclude group B is better than Group A in terms of pain reduction as on VAS. (Table No.3)

COMPARISON OF GROUPS IN TERMS OF AGE, HEIGHT, WEIGHT

Group	Age (years)		Height		Weight	
	Mean	SD	Mean	SD	Mean	SD
A	19.93	0.92	164.8	4.11	60.8	2.54

B	19.66	1.01	160.83	4.14	50.56	2.21
P value	0.405		0.106		0.161	

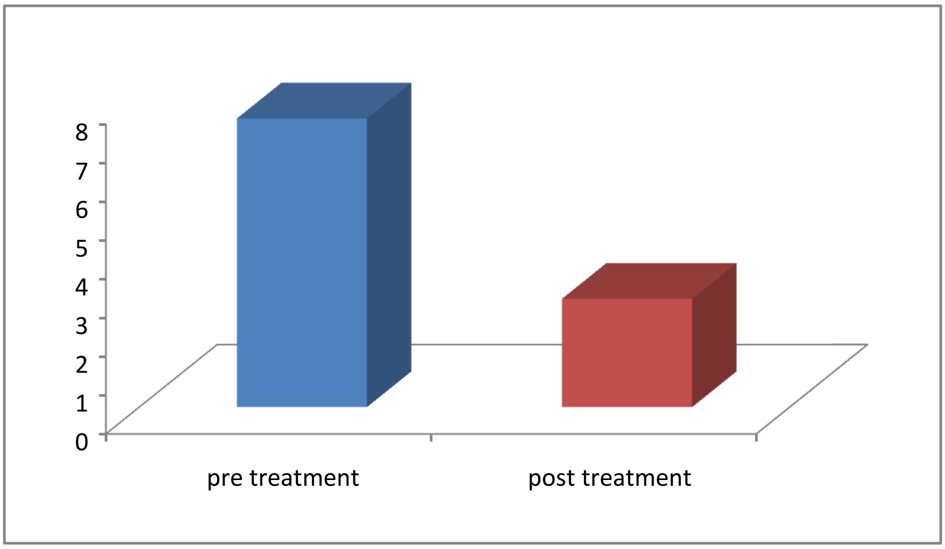
COMPARISON OF PAIN SCORES AS ON VAS WITHIN GROUP A, GROUP B

Groups	Pre Treatment		Post Treatment		t value	P value
	Mean	SD	Mean	SD		
Group A	7.46	1.05	0.93	0.62	2.60	<0.005
Group B	7.56	1.11	1.06	0.67	8.19	<0.005

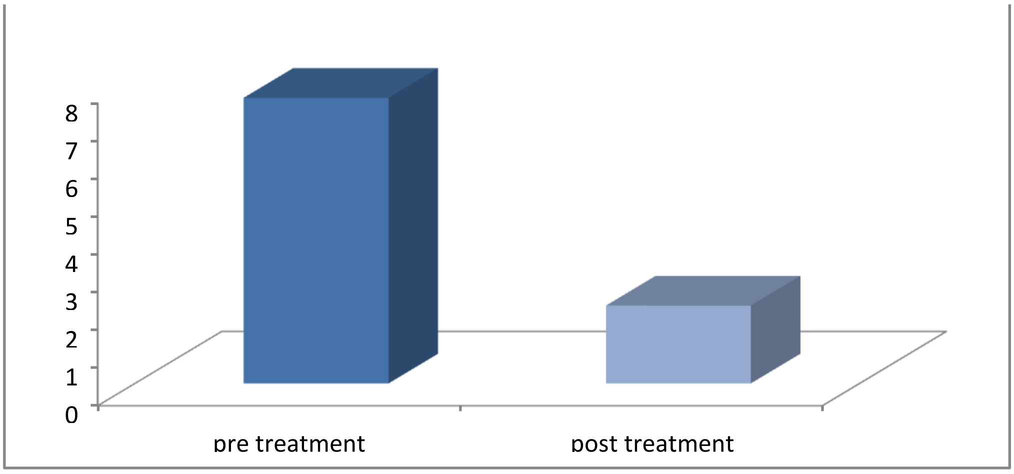
COMPARISON OF DIFFERENCES BETWEEN MEANS OBTAINED FOR VAS OF GROUPS A, B

	Group A	Group B	T value	P value
Mean	0.93	1.06	0.1772	<0.005
SD	0.62	0.67		

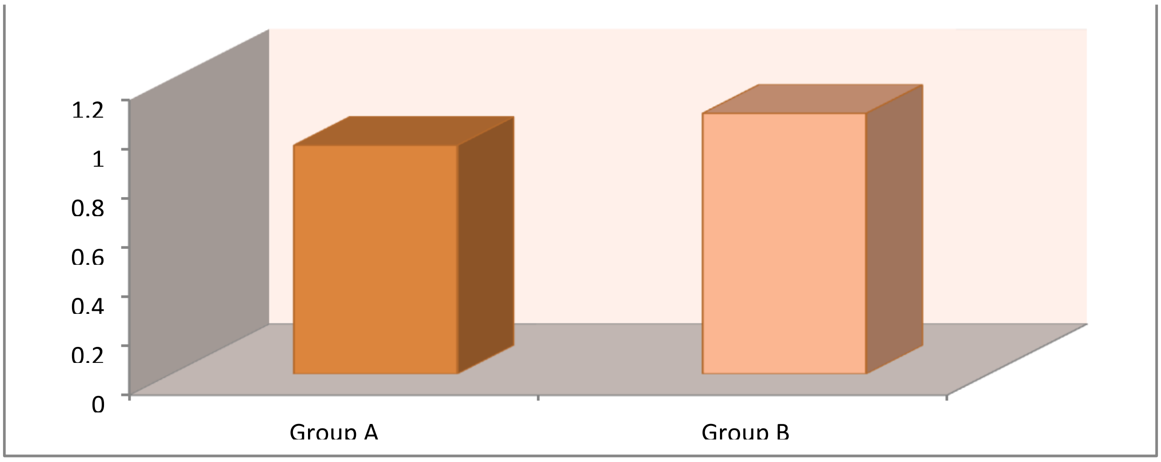
Graph : Showing Group A



GRAPH :Showing Group B VAS



Graph : Showing Comparision of differences between means obtained for VAS of Groups A ,B



BIBLIOGRAPHY

1. M.A.Hutson: Back pain recognition and management. Butterworth, Heinmann London, England;1993.
2. W.H.Kirkaldy Willis, Thomas N. Bernard: Managing low back pain. Churchill Livingstone, 4th ed ;1999.
3. Oatis CA.Kinesiology: The mechanics and pathomechanics of human movement. Philadelphia, Lippincott Williams and Wilkins; 2004.
4. Krismer M, van Tulder M. Low back pain (non-specific). Best Pract Res Clin Rheumatol. 2007;21(1):77-91.
5. Trainor TJ, Wiesel SW. Epidemiology of back pain in the athlete. Clin Sports Med. 2002;21(1):93-103.
6. Nadler SF, Malanga GA, Bartoli LA, Feinberg JH, Prybicien M, Deprince M. Hip muscle imbalance and low back pain in athletes: influence of core strengthening. Med Sci Sports Exerc 2002;34(1):9-16.
7. Patricia A Downie (FCSP): Cash"s textbook of orthopedics and rheumatology for physiotherapists,1st Indian edition 1993.
8. Ong A, Anderson J, Roche J. A pilot study of the prevalence of lumbar disc degeneration in elite athletes with lower back pain at the Sydney 2000 Olympic Games. Br J Sports Med.2003;37:263-266.
9. Williams P.L. etal, Gray"s anatomy: Churchill Livingstone; 38th ed (International student ed).

10. Elliot B, Khangure M. Disk degeneration and fast bowling in cricket: an intervention study. Med Sci Sports Exerc. 2002;34(11):1714-1718.
11. Gray J, Derman W, Vaughn CL. Low back pain in cricket fast bowlers. Int J Sports Med [serial on the Internet]. 2000; [cited 2008 Oct 20]; 1(4): [about 5 p.].
12. Orchard J, James T. Cricket Australia Injury Report 2003, Official Report, Version 3.2. Victoria,Australia: Cricket Australia; 2003.
13. Brian D"orazio: Back pain rehabilitation, Andover Medical publishers, Butterworth Heinemann; 1993.
14. Moore KL, Dalley AF. Clinically orientated anatomy. 4th ed. Maryland: Lippincott Williams & Wilkins; 1999.
15. Nadler SF, Malanga GA, Bartoli LA, Feinberg JH, Prybicien M, Deprince M. Hip muscle imbalance and low back pain in athletes: influence of core strengthening. Med Sci Sports Exerc 2002;34(1):9-16.
16. W. Ben Kibler, Joel Press and Aaron Sciascia. The Role of Core Stability in Athletic Function. Sports Med 2006; 36 (3): 189-198
17. Oetterly S, Larsen C 1996 Physiotherapy. Z Schweiz Physiotherapeutenverbandes 6:23-35
18. Marcks LK 1993 Using the PhysioRoll for the facilitation of motor skills. Pediatr Phys Ther(Fall):154-155
19. Beate Carriere, The Swiss Ball;Springer Publication,1st Ed.2000.p.2-3
20. Stanton R, Reaburn PR, Humphries B. The effect of short-term Swiss ball training on core stability and running economy. J Strength Cond Res. 2004 Aug;18(3):522-8.
21. Stanton R, Reaburn PR, Humphries B. The effect of short-term Swiss ball training on core stability and running economy. J Strength Cond Res. 2004 Aug;18(3):522-8.
22. Carolyn Kisner, Therapeutic Exercise; Jaypee Brothers; 5th edition 2007: 216- 218
23. M van Tulder. Low back pain and sciatica. Clinical evidence. BMJ Publishing Group 2000:496-512.
24. Van Tulder M, Malmivaara A, Esmail R, Koes B. Exercise therapy for low back pain. A systematic review within the framework of the Cochrane Collaboration Back Review Group. Spine 2000;25:2784-96.
25. NHS Centre for reviews and dissemination. Acute and chronic low back pain. Effective Health Care 2000;Vol 6 No 5 ISSN:0965 0288.
26. Waddell G, McIntosh A, Hutchinson A, Feder G, Lewis M. Low Back Pain Evidence Review. London: Royal College of General Practitioners, 1999.
27. Klaber Moffat J, Torgerson D, Bell-Dyer S et al. Randomised controlled trial of exercise for low back pain: clinical outcomes, costs and preferences. BMJ 1999; 319:279-83.
28. Faas A. Exercises: which ones are worth trying, for which patients, and when? Spine 1996;21(24):2874-77.
29. Van Tulder MW, Malmivaara A, Esmail R, Koes BW. Exercise therapy for low back pain (Cochrane review). In: The Cochrane Library, Issue 4, 2000. Oxford: Update Software.
30. McGill SM. Low back stability: from formal description to issues for performance and rehabilitation. Exerc Sport Sci Rev 2001;29(1):26-31.
31. Nadler SF, Malanga GA, Bartoli LA, Feinberg JH, Prybicien M, Deprince M. Hip muscle imbalance and low back pain in athletes: influence of core strengthening. Med Sci Sports Exerc 2002;34(1):9-16.
32. Hides JA, Richardson CA, Jull GA. Multifidus muscle recovery is not automatic after resolution of acute, first episode low back pain. Spine 1996;21(23): 2763- 9.

33. Hides JA, Stokes MJ, Saide M, Jull GA, Cooper DH. Evidence of lumbar multifidus muscle wasting ipsilateral to symptoms in patients with acute/subacute low back pain. Spine 1994;19:165-77.
34. Saunder"s H.D: Unilateral lumbar traction: Physical Therapy 1981. Feb: 61 (2): 221-225.
35. Key C.A : Pathological description of spondylosis, Guy"s Hospital: Report 3, 17, 1838.
36. McCulloch J.A., Transfeldt E.E.: Macnab"s Backache: 3rd ed., Williams and Wilkins, 1997.
37. Fritz JM, Delitto A, Erhard RE. Comparison of classification-based physical therapy with therapy based on clinical practice guidelines for patients with acute low back pain: A randomized clinical trial. Spine. 2003;28:1363-1372
38. Cherkin DC, Sherman KJ, Deyo RA, Shekelle PG. A review of the evidence for the effectiveness, safety, and cost of acupuncture, massage therapy, and spinal manipulation for back pain. Ann Intern Med. 2003;138:898-906
39. Kopec JA, Sayre EC, Esdaile JM. Predictors of back pain in a general population cohort. Spine. 2004;29:70-78
40. Deyo RA, Tsui-Wu Y. Descriptive epidemiology of low-back pain and its related medical care in the united states. Spine. 1987;12:264-268
41. Schochat T, Jackel WH. [prevalence of low back pain in the population]. Rehabilitation (Stuttg). 1998;37:216-223
42. Waxman R, Tennant A, Helliwell P. A prospective follow-up study of low back pain in the community. Spine. 2000;25:2085-2090
43. Burton A, Tillotson K, Main C, Hollis S. Psychosocial predictors of outcome in acute and subchronic low back trouble. Spine. 1995;20:722-728
44. Truchon M. Determinants of chronic disability related to low back pain: Towards an integrative biopsychosocial model. Disabil Rehabil. 2001;23:758- 767
45. Mendez FJ, Gomez-Conesa A. Postural hygiene program to prevent low back pain. Spine. 2001;26:1280-1286
46. Waddell G. A new clinical model for the treatment of low back pain. Spine. 1987;12:632-644
47. Liebenson C. Rehabilitation and chiropractic practice. J Man Physiol Ther. 1996;19:134- 140
48. Van Tulder M, Koes B. Chronic low back pain and sciatica. Clin Evidence. 2003;Feb:259-261
49. Frymoyer JW, Cats-Baril W. Predictors of low back pain disability. Clin Orthop.1987;221:89-98
50. Andersson GBJ. Epidemiological features of chronic low-back pain. Lancet. 1999;354:581-585
51. Frymoyer JW. Back pain and sciatica. N Eng J Med. 1988;318:291-300
52. Hart LG, Deyo RA, Cherkin DC. Physician office visits for low back pain. Frequency, clinical evaluation, and treatment patterns from a us national survey. Spine. 1995;20:11-19
53. Andersson GBJ. Low back pain. J Rehabil Res Dev. 1997;34:ix-x
54. Deyo RA, Cherkin D, Conrad D, Volinn E. Cost, controversy, crisis: Low back pain and the health of the public. Annu Rev Public Health. 1991;12:141-156
55. Frymoyer JW, Cats-Baril WL. An overview of the incidences and costs of low back pain. Orthop Clin North Am. 1991;22:263-271
56. Walker BF. The prevalence of low back pain: A systematic review of the literature from 1966 to 1998. J Spinal Disord. 2000;13:205-217
57. Ware JE, Kosinski M, Bayless MS, McHorney CA, Rogers WH, Raczek A. Comparison of methods for the scoring and statistical analysis of sf-36 health profile and summary measures: Summary of results from the medical outcomes survey. Med Care.1995;33(suppl):264-279

58. Andersson GBJ. The epidemiology of spinal disorders. In: Frymoyer JW, ed. The adult spine: Principles and practice. Philadelphia, PA: Lippincott-Raven; 1997:93-141.
59. Spencer, CW Jackson DW. Back injuries in the athlete. Clin sports med.1983;2(1);191-215
60. D"hemecourt PA ,Zurakowski D ,Kriemler S, Micheli LJ.Spondylolysis; returning the athlete to sports participation with brace treatment. Orthopedics.2002;25(6);253-7
61. Orchard J, James T. cricket Australia injury report 2003. SportHealth 2004;21;4;10-18
62. Newman D. A prospective survey of injuries at first class countries in England and whales 2001 and 2002 seasons. In - Stretch R ed. Second World Congress of Science and medicine in Cricket. Cape Town , 2003; 234-350
63. Spitzer W. Diagnosis of the problem (the problem of diagnosis). In: Scientific approach to the assessment and measurement of activity related spinal disorders: A monograph for clinicians-report of the Quebec Task Force on spinal disorders. Spine. 1987;12:S16-S21
64. Werneke M, Hart DL. Centralization phenomenon as a prognostic factor for chronic low back pain. Spine. 2001;26:758-765
65. Bogduk N. Clinical anatomy of the lumbar spine and sacrum. London, UK: Elsevier Limited; 2005.
66. Cook C. Orthopedic manual therapy: An evidence based approach. Upper Saddle River, NJ: Pearson Prentice Hall; 2007.
67. Bogduk N. The anatomical basis for spinal pain syndromes. J Manipulative Physiol Ther.1995;18:603-605
68. Laslett M. Diagnosis in the lumbopelvic region: The utility of the clinical examination. AAOMPT, 9th Annual Conference. 2003
69. Dontigny RL. Pelvic dynamics & the SP3 subluxation of the sacroiliac joint. AAOMPT 9th Annual Conference. 2003
70. Bernard TN K-WW. Recognizing specific characteristics of nonspecific low back pain. Clin Orthop. 1987;217:266-280
71. Woolf SK, Barfield WR, Nietert PJ, Mainous AG, 3rd, Glaser JA. The Cooper River Bridge run study of low back pain in runners and walkers. J South Orthop Assoc. 2002;11:136-143
72. Bigos SJ, Spengler DM, Martin NA, Zeh A, Fisher L, Nachemson A, Wang MH. Back injuries in industry: A retrospective study. II. Injury factors. Spine. 1986;11:246-251
73. Bigos SJ, Battie MC, Spengler DM. A longitudinal, prospective study of industrial back injury reporting. Clin Orthop. 1992;279:21-34 112
74. Bigos SJ, Battie MC, Spengler DM. A prospective study of work perceptions and psychological factors affecting the report of back injury. Spine. 1991;16:1-6
75. Marras WS, Lavender SA, Leurgans SE, Rajulu SL, Allread WG, Fathallah FA, Ferguson SA. The role of dynamic three-dimensional trunk motion in occupationally related low back disorders: The effects of workplace factors, trunk position and trunk motion characteristics on risk of injury. Spine. 1993;18:617-628
76. Croft PR, Papageorgiou AC, Ferry S, Thomas E J, ayson MI, Silman AJ. Psychologic distress and low back pain: Evidence from a prospective study in the general population. Spine. 1995;20:2731-2737
77. Mannion AF, Dolan P, Adams MA. Psychological questionnaires: Do 'abnormal' scores precede or follow first-time low back pain. Spine. 1996;21:2603-2611
78. Papageorgiou AC, Macfarlane GJ, Thomas E, Croft PR, Jayson MI, Silman AJ. Psychosocial factors in the workplace: Do they predict new episodes of low back pain? Evidence from the south manchester back pain study. Spine. 1997;22:1137-1142

79. Norman R, Wells R, Neumann P, Frank P, Shannon H, Kerr M. A comparison of peak vs cumulative physical work exposure risk factors for the reporting of low back pain in the automotive industry. Clin Biomech. 1998;13:561-573
80. Perez CE. Chronic back problems among workers. Health Rep. 2000;12:41-5
81. Viikari-Juntura E, Vuori J, Silverstein BA, Kalimo R, Kuosma E, Videman T. A life-long prospective study on the role of psychosocial factors in neck-shoulder and low-back pain. Spine. 1991;16:1056-1061
82. Miranda H, Viikari-Juntura E, Martikainen R, Takala EP, Riihimäki H. Individual factors, occupational loading, and physical exercise as predictors of sciatic pain. Spine.2002;27:1102-1109
83. Waddell G. Biopsychosocial analysis of low back pain. Baillieres Clin Rheumatol. 1992;6:533-557
84. Goldberg MS, Scott SC, Mayo NE. A review of the association between cigarette smoking and the development of nonspecific back pain and related outcomes. Spine. 2000;25:995-1014
85. Burdorf A, Sorock G. Positive and negative evidence of risk factors for back disorders. Scan J Work Environ Health. 1997;23:243-256
86. Skovron ML. Epidemiology of low back pain. Baillieres Clin Rheumatol. 1992;6:559-573
87. Battie MC, Bigos SJ, Fisher LD, Hansson TH, Nachemson AL, Spengler DM, Wortley MD, Zeh J. A prospective study of the role of cardiovascular risk factors and fitness in industrial back pain complaints. Spine. 1989;14:141-147
88. Leino DI. Does leisure time physical activity prevent low back disorders? A prospective study of metal industry employees. Spine. 1993;18:863-871
89. Battie MC, Haynor DR, Fisher LD, Gill K, Gibbons LE, Videman T. Similarities in degenerative findings on magnetic resonance images of the lumbar spines of identical twins. J Bone Joint Surg Am. 1995;77-A:1662-1670
90. Andersson GBJ. Epidemiology of low back pain. Acta Orthop Scan. 1998;69(suppl):28-31
91. Svensson HO, Vedin A, Wilhelmsson C, Andersson GB. Low-back pain in relation to other diseases and cardiovascular risk factors. Spine. 1983;8:277-285
92. Frank JW, Kerr MS, Brooker AS, DeMaio SE, Maetzel A, Shannon HS, Sullivan TJ, Norman RW, Wells RP. Disability resulting from occupational low back pain: part I: What do we know about primary prevention? A review of the scientific evidence on prevention before disability begins. Spine. 1996;21:2908- 2917
93. Biering-Sorensen F. Physical measurements as risk indicators for low back trouble over a one year period. Spine. 1984;9:106-119
94. Celan D, Turk Z. The impact of anthropometric parameters on the incidence of low back pain. Coll Antropol. 2005;29:101-105
95. Hestbaek L, Leboeuf-Yde C, Manniche C. Low back pain: What is the long- term course? A review of studies of general patient populations. Eur Spine J. 2003;12:149-165
96. Hestbaek L, Leboeuf-Yde C, Engberg M, Lauritzen T, Bruun NH, Manniche C. The course of low back pain in a general population. Results from a 5-year prospective study. J Manipulative Physiol Ther. 2003;26:213-219
97. Ware JE, Kosinski M, Bayless MS, McHorney CA, Rogers WH, Raczek A. Comparison of methods for the scoring and statistical analysis of sf-36 health profile and summary measures: Summary of results from the medical outcomes survey. Med Care. 1995;33(suppl):264-279
98. Von Korff M. Studying the natural history of low back pain. Spine. 1994;19:2041-2046

99. Cedraschi S, Robert J, Goerg D, Perrin E, Fischer W, Vischer TL. Is chronic non-specific low back pain chronic? Definitions of a problem and problems of a definition. Br J Gen Pract. 1999;49:358-362
100. MacDonald D, Jemmett R. Physiotherapeutic management of lumbar spine pathology. Halifax, Nova Scotia: Novont Health Publishing Limited; 2005.
101. Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. J Spinal Disord. 1992;5:383-389
102. Panjabi MM. The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. J Spinal Disord. 1992;5:390-397
103. Gardner-Morse MG, Stokes IAF, Laible JP. Role of muscles in lumbar spine stability in maximum extensor efforts. J Orthop Res. 1995;13:802-808
104. McGill SM. Low back disorders: Evidence-based prevention and rehabilitation. Champaign, IL: Human Kinetics; 2002.
105. Richardson CA, Hodges P, Hides J. Therapeutic exercise for lumbopelvic stabilization: A motor control approach for the treatment and prevention of low back pain. Edinburgh, UK: Churchill Livingstone; 2004.
106. Lephart SM, Pincivero DM, Giraldo JL, Fu FH. The role of proprioception in the management of athletic injuries. Am J Sports Med. 1997;25:130-137
107. Steven J. Karageanes, Principles Of Manual Sports Medicine; Lippincoti Williams & Wilkins.2005.p.113-114
108. Jacchia CE, Butler UP, Innocenti M, et at. Low back pain in athletes: Pathogenetic mechanisms and therapy. Chir Organi Mov. 1994 Jan-Mar; 79(1):47-53.
109. Optimum Performance Training for the Performance Enhancement Specialist course manual 2002. National Academy of Sports Medicine. Chapter 6.
110. Meadows. J. North American Instirute of Manual Therapy Lower Quadrant
Level TII course manual, October 2003 pp. 20-56.
111. *Boonstra, Anne M, Schiphorst Preuper, Henrica R, Reneman, Michiel F, Posthumus, Jitze B, Stewart Roy E.* Reliability and validity of the visual analogue scale for disability in patients with chronic musculoskeletal pain. International Journal of Rehabilitation Research. June 2008;31(2):165-169.
112. Olaogun, Matthew, et.al.: Reliability of rating low back pain with a visual analogue scale (VAS) and semantic differential scale (SDS), Physical therapy theory and practice 2004; 20(2): 135-142.
113. Ehrlich G E: Low back pain, Bulletin of the world health organization 2003; 81: 671-676.
114. Davidson M and Keating JL: A comparison of five low back disability questionnaires, reliability and responsiveness2001.
115. Hughes, C.J., Hurd, K. Jones, A. & Sprigle, S. (1999). Resistance properties of thera-band tubing during shoulder abduction exercise. Journal of Orthopaedic and Sports Physical Therapy, 29, 413-420.
116. Anderson, L., Rush, R., Shearer, L., & Hughes, C.J. (1992). The effects of a Thera-Band exercise program on shoulder internal rotation strength. Physical Therapy, 72(Suppl.), 540.
117. Ward, K., Paolozzi, S., Maloon, J., Stanard, H., & Bell, A. (1997). A comparison of strength gains in shoulder external rotation musculature trained with free weights versus TheraBand. Section on Research Newsletter, 30, 21

118. Simoneau, G.G., Bereda, S.M., Sobush, D.C., & Starsky, A.J. (2001). Biomechanics of elastic resistance in therapeutic exercise programs. Journal of Orthopaedic and Sports Physical Therapy, 31, 16-24.
119. McGill SM, et al. Endurance times for stabilization exercises: clinical targets for testing and training from a normal database. Arch Phys Med Rehabil. 1999;80:941-944.
120. Clark MA, Fater D, Reuteman P. Core (trunk) stabilization and its importance for closed kinetic chain rehabilitation. Orthop Phys Ther Clin North Am. 2000;9:119-135.
121. Hodges, P., Richardson, C. and Jull, G. (1996) Evaluation of the relationship between laboratory and clinical tests of transversus abdominis function. Physiotherapy Research International, 1: 30-40
122. T Rowland And V Sparkers. Reliability Of The Pressure Biofeedback Unit. J Bone Joint Surg Br 2009 Vol. 91-B No. Supp Ii 283
123. Flett, Maureen (2003). Swiss Ball: For Strength, Tone and Posture. Sterling Publishing Company, Inc. ISBN 185648663X.
124. Klein-Vogelbach, Susanne (1990). Functional Kinetics: Observing, Analyzing, and Teaching Human Movement. Springer-Verlag. ISBN 0387153500.
125. Carriere, Beate; Renate Tanzberger (1998). The Swiss Ball: Theory, Basic Exercises Clinical Application. Springer. ISBN 3540611444.
126. Hillman, Susan Kay (2005). Introduction to Athletic Training. Human kinetics. ISBN 0736052925.
127. Milligan, James (2005). Swiss Ball For Total Fitness: A Step-by-step Guide. Sterling Publishing Company, Inc.. ISBN 1402719655.
128. Vera-Garcia FJ, Grenier SG, McGill SM. Abdominal muscle response during curl-ups on both stable and labile surfaces. Phys Ther. 2000 Jun;80(6):564-9.
129. Stanton R, Reaburn PR, Humphries B. The effect of short-term Swiss ball training on core stability and running economy. J Strength Cond Res. 2004 Aug;18(3):522-8.
130. Marshal, P.W.M., and Murphy, B.A. (2005). Evaluation of functional and neuromuscular changes after exercise rehabilitation for low back pain using a swiss ball: a pilot study. Journal of manipulative and physiological therapeutics. Vol 29 (7) pp 550-560
131. Reynolds KL, Winter C, Paolone V, Jones MT. Cosio-Lima LM. Effects of physioball and conventional floor exercises on early phase adaptations in back and abdominal core stability and balance in women. J Strength Cond Res. 2003 Nov;17(4):721-5.
132. Richard A. Ekstrom, Robert A. Donatelli, Kenji C. Carp,.Electromyographic Analysis of Core Trunk, Hip, and Thigh Muscles During 9 Rehabilitation Exercises. J Orthop Sports Phys Ther 2007;37(12):754-762.
133. Treiber Fa, Lott J, Duncan J, Slavens G, Davis H. Effects of Theraband and lightweight dumbbell training on shoulder rotation torque and serve performance in college tennis players. Am J Sports Med. 1998 Jul- Aug;26(4):510-5.
134. Stoppani, J. Encyclopedia of Muscle & Strength. Human Kinetics, Champaign, IL. 2005.
135. CT Axler; SM McGill (1997). "Low back loads over a variety of abdominal exercises: Searching for the safest abdominal challenge". Medicine & Science in Sports & Exercise 29 (6): 804-810.
136. Edwin Choon Wyn Lim, Ruby Li Choo Poh, Mclinphty, Ai Ying Low, Wai Pong Wong. Effects of Pilates-Based Exercises on Pain and Disability in Individuals With Persistent Nonspecific Low Back Pain: A Systematic Review With Meta-analysis. J Orthop Sports Phys Ther 2011;41(2):70-80