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ABSTRACT

Swimming is a unique sport that combines upper extremity, lower extremity and spine exercises with cardiovascular training in a non-weight bearing environment. So, there's no impact and less gravity and the swimmers bones don't get this benefit and may actually decrease in density (much like an astronaut's). The highly repetitive motion that occurs in the normal swimming stroke can predispose to musculoskeletal injuries of the upper limb, knee, and spine (Wanivenhaus et al., 2012). The low Back pain in swimmers is most commonly due to hyperextension, myofascial involvement and disc degeneration (Kenal et al., 1996). Hyper- mobility of lumbar spine, hamstring and hip flexors tightness, anterior pelvic tilt also contribute for the same (Gaunt et al., 2012).So, the low back pain in swimmers has a high impact on musculoskeletal system. Therefore cross-training is an important part of swimming e.g. Running, soccer, and yoga. Injury surveillance and potential prevention strategies should focus on the axial spine for cross-training activities (Wolf et al., 2009).

There are four different strokes are recognized in swimming as a sports: **.**Out of the four strokes i.e. freestyle, butterfly, backstroke, and breaststroke, three strokes (freestyle, backstroke and butterfly) are similar in the arm positions with assistance of the body roll(Wanivenhaus et al., 2012). The body position and spinal motion differs among the strokes with freestyle and backstroke characterized by rolling.The roll of the torso in freestyle and backstroke is created by paraspinal and abdominal muscle to provide much needed power via increased force generation and reduced segmental rotation and torque force in individual spinal segments. In butterfly stroke, swimmers should have an effective spinal undulation motion with repetitive and rhythmic flexion and extension of lumbar spine. In breaststroke there is less gliding and body roll motions. This change has increased the relative lumbar extension and stress to the facet joint and thus increased the risk of spinal injury and pain. The wrong biomechanics while swimming can predispose to spinal injury (Micheli et al., 2014).

The purpose of the study was to analyse the risk factors for low back pain due to the altered biomechanics in swimmers that, as it is one of the common problems seen in swimmers and there is lacuna of studies, particularly in India, related to low back pain in swimmers.

150 swimmers in the age group of 18 to 27 years were taken from different areas of Punjab, who has participated in at least interuniversity level swimming

championship and subjects who satisfied the inclusion criteria the study. Informed consent was obtained from the recruited subject, who volunteered for the study and meeting the inclusion criteria for both male and female subjects. The design of the study was descriptive, cross-sectional survey. The inclusion criterion for this study was swimmers who have participated at least at interuniversity level, Age Group of 18 to 27 years and both Male & Female swimmers and the exclusion criteria for this study were, subjects with a history of previous back surgery, Nerve root compromise, Neurologic Deficits, Current lumbar radiculopathy, Adolescent Idiopathic functional scoliosis, Swimmers not satisfying the mentioned age group.

The dependent variables measured were angle of lumbar lordosis by flexicurve, strength of Transverse abdominis by pressure biofeedback unit, tightness of hip flexors, hamstring and hip internal rotation range of motion for both left and right sides by goniometre. The independent variables were age and gender of the subjects.

Consent from were filled up and signed by the subjects and they were divided into groups of 5 each, in one time and asked to answer the questionnaire given to them, which contained 50 sections, with prior explanation to that, followed by each subjects variables were measured individually .

The result of the present shows that, the prevalence of low back pain in swimmers is 43%. The Occurrence of low back pain in male swimmers is higher than that of female swimmers. At National level swimmers showed highest rate of prevalence of low back pain as compare to state and university level swimmers. There is highest prevalence of low back pain seen in freestyle swimmers followed by butterfly and breast stroke swimmers. The Strength of transverse abdominis and lumbar flexibility was better in no pain group of swimmers, both in male and female.

Future study should be conducted on larger sample size, equality in number of male and female subjects, equal number of subjects from different level of participants like national, state etc., equal number of subjects from each strokes of swimming. More future work is required on the basis of volume, intensity and duration of swimming.

CONTENTS

1.INTRODUCTION

1.1 About the game:

Competitive swimming was first introduced as an Olympic sport in 1896 for men and in 1912 for women, with 05 recognized strokes: freestyle, butterfly, backstroke, breaststroke and medley (Lord, 2008; Stavrianeas, 2010). The different level of competitions in swimming in India is interuniversity level, state level and national level. According to the distance covered in competitive swimming, it has categorized into Sprinter, Middle-distance swimmer and distance swimmer which included both the genders.

The phases of swimming strokes include early pull through, mid pool through, late pull through and recovery phases. In early pull through phase initiation of backward arm movement is marked .The palm and forearm should force the backward direction with the finger tips pointing down .The point at which the humorus is perpendicular to the boy is called mid pull through. It is followed by late pull through phase. In this phase the hand continues back and passed next to the hip until it exits the water. In recovery phase the arm exits the water and is accompanied by axial rotation of the trunk. Swimmers are taught to rotate some degree of rotation towards the side of arm entry as the arm is entering the elbow should be extended. The shoulder and side of the body rotate below the surface of the water. During the recovery phase same shoulder and side of the body begin to counter rotate above the surface of the water. The trunk rotation was the important component in swimming technique (Pink et al., 2007).

1.2 Swimming and its effect on low back:

Swimming is a unique sport that combines upper extremity, lower extremity and spine exercises with cardiovascular training in a non-weight bearing environment. So, there's no impact and less gravity and the swimmers bones don't get this benefit and may actually decrease in density. The highly repetitive motion that occurs in the normal swimming stroke can predispose to musculoskeletal injuries of the upper limb, knee, and spine (Wanivenhaus et al., 2012). The low Back pain in swimmers is most commonly due to hyperextension, myofascial involvement and disc degeneration (Kenal et al., 1996). Hyper- mobility of lumbar spine, hamstring and hip flexors tightness, anterior pelvic tilt also contribute for the same (Gaunt et al., 2012).So, the low back pain in swimmers has a high impact on musculoskeletal system. Therefore cross-training is an important part of swimming e.g. running, soccer, and yoga. Injury surveillance and potential prevention strategies should focus on the axial spine for cross-training activities (Wolf et al., 2009).

There are four different strokes are recognized in swimming as a sports**.** Out of the four strokes i.e. freestyle, butterfly, backstroke, and breaststroke, three strokes (freestyle, backstroke and butterfly) are similar in the arm positions with assistance of the body roll (Wanivenhaus et al., 2012). The body position and spinal motion differs among the strokes with freestyle and backstroke characterized by rolling .The roll of the torso in freestyle and backstroke is created by paraspinal and abdominal muscle to provide much needed power via increased force generation and reduced segmental rotation and torque force in individual spinal segments. In butterfly stroke, swimmers should have an effective spinal undulation motion with repetitive and rhythmic flexion and extension of lumbar spine. In breaststroke there is less gliding and body roll motions. This change has increased the relative lumbar extension and stress to the facet joint and thus increased the risk of spinal injury and pain. The wrong biomechanics while swimming can predispose to spinal injury. (Micheli et al., 2014)

Some researchers have suggested that, it is repetitive flexion and extension that leads to stress concentration in the pars, as this is the site of spinal rotation during flexion and extension (Goldstein et al, 1999). A study carried out showed an increase incidence of disc disease with resultant back pain and sciatica in younger age group in correlation with the increased participation in sports at this time (Glick and Katch, 1998).

Critical factors for the prevention of low back pain in elite junior divers and concluded that shoulder flexibility is important for preventing LBP in elite-male junior divers, since they require full shoulder flexion during the water entry phase. Limited shoulder flexibility could cause lumbar hyperextension when adjusting for the angle of water entry (Narita et al, 2014). Moderate evidence indicates, increased shoulder counter rotation, associated with mixed bowling actions in cricket and decreased anterior abdominal fascial slide may be associated with LBP in cricketers. Acute bone stress as a risk factor for developing lumbar stress fractures .This was the result of a study on risk factors and successful interventions for cricket-related low back pain: a systematic review by 12 studies (6 of high quality), investigating the factors associated with LBP in cricketers and 5 low-quality studies evaluating the interventions for the treatment/ prevention of LBP in cricketers.(Morton et al. 2012). Spondylolysis as a cause of low back pain in athletes today appears to be increasing in frequency. The mechanism of injury is repetitive microtrauma from flexion, extension, or rotation may result in damage to all posterior elements of lumbar spine, including pars interarticularis, facets, pedicles, lamina and the spinous processes. The pars interarticularis is the most common site of injury. Studies have suggested that hyperextension in particular, results in shear stress at pars, with eventual stress fracture(Croft, 2004).

Anteriorly, the lumbar spine has five vertebral bodies linked by the intervertebral discs. The neural canal lies centrally, containing peripheral nerves with dural coating. Dorsally are the posterior elements of the spine: the facets, the transverse processes, the pars interarticularis, and the pedicles. Normal lumbar lordosis is 40 to 60 degrees. Abnormal structural alignments, such as hyperlordosis of the lumbar spine or a structural flatback, may be factors in low back pain (Sward et al., 1995).

Vertebral body microfracture at anterior margin is another cause of low back pain in athletes. These fractures are result of repetitive microtrauma, usually repetitive flexion that injures anterior portions of vertebral end plates with wedging and schmorl's node formation. Often this occurs in gymnasts who begin their training before the age of 5 (Jacob, 2000).

In spite of the increasing incidence of repetitive microtrauma induced low back pain in athletes, they have a tendency to neglect their low back pain in seeking medical advice. That may affect their overall performance (Wolf et al, 2002 and Fordham, 2007).

Disk degeneration at L5-S1was significantly more frequently degenerated in the high-load group ($P = .026$) among Elite Competitive Swimmers. This concludes that, excessive competitive swimming activities might exaggerate lumbar intervertebral disk degeneration, especially in the L5-S1 intervertebral segment ((Kaneoka et al., 2007)).

Continuous competitive swimming and baseball activities during youth may be associated with disk degeneration in athlete. The experience of severe low back pain might be a predictor of disk degeneration in youth. The authors hope that preventive measures and management to protect against disk degeneration and low back pain in athletes will be established by further studies based on these results (Hangi et al., 2008).

Knaepen et al, (2009) worked on Low-back problems in recreational self-contained underwater breathing apparatus divers: prevalence and specific risk factors and concluded that sport-specific risk factors for LBP found in this study are the diving certificate and the amount of weight used on the weight belt but further (biomechanical) research should clarify the underlying mechanisms.

From of a longitudinal 03 Years follow-up study in athletes and controls on lumbar mobility and low back pain during adolescence concluded that, the low individual physiologic maximum of lower segment lumbar extension mobility may cause overloading of the low back among athletes involved in sports with frequent maximal lumbar extension and that it predicts future low back pain (Kujala et al, 1997).

Musculoskeletal screening to detect asymmetry in swimming and concluded that, asymmetry of the clinical strength measures was found in 85% of swimmers. Athletes with symmetry of all clinical strength measures displayed symmetrical bilateral hand force production. Approximately 50% of clinically asymmetrical swimmers were able to compensate, due to summated muscle symmetry and/or an altered kinematic movement pattern, and generate symmetrical hand force. Symmetry of clinical strength was directly related to symmetrical force output. It is important to connect the clinical screening results to the sport-specific performance measures to ensure functional and valid screening is undertaken. Clinicians should aim for symmetry of strength in order to minimise the requirement for compensatory strategies (Evershed et al., 2014).

Study on Prevalence of low back pain in adolescent athletes - an epidemiological investigation, concludes that LBP prevalence correlates with sports participation and individual competitive level. Adolescent athletes with LBP should receive a thorough diagnostic work-up and adapt training and technique correspondingly when indicated (Zwingenberger et al, 2014).

Among the injuries in competitive swimmers and concluded that, back injuries are most commonly due to disc degeneration, hyperextension and myofascial involvement. . Highly repetitive motion of competitive swimming can lead to overuse injuries of back. To fully understand the mechanisms leading to swimmers pathology requires a thorough knowledge of anatomy, basic strokes mechanism and specific bio-mechanics (Katherine et al., 1996).

1.3 Prevalence:

Low Back Pain among swimmers, which is the second most common injury location and the overall anatomical location of back pain due to injury is 16.1% with 33.3% of butterfly swimmers and 22.2% of breaststroke swimmers experience low back pain (Capaci et al., 2002).

27.5% low back pain with recurrence of low back pain in the same anatomical site is 44% (Ristolainen et al., 2010). In Sweden the incidents of low back pain ranges from 5 to 85%, of 142 top athletes, depending upon the sport (Wolf et al., 2009).

In the injury patterns of Danish competitive swimming, a total of 100 injuries in 80 swimmers with an incidence of 0.9 injuries per swimmer per 1,000 hours of swimming and a point prevalence of 15% on the day of competition. The shoulder, the back and the knee joint were most commonly involved. No particular swimming stroke was associated with a greater risk of injury. There was however a tendency for butterfly swimmers to have more frequent shoulder injuries and for breaststroke swimmers to have more frequent knee-injuries. Medal winners were significantly more frequently injured. Half of the injured swimmers were seen by a doctor (Bak et al., 1989).

Musculoskeletal problems in elite competitive male swimmers that interfere with effective training are serious and may result in decreased performance in the swimming athlete. It was found that 23 of the 38 competitive male swimmers examined reported musculoskeletal pain in this study. 7 had low back pain. Ten swimmers with pain never stopped training and only one swimmer had to stop swimming for a period of one month. Injuries leading to pain may be acute or caused by repeated micro-traumas, eventually leading to an overuse injury. Corrections of factors contributing to overuse injuries should be properly treated, so that the swimmers may return rapidly to swim safely (Capaci et al., 2002).

The injury patterns in division I collegiate swimming concluded that, the overall injury rates were estimated at 4.00 injuries per 1000 exposures for men and 3.78 injuries per 1000 exposures for women. 37% injuries resulted in missed time. The shoulder/upper arm was the most frequently injured body part, followed by the neck/back. Freshman swimmers suffered the most injuries as well as the highest mean number of injuries per swimmer. A significant pattern of fewer injuries in later years of eligibility was also demonstrated. The relative risk (RR) for injury was higher among non freestyle stroke specialties (RR, 1.33 [1.00–1.77]). Injury most often occurred as a result of or during practice for all swimmers. However, 38% of injuries were the result of team activities outside of practice or competition, such as strength training. No significant relationship was found between occurrence of injury, gender and level of participation. There was no significant relationship between body parts injured and stroke specialty. An increased number of total injuries and an increased risk of injuries in freshman collegiate swimmers were found (Wolf.et al., 2009). 68% of 56 elite swimmers (mean age, 19.6 years) and 29% of 38 recreational swimmers (mean age, 21.1 years) demonstrated degenerated disks at various levels (Wanivenhaus et al., 2012).

The distribution of pain in body parts in prevalence in swimmers was higher in shoulder (40%), thigh (22%), knee (21%) and low back pain (17%).The other areas are least commonly effected. There is a significant difference seen in butterfly freestyle, medley, and breast stroke except back stroke. They reported that middle distance and sprinters were seen higher prevalence rate ($p<0.001$) than distance swimmers ($p=0.003$). According to the level of participation state and national level swimmers showing higher prevalence rate ($p<0.001$) then international swimmers ($p=0.01$). They concluded that there was a higher prevalence of moderate pain seen with shoulder and thigh regions and they identified that pain correlated with all swimming styles except back stroke. There was no correlation with time of sports practice (Venancio1 et al., 2012).

A prospective study of injury affecting competitive collegiate swimmers and concluded that, The most common injury locations were the shoulder (38.7%), back (16.1%), and knee (12.9%). The most commonly injured anatomical location for male and female swimmers was the shoulder (46% and 33.3%, respectively). Based on Fisher's exact test there were no statistical differences found between gender and injury location ($p=0.27$). The back (i.e., strain) was the second most common injury location (16.1%) in this study and has been a common location in other studies, ranging from 3.0% to 37.1% of all injuries. High practice injury rates relative to other NCAA sports, especially for females. Previous injury is a risk factor for new injury among competitive swimmers (Chase et al., 2014).

An injury starts within 6 years of swimming career. 45% of athletes took some time off from swimming and the mean age at which this occurred was 16.5 years (SD=2.6). 17% of the athletes (n=29) took a break of less than 1 year, 10.6% (n=18) took a break of 1-2 years, 9.4% (n=16) took a break of 2-3 years, and 7.1% (n=12) took a break from swimming lasting more than 3 years. Only male swimmers showed statistically significant (Abgarov et al., 2012).

1.4 Parameters which influences the low back pain:

The athlete with back pain presents a clinical challenge. Self-limited symptoms must be distinguished from persistent or recurrent symptoms associated with identifiable pathology. Athletes involved in impact sports, appears to have risk factors for specific spinal pathologies that correlate with the loading and repetition demands of specific activities. There are no reliable studies examining the long-term consequences of athletic activity on the lumbar spine (Lawrence et al, 2006).

Perich et al., (2011) worked on low back pain in adolescent female rowers: a multi-dimensional intervention study and concluded that, the multi-dimensional approach to reducing the incidence of low back pain and disability in schoolgirl rowers in this study was effective. Several secondary outcome variables measured in the group considered to be of importance in low back pain significantly improved. These included physical fitness (aerobic conditioning, lower limb and back muscle endurance and sit and reach flexibility) and seated posture (usual and slump sitting).

A study on low back pain in the pediatric athlete and concluded that no consistent demonstrable association was established between clinical presentation and final diagnosis. It was found that red flags could not be relied upon for the inclusion or the exclusion of a significant radiological finding. This study therefore suggests that, in this population group, a significant diagnosis cannot always be reliably excluded from clinical assessment alone (Roy et al., 2014).

Low back disorders among athletes and its prevention and concluded that the exercise therapies described by this researcher are designed not only for athletes, but are also indicated in regular low back pain patients and they expect them to become more commonly used. However, because the training protocol require a great deal of strength, methods that match the level of each patient and gradual increases in strength would therefore be necessary (Kaneoka., 2013).

An understanding of swimming biomechanics and typical injuries in swimming aids in early recognition of injury, initiation of treatment, and design of optimal prevention and rehabilitation strategies. Muscle strength, endurance, and flexibility protect against low back pain and/or injuries. Mechanical loading of the spine in competitive sports results in lumbar intervertebral disk degeneration. A significantly greater proportion of swimming athletes had degenerative disk changes at one or more disk levels compared with a control group. There were no significant gender differences in the rate or swimming strokes. The main variables were training intensity, duration and distance, suggesting that competitive swimming aggravates the lumbar intervertebral disk degeneration. The L5-S1 levels are more frequently involved in elite swimmers. All swimming strokes maintain hyperextension of the lower back to achieve a streamlined position. This position is exaggerated in the wave pattern of breaststroke and butterfly swimming. The high intensity and repetitiveness of these strokes load the posterior structures of the lumbar spine, which can result in spondylolysis and possible spondylolisthesis. Increased intensity can increase the risk of damage. Muscle and ligament sprains can occur but settles rapidly with core stability programs and manual therapies. Additional risk factors for the development of low back pain in competitive swimmers are training devices such as fins, kick boards, or pull buoys. These produce excessive hyperextension of the lumbar spine (Wanivenhaus et al., 2012).

Research regarding swimming injuries is not sufficient in terms of methodology and reporting clinical findings. Given the scarcity of recent publications regarding the treatment and rehabilitation of swimming injuries, this field of sports medicine lacks the input from progress in related areas of sports medicine, such as that in other overhead athletes. Most literature on swimming injuries is directed towards swimmers' shoulder and impingement syndrome and few literatures on other injuries encountered. Most studies identified were retrospective cohort studies. Although prospective studies are more expensive and complicated, an effort should be made to monitor progress in treatment and rehabilitation of injured swimmers in this more methodologically sound way (Trevor et al., 2013).

Lumbar myofascial strain can result from twisting motions, involved in flip-turning or when the body does not roll uniformly during freestyle. Also, hyperextension of the spine (e.g. technically poor butterfly stroke may increase the likelihood of posterior facet irritation. If combined with lateral flexion, it may impinge on the lateral facets also. Tightness of hamstrings and hip flexors may increase the anterior pelvic tilt and increases the load on the vertebral facet joints (Kenal et al., 1996). Aetiology of low back pain in young athletes according to the role of sports type states that, complaints of LBP in young athletes are highly correlated with lumbar spinal abnormalities (Hosea T et al., 2011).

On understanding trends and risk factors of swimming-related injuries in varsity swimmers, there were a high number of injuries among the varsity population with extensive histories of past injuries, with higher prevalence among males. Findings highlight extensive injury histories, high prevalence of injury in varsity swimmers, and significant risk factors associated with occurrence of new injury (Abgarov et al., 2012).

A retrospective 12-month study concluded that, acute injuries in swimmers are 58%, which occurres during exercise other than own event. Swimming has lesser absence time from the game due to injury than soccer and running. Type of loading is strictly associated with the anatomical location of an overuse injury. Increased understanding of the mechanisms by which injuries occur would be of value, both in the prevention of injuries and in tailoring substitute exercises or rehabilitation programs to meet the needs of injured individuals. (Ristolainen et al., 2010).

Hip rotations and trunk rotations during swimming were desirable and important to improve their performance. The trunk and hips acts as a semi rigid cylinder held in a place by guided wires. These structures are needed to maintain the natural curvature of the spine. The muscles located in the front are rectus abdominus, transverse abdominis and the lateral side of the trunk muscles are internal and external oblique. The muscle located in the back includes erector spinae and other spinal extensors work together both in bending and twisting activities. They provide postural stability and can generate large amount of forces to transmit these forces through upper and lower extremities in various sports activities. Closed kinematic chain movement takes place with the distal segment held in relatively immobile, where as in open kinematic chain, the distal segment moves freely during the activity such as during kicking and swimming. Based on the segmental interaction principal the potential and contractile energy generated from the various segments can be transferred during the motion between the segments. Consequently the link between the segments contributes effective body movements (Prinse et al., 2007).

In elite swimmers a maximum trunk rotation of 30 t0 40 degree occurs from the surface of the water on each side. The importance of the rotation should be helps in the forward progression of the body but not to rotate the body on to its side. Sometimes it is common for a swimmer to rotate the trunk excessively during a breath cycle. This leads to over rotation of the trunk and causes humoral hyperextension. If the swimmers avoid the humoral hyperextension by keeping the arm in front of the body, it is a major faulty mechanism that may minimize the propulsion of the boy. This faulty mechanisms cause altered muscle firing patterns and may cause muscle fatigue. The changes in the muscle firing patterns are not visually apparent as the body rotation. However knowing of the faulty muscle firing patterns allows the clinician to effectively diagnose and treat and rehab the probable (Pink et al., 2007).

1.5 Purpose of the study:

As low back pain is one of the common problems seen in swimmers and there is lacuna of studies, particularly in India, related to low back pain in swimmers. Hence, the present study has been designed to analyse the risk factors due to the altered biomechanics in swimmers.

1.6: Problem statement:

Prevalence and analysis of risk factors for occurrence of low back pain in swimmers.

1.7 Aim of the study:

The aim of the study is to study the prevalence of low back pain and to assess the potential risk factors associated with low back pain in swimmers.

1.8 Objectives of the study:

1. To study the prevalence of low back pain in swimmers.
2. To study the risk factors for low back pain in swimmers.
3. To identify the cause of low back pain due to altered biomechanics in swimmers.
4. To study the gender difference for prevalence & risk factors of low back pain in swimmers.

1.7 Hypothesis

H1: Analysis of prevalence and risk factors may show association to the cause of low back pain in swimmers.

1.8 Null Hypothesis

Ho: Analysis of prevalence and risk factors may not show association to the cause of low back pain swimmers.

1.9 Clinical Significance

1. If the result of this study found to be significant, it will be useful in understanding the biomechanical reason of low back pain in swimmers, which will help the sports medicine physician, Physiotherapist to formulate preventive strategies and rehabilitation plan suitable for individual swimmers.

2. The study will provide information regarding prevalence of low back pain with respect to gender and different swimming strokes.

3. The present study will be a guideline for swimming coaches in planning of strategy training for prevention of occurrence of low back pain in swimmers as well as management of existing low back pain.

2.REVIEW OF LITERATURE

A literature is a body of text that aims to review the critical points of current knowledge including substantive finding as well theoretical and methodological contribution to a particular topic. The literature review is a "legitimate and publishable scholarly documents."

In the present study, the review of literature was conducted from the following places:

- Bhai Gurudas Liberary ,G.N.D.U., Amritsar
- www.aapb.org
- www.bcia.org
- www.bfe.org
- www.google.com
- www.pubmed.com
- www.sciencedirect.com
- www.freesportmediournals.com
- www.snr-jnt.org

Hangai et al.(2014) did a prospective longitudinal study on 57 Japanese swimmers(29M, 28F) from the Beijing and London Olympic on elite swimmers from 2009 to 2011 and concluded that, no London Olympian who could not perform due to low back pain and a low back pain prevention program may be effective in swimmers in terms of performance.

Chase K et al. (2013) worked on an exposure-based prospective cohort study on 34 swimmers (16M, 18F) from a university in USA over one academic year and concluded that, the back was the second most common injury location (16.1%).

Swimming has high practice injury rate relative to other sports in national collegiate athlete association (NCAA), USA, especially for female. But they urged to work on larger sample size and over several competitive seasons to generalization of data.

Wanivenhaus et al.(2012) did a literature review on epidemiology of injury and prevention strategies in competitive swimmers from Google scholar, OVID, and PubMed articles published from 1972 to 2011 and concluded that, a understanding of swimming biomechanics and typical injuries in swimming aids in early recognition of injury, initiation of treatment, and design of optimal prevention and rehabilitation strategies.

Mohsen et al.(2012) did a study on Swimming injuries and their risk factors among Iranian elite freestyle and butterfly swimmers, on 89 subjects with at least three years background ,age group between 15-24 years through interviews and by using self-made questionnaire to elicit the data to find out the swimming injuries and their risk factors and concluded that, insufficient warm-up before training or competition, wrong technique, lack of adequate physical fitness, wrong exercise, less scientific principles of exercise and poor conditions of swimming pool for training were the highest causes of injuries. There was no significant difference found among the kind of injuries in head and face, trunk and vertebral column, lower limb, joint, bone and each type of swimming. There was a significant difference found among the kind of injuries in upper limbs, skin, muscle - tendon, infection, sensitivity and each type of swimming. Repetitive injuries include inner back problems and back injuries from dolphin kicks or dry-land cross-training.

Venancio et al. (2012) did a survey with 19 questions was applied to 71 athletes (30 female and 41 male) ,in child I (10-12 years old), child II (12-14 years old), juvenile

(14-16 years old), junior (16-18 years old) and senior (From 18years old) categories, to verify the pain prevalence and the body areas with pain, correlating with main style and practice time in swimming athletes and concluded that, pain prevalence was of 74.6%, with low back pain 6% and the back stroke swim was the only style that had no correlation with pain (Mello et al.,2007). They suggested that further research is suggested both with a bigger sample and other region, with the aim to obtain broader results of pain prevalence in swimming athletes, since this sport is going through a moment of great success in the national and international sports scenario.

Abgarov et al. (2012) did a descriptive survey on 170 university-level swimmers competing in the 2007-2008 to understand the trends and risk factors of swimming-related injuries in university swimmers season, who completed a retrospective survey of injury history through questionnaire and concluded that, a high incidence of injury in current competitive swimmers. Findings support the conception that shoulders, knee, back are the common injury sites. Moreover, a greater proportion of injuries were of gradual onset. Their study did not find any significant differences in injuries across gender. It is important to stimulate research in the treatment and prevention of such injuries to ensure athletes' positive sport experiences and the maximization of athlete potential. They proposed for further research on examining the timeline of athletes' injuries across their careers. Such research could help coaches and practitioners prevent injuries in higher risk periods during athlete development. They suggested that further investigation is needed to understand the reason behind this and determine whether injuries played any role in their withdrawal with should use prospective data collection methods throughout a competitive season to verify the present result.

Gaunt and Maffulli (2011) has done a literature review using PubMed, Google Scholar and Ovid search engines with strict inclusion/exclusion criteria on a systematic review of the epidemiology, diagnosis, treatment and rehabilitation of musculoskeletal injuries in competitive swimmers and concluded that research regarding swimming injuries is sub-optimal in terms of methodology and reporting clinical findings. Given the scarcity of recent publications regarding the treatment and rehabilitation of swimming injuries, this field of sports medicine lacks the input from progress in related areas of sports medicine, such as that in other overhead athletes. Most literature on swimming injuries is directed towards swimmers' shoulders and impingement syndrome, and less on other injuries encountered. Most studies identified were retrospective cohort studies.

Ristolainen et al. (2010) worked on a 12 month retrospective survey on injury profile related to type of sport: A study on cross country skiers, swimmers, long-distance runners and soccer players .They Recruited 1200 competitive top-level male and female athletes (range 15–35 years) through questionnaire and concluded that type of loading is strictly associated with the anatomical location of an overuse injury and that in some sports many injuries occur in sports other than the main event. While overuse injuries occurred mainly while swimming. There was a previous injury in the same anatomic location in 36% of acute injuries and 38% of overuse injuries. Although swimmers had a great number of injuries, long-term time loss was rare. Retrospective data collection is a limitation in our study. Acute injuries among cross country skiers and swimmers occurred mainly in sport other than their own event. The knowledge derived from their study can be used in the prevention of injuries and in tailoring substitute training or rehabilitation programs to physically active individuals.

Wolf et al. (2009) worked to describe the pattern of injuries incurred for division 1 national collegiate athletic association among men's and women's swimming team over 5 seasons, through a descriptive epidemiology study and concluded that from 2002–2007, out of 44 male and 50 female athletes, the overall injury rates were estimated at 4.00 injuries per 1000 exposures for men and 3.78 injuries per 1000 exposures for women. 37% of injuries resulted in missed time. The relative risk (RR) for injury was higher among non-freestyle stroke specialties. Injury surveillance and potential prevention strategies should focus on the axial spine for cross-training activities.

Capaci et al. (2002) did a study on musculoskeletal pain in elite competitive male swimmers and found that 23 of the 38 competitive male swimmers examined reported musculoskeletal pain in this study with 7 low back pain cases. They concluded that, corrections of factors contributing to overuse injuries should be properly treated, so that the swimmers may return rapidly to swim safely.

Bue et al. (1989) did a survey on a total of 432 Danish competitive swimmers. They were asked to complete a questionnaire about the epidemiology of injuries sustained during swimming in the season of 1986-1987. They found a total of 100 injuries in 80 swimmers with an incidence of 0.9 injuries per swimmer per 1,000 hours of swimming and a point prevalence of 15% on the day of competition. The shoulder, back and the knee joint were most commonly involved. No particular swimming stroke was associated with a greater risk of injury. Medal winners were significantly more frequently injured. Half of the injured swimmers were seen by a doctor.

Evershred et al.(2014) did study a cross-sectional on Musculoskeletal screening to detect asymmetry in swimming to investigate the influence of asymmetry of clinical strength musculoskeletal screening measures and 3D kinematic movements on bilateral hand-force performance measures in swimmers taking 32 national-ranked junior swimmers, 100 m freestyle swimmers. They measured their clinical strength, kinematic movements, and bilateral hand-force. Asymmetry was defined as a percentage difference greater than 10%, either left (negative) or right (positive) for all variables and found that, asymmetry of the clinical strength was found in 85% of swimmers. Athletes with symmetry of all clinical strength measures displayed symmetrical bilateral hand force production. Approximately 50% of clinically asymmetrical swimmers were able to compensate, due to summated muscle symmetry and/or an altered kinematic movement pattern and generate symmetrical hand force. From this study they concluded that, symmetry of clinical strength was directly related to symmetrical force output. It is important to connect the clinical screening results to the sport-specific performance measures to ensure functional and valid screening. Clinicians should aim for symmetry of strength in order to minimise the requirement for compensatory strategies.

Micheli et al. (2014) reported that, swimming requires significant power and endurance and has been of as both an upper-extremity and spine-intensive sport. Swimming is a popular recreational and competitive sport for young athletes, ranking 8 for female and 10 for male youth sport participation in the USA. There are four main stroke types (freestyle, backstroke, butterfly, and breaststroke) and three kick types (flutter, whip, and dolphin) that, creates the swimming motion. Each stroke and kick has specific technical factors that can predispose an athlete to injury, where the spine being a vulnerable anatomic area for swimmers. Training in breaststroke and butterfly accounts for most of the spinal injuries seen in youth swimmers. The majority of spinal injuries in swimmers are overuse injuries and result from repetitive stress during practices rather than from acute trauma during swimming competitions. The adolescent swimmer is at particular risk due to rapid growth and maturation of the skeleton along with drastic increases in training volumes and introduction of new swimming techniques. Knowledge of swimming technique errors, intrinsic risk factors in each swimmer and vulnerable spinal anatomic sites will assist in the assessment and management of the young swimmer with spinal problems. The body position and spinal motion differs among the strokes with freestyle and back stroke characterized by rolling while butterfly and breast stroke have an up and down rhythmic motion. The roll of the trunk in free style and back stroke is created by paraspinal and abdominal muscles to provide much needed power via increased force generation and reduced segmental rotation and torque forces, in individual spinal segment. In butterfly stroke swimmers should have an effective spinal undulation motion with repetitive and rhythmic flexion and extension of lumbar spine. In breast stroke less gliding and body roll motion occurs. These changes have increased the relative lumbar extension and stress to the facet joints and thus increase the risk of spinal injury and pain. Errors in technique within the strokes, including arm position, body roll, kick and head position for breath can predispose to spinal injury. They reported rates of low back pain injuries among swimmers of all age range from 4 to 37%. More injuries are seen in non-free style swimmers, mostly in breaststroke and butterfly. Swimming injuries are more chronic and overuse rather than acute.

Katherine (1996) et al. worked on rehabilitation of injuries in competitive swimmers and stated that, competitive swimmers perform highly repetitive motions. Therefore characteristic overuse of shoulder, back and knee can occur. A thorough history and examination should be performed by both physician and Physiotherapist. Combination of hypovasuclarity, fatigue, poor stroke mechanism and progressive instability of hypermobile joints results in injury and pain. Back injuries are most commonly due to degeneration of disk, hyperextension and myofasial involvement. Rehabilitation should be focus on stabilization of hypermobile joint, postural correction, strengthening and flexibility. The highly repetitive motion of competitive swimming can lead to characteristic over use injury in shoulder, back and knee. To fully understand the mechanisms leading to swimmers pathology requires a thorough knowledge of anatomy, basic stroke mechanism and specific biomechanics. This together with an accurate diagnosis, lead to appropriate treatment and a timely return of swimmer should promote the incorporation of preventive measures into the training programme of a competitive swimmer. An accurate history must be obtained to determine the onset, duration and specific motion which precipitate the pain. The swimmer should describe the positioning of the involved body part at the point of maximal pain detailing of the recurrent nature of injury, previous treatment and compliance. Together this information will help to explain the aetiology of the condition and facilitate a focus in the clinical examination. A systemic approach to the physical examination must be employed on each patient that includes gradual inspection, palpation and assessment of range of motion, strength, joint laxity, and neurological testing are elemental. Provocative and diagnostic test will then lead to specific diagnosis.

Koji Kaneoka. (2013) surveyed the relationship between sports competition history and incidence of LBP in 4,667 freshmen belonging to a physical education department. The results showed a 50% LBP incidence in the non-exercise group of subjects with no history of sports competition. In contrast, subjects in the moderate stress group, who had played competitive sports in either primary, junior high, or high school showed an incidence of 62%, whereas the high stress group, who had played competitive sports throughout primary, junior high, and high school had an incidence of 72%. Thus, more years in competitive sports led to higher low back pain rates, indicating that physical stress from competitive sports is a risk factor for low back pain. Furthermore, the survey results on LBP experience rate by specific competitive sports. Volleyball players were the most likely to experience low back pain (odds ratio: 3.8), followed by baseball, track and field, basketball, swimming, kendo fencing, tennis, and soccer. These results indicate that the physical movements and practice styles specific to each sport lead to different levels of low back pain frequency.

Kaneoka et al. (2007) did a case control study on lumbar inter-vertebral disk degeneration in elite competitive swimmers in level of evidence 3. They worked on Fifty-six elite swimmers (high-load group, 35 men and 21 women; mean age, 19.6 years) and a control group of 38 university recreational level swimmers (low-load group, 24 men and 14 women; mean age, 21.1 years) and evaluated for lumbar disk degeneration using magnetic resonance imaging. They compared the prevalence of disk degeneration and the disk level between the 2 groups and further investigated the relationship among their symptoms, swimming styles and disk degeneration. In result they found that 68% (N=38) elite swimmers and 29 %(N=11) controls had degenerated disks at various disk levels and the prevalence was significantly greater in the elite swimmers ($P = .0002$). Comparison between the 2 groups of the prevalence of disk degeneration at each level revealed that, the disk level of L5-S1 was significantly more frequently degenerated in the high-load group (*P* = .026). There was no significant relationship observed among the variables of low back pain symptoms, swimming strokes and disk degeneration. From this study they concluded that, excessive competitive swimming activities might exaggerate lumbar intervertebral disk degeneration, especially in the L5-S1 intervertebral segment.

Hosea et al., (2011) worked on aetiology of low back pain in young athletes: role of sport type, to test the hypothesis that, rowing athletes with LBP have a higher likelihood of degenerative disc disease than athletes from other sports in a retrospective case series of 199 athletes (14–25 years) with low back pain. Results of the history, physical examination and radiographic studies were evaluated and the data were analyzed by t-test or chi square and concluded that complaints of low back pain in young athletes are highly correlated with lumbar spinal abnormalities.

Daniels J M et al. (2011) performed a literature search (PubMed, Ovid) for the years 1995 through 2010 on evaluation of low back pain in athletes in the search engine and found results that, athletes with low back pain represent a very diverse group. The evaluation depends on the athlete's age and the presence of "red flags". The most common causes of low back pain in the preadolescent population are infection, tumour and trauma. In the adolescent population, trauma spondylolysis/spondylolisthesis and hyperlordosis are commonly seen. Leading causes in the adult population are mechanics and osteoarthritis. The elderly frequently present with osteoarthritis, spinal stenosis and internal medical aetiologies. They concluded that Athletes with back pain should have a diagnostic workup guided by their age, history and physical examination. Although this work up is similar in nonathlete, the demands of the athlete must be taken into account in a treatment plan.

Trainor et al. (2004) studied the aetiology of low back pain in athlete and quoted that aetiology of low back due to spinal trauma in sports is 6% to 13%. Incidence of low back pain in athlete is 60%. There are many different epidemiology of low back exists between athlete and non athlete. Sports requiring repetitive hyperextension of low back have proven to be risk factor of spondylolysis. During the adolescent growth sput, the axial skeleton tends to grow more quickly than the surrounding thoracolumbar fascia and soft tissues. Consequently pathologic tightness occurs, stretching the spine and resulting in low back pain. Athletes do not have stronger back muscles at the beginning of the season when at athletes return from prolonged period of inactivity. The erector spinae and abdominal muscles stabilizes the back during athletic activities. The normal extensor to flexor muscle strength ratio is 1:321. This ratio was reduced in athletes with back pain. An offseason conditioning programme helps in maintains of normal ratio.

Harvey et al.(1991) studied on low back pain in young athletes and reported that, low back pain occur in 85% of general population but only 5 to 8 % of the athletic population . The predisposing factors that may cause back injury includes growth sput, abrupt increase in training intensity and frequency, poor technique ,unsuitable sports equipments and leg length discrepancy, poor back extensor strength and abdominals, lack of flexibility of lumbar spine, hamstrings and hip flexors mainly contribute to chronic low back pain. Athletes who involved in sports that involve repeated and forceful hyperextension of the spine may suffer from lumbar fact syndrome and other back problems. In thorough history and physical examinations helps in proper diagnosis and treatment protocol. Most of the low back cases respond to conservative management. At least strengthening exercise and flexibility exercise may helps in prevention of recurrent low back. They concluded that, athletes back rehabilitation program includes a long term stretching, back and abdominal strengthening program.

Roach et al. **(2003)** studied the concurrent validity of digital inclinometer and universal goniometer in assessing passive hip mobility in healthy subjects. They investigated the concurrent validity of passive range of motion, measurements of hip extension, internal and external rotation using a digital inclinometer and goniometer. They recruited 30 health subjects without low back pain and they measured passive hip passive range of motion for extension, internal and external rotation by using both digital inclinometer and universal goniometer. They observed statically significant difference between goniometer and digital goniometer in hip range of motion except for right hip external rotation. Hip range of motion is an important component in assessing clinical orthopaedic conditions of the hip, low back and lower extremities. However it remains unclear as to what constitutes the best tool for clinical measurement. The difference between the goniometer and digital inclinometer in extension range was 3.2 degree, internal rotation was 4.5 degree and external rotation was 3.8 degree. They found inclinometer has greater measurement during extension and external rotation. There was no significant difference found between both right and left side of both instruments. They concluded that a significance difference exists between the two devices in all measurements except right hip extension. The difference noted was between from 3 to 5 degree, for all plane measurements.

Seidi et al. **(2009)** worked on the Iranian flexible ruler reliability and validity in lumbar lordosis measurements. They recruited 20 healthy men subjects and measured lumbar lordosis two times per each individual with a time gap of 1 mint. They measured the lordosis from T12 to S2 spinous process by Youdas method, for calculating lumbar lordosis angle and they connected the T-12 dot to S-2 dot by a straight line and draw a line perpendicular to the centre passing the curve. These lines were named as L and H. These length values are used in the specified equation or formula. At the same time the lumbar lordosis measured by standard X-ray method, the data obtained from both flexible ruler method and x ray methods were compared to establish the validity of the flexible ruler method. The Pearson's correlation coefficient between the X-ray method and flexible ruler method was 0.91, which shows high validity of the flexible ruler method for measurement of lumbar lordosis. At the same time the intra-tester reliability was measured by using the interclass correlation coefficient test at 0.01, the intra-tester reliability of flexible ruler method for the first tester and second tester were 0.92 and 0.82 respectively and the inter-tester reliability turned out to be 0.82. They concluded that flexible ruler method was a ideal method for measuring lumbar lordosis.

Garnier et al. (2009) worked on the topic Reliability of a test measuring transverse abdominis muscle recruitment with a pressure biofeedback unit. In this method the transverse muscle activation was measured in prone lying position by using a pressure bio-feedback unit, it has been used a device to train and to examine the subjects ability to perform segmental stabilization exercises properly. They measured transverse abdominis muscle activation in 39 female and 1 male subjects with at least single incidence of low back pain. They performed the test on two different days. On the first day, 1 researcher performed two similar tests each with four exercises and on the second day two examiners conducted 1 test on each individual, they found an intraclass co-efficient of

0.47 for inter-observer reliability and the intraclass correlation coefficient of 0.81 for test retest reliability. They concluded that prone lying test had relatively low inter-tester observer reliability and higher test retest reliability. They suggested that, by providing visual feedback to the subjects during the procedure may enhance deep abdominal muscle recruitment.

Hodges et al. (1996) did a study on inefficient muscular stabilization of the lumbar spine associated with low back pain: a motor control evaluation of transverse abdominis to evaluate the temporal sequence of trunk muscle activity associated with arm movement and to determine if dysfunction of this parameter was present in patients with low back pain. In standing, 15 patients with low back pain and 15 matched control subjects performed rapid shoulder flexion, abduction, and extension in response to a visual stimulus. Electromyography activity of the abdominal muscles, lumbar multifidus and the contra lateral deltoid was evaluated using fine-wire and surface electrodes. In result they found that, movement in each direction resulted in contraction of trunk muscles before or shortly after the deltoid in control subjects. The transverse abdominis was invariably the first muscle active and was not influenced by movement direction, supporting the hypothesized role of this muscle in spinal stiffness generation. Contraction of transverse abdominis was significantly delayed in patients with low back pain with all movements. Isolated differences were noted in the other muscles. From this result they concluded that, the delayed onset of contraction of transverse abdominis indicates a deficit of motor control and is hypothesized to result in inefficient muscular stabilization of the spine.

Tousignant et al. (2005) studied on the Modified-Modified Schober's Test for range of motion assessment of lumbar flexion in patients with low back pain: a study of criterion validity, intra- and inter-tester reliability and minimum metrically detectable change. They measured the lumbar flexion range in 31 low back pain subjects after a warm-up session in neutral position, by using the modified-modified Schober's test (MMST). At the same time the lumbar flexion range was measured by gold standard method (X-ray technique). They compared the modified Schober's test values with standard X-ray method taken by the researcher. Pearson's correlation was made between modified –modified Schober's test and gold standard technique. They concluded that, the MMST explained moderate validity (r=0.67 at 95% confidence interval) and good reliability (intraclass correlation coefficient =0.95 at 95% confidence interval, interclass correlation coefficient =0.91 at 95% confidence interval) with the standard X-ray technique.

3.DESIGN AND METHODOLOGY

Study design and methodology is the "bottle neck " of the research study which combines/holds all the content of the study .it has been realized that methodology og investigation maes the most dominant contribution towards the success or failure of any research work and also depicts scientific attitude and validity of work .hence it is essential part of every project .it includes sampling, inclusion and exclusion criteria, data collection and tools used to collect data ,procedure for data collection and statistical analysis .thus it must be properly planned with greater care to have reliable and valid information for the authentic results and conclusions.

3.1 DESIGN: Descriptive, cross-sectional survey.

3.2 SAMPLING:

150 swimmers in the age group of 18 to 27 years were taken from different areas of Punjab like from Guru Nanak Dev University, Amritsar, Punjab Armed Police, Jalandhar, National Institute of Sports, Patiala, Punjabi University, Patiala, State swimming club, Patiala, Institute of water sports, Talwada, who has participated in at least interuniversity level swimming championship and subjects who satisfied the inclusion criteria for the study.

Out of the total sample in no pain group, there were 8 male and 5 female at university level, 13 male and 18 female at state levels and 22 male and 19 female in national level of participation (Table 3.1, Figure 3.1). In the pain group there were 7 male and 3 female at university level, 11 male and 11 female at state level and 22 male and 11 female at national level (table 3.2,Figure 3.2).

Informed consent was obtained from the recruited subjects, who volunteered for the study and met the inclusion criteria for both male and female subjects.

Fig. 3.1: The pie shows the comparison among different level of participations between in both male and female without low back pain.

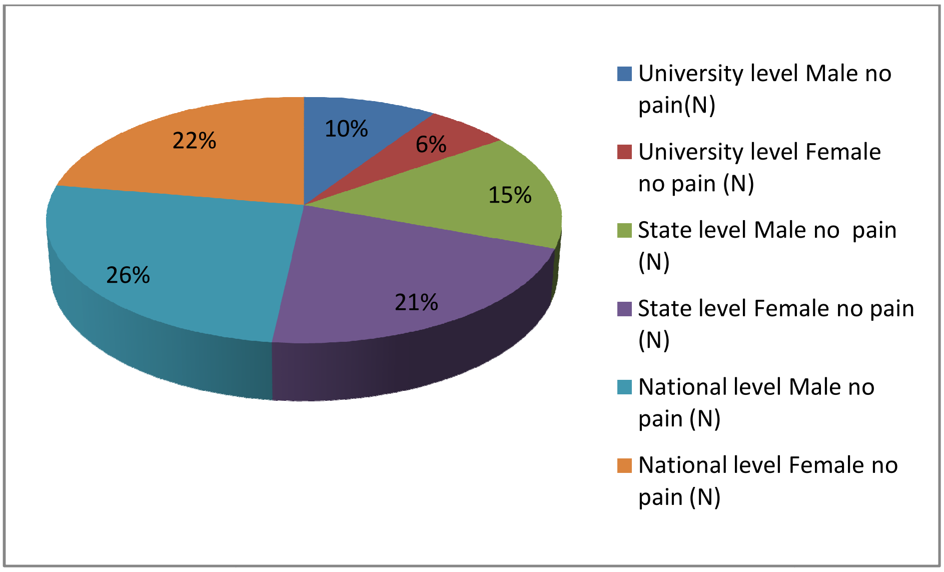


Table 3.1: Shwoing distribution of male and female in no pain group according to the level of participation

	University level		**State level**		**National level**	
	Male no pain	**Female no pain**	**Male no pain**	**Female no pain**	**Male no pain**	**Female no pain**
N	8	5	13	18	22	19
%	53.33	62.50	54.17	62.07	50.00	36.67

Fig 3.2: The pie shows the comparison among different level of participations between in both male and female with low back pain.

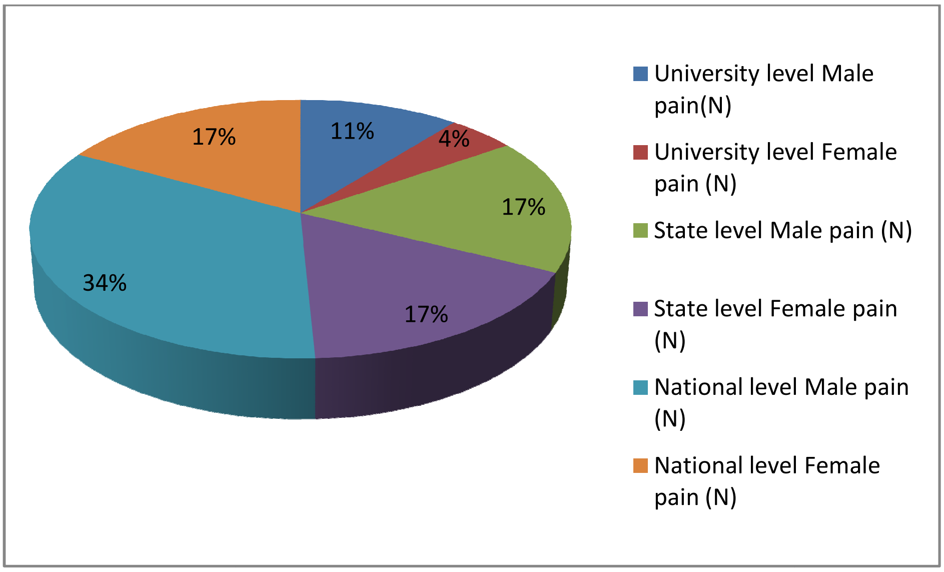


Table 3.2: showing distribution of male and female subjects in pain group according to the level of participation.

	University level		State level		National level	
	Male pain	**Female pain**	**Male pain**	**Female pain**	**Male pain**	**Female pain**
N	7	3	11	11	22	11
%	46.67	37.50	45.83	37.93	50	36.37

3.3 INCLUSION CRITERIA:

1. Swimmers who have participated at least at interuniversity level.
2. Swimmers who are regularly going to the swimming pool for recreation or fitness purpose for a minimum of 1 season duration.
3. Age group of 18 to 27 years.
4. Male and Female swimmers.

These inclusion criteria were incorporated to exclude the recreational swimmers.

3.4 EXCLUSION CRITERIA:

1. Subject with a history of previous back surgery
2. Nerve root compromise
3. Neurologic deficits
4. Current lumbar radiculopathy
5. Adolescent Idiopathic functional scoliosis
6. Swimmers not satisfying the mentioned age group.

3.4 VARIABLES MEASURED

1. Dependent variable:

Following dependent variables were measured:-

Angle of lumbar lordosis in degrees measured at T-12 and S-2, strength of transverse abdominis measured in seconds, tightness of hip flexors, hamstring and hip internal rotation range of motion for both left and right sides were measured.

2. Independent variable:

The independent variables were age and gender of the subjects.

3.5 INSTRUMENTATION

The following instruments were used:-

1. **Flexicurve**: A flexible calibrated scale which can be moulded to any shape was used to place over the lumbar spine into its counter, used for measuring angle of lumbar lordosis in degree. Skin markers were used to mark the T-12, S-2 spinous processes of lumbar spine. A poster paper was used, where the flexible curve was traced to measure the lumbar lordosis. The reliability for the flexicurve is 0.82 and validity 0.91 (Seidi et al., 2009).
2. **Visual Analog Scale**: was used to measure subjective pain intensity. It is an uncalibrated scale ranging from 0 to 10 and a corresponding 10 cm ruler on the other side (with each cm representing one pain level). It has a pointer, which could be easily moved from one end to the other.
3. **Pressure Bio-feedback Unit:** A Sphygmomanometer was used to measure the strength of transverse abdominis muscle, manufactured by Chattanooga Group**.** The reliability of this pressure biofeedback unit is ICC of 0.81 (95% CI 0.67 to 0.90) for test–retest reliability.
4. **Universal Goniometer**: To measure the range of motion of hip internal rotation in case of piriformis tightness and amount of tightness (in degree) in case of hip flexor and hamstring tightness.
5. **Inch tape**: Used to measure lumbar spine flexibility by modified Schober's Test.

3.6 PROCEDURES

1. Questionnaire:

A questionnaire consisting 50 different components, relating to low back pain were given to these swimmers, containing questions including demographic factors (e.g. name, age, gender, years of practice etc.) with details of swimming type, practice and with the history of present and previous low back pain, Visual Analog Scale (VAS) to rate the severity of low back pain. The subjects were gathered in a group of 5 at a time and allotted 20 minutes to answer to questions in their own handwriting. Prior to that, each group of subjects was explained regarding the content of questionnaire in the Hindi language.

2. Lumbar lordosis measurement (in angles):

Lumbar lordosis was measured with flexicurve, moulded to the contour of the subject's lumbosacral spine. Site along the flexible curve that were touching the subjects skin were marked at the level of spinous processes of T-12 and S-2. The shape of the curve's outline was traced on a piece of poster board and marks corresponding to the spinous processes of T-12 and S-2 were marked along the curve's contour. Over the traced curve on the poster board a vertical line was drawn joining between T-12 & S-2 and measure in centimetre, named as L. Then a vertical line from the L to the deepest part of the curve was drawn in centimetre named as H. Quantification of the curve (in degrees) was done with the Tan arc formulae using trigonometric method. (Seidi et al., 2009) (Fig. 4.6)

$$\theta = 4 Arc\tan {}^{2H}\!/_{L}$$

Figure 4.6: Measurement of lumbar lordosis by flexicurve

3. **Transverse abdominis strength measurement:**

The pressure biofeedback unit is a modified sphygmomanometer. It is accurate method of assessing the functioning of the Transverse abdominis. It consists of three-sections, inelastic inflatable pad and pressure pump connected to a sphygmomanometer gauge. In order to assess muscle isometric contraction, the pressure biofeedback unit was placed under the navel and the inflatable bag which was deflated completely, then pumped to a pressure of 70 mm Hg, while the subject was lying prone. The subject then pulls the navel up toward the spine and holds it for 10 seconds while breathing normally. As the transverse abdominis contracts and supports the weight of the abdominal contents, the biofeedback unit shows a decrease in the amount of pressure on the inflatable pad. When the contractions of the Transverse abdominis are performed correctly, the pressure will be reduced by 6-10 mm Hg. (Richardson & Jull, 1995, Richardson, et al., 2002). (Fig. 4.7)

Figure 4.7: Measurement of abdominal strength by pressure bio-feedback unit

4. **Hip flexor tightness Measurement**(Thomas test)**:**

Hip flexor tightness measurement was measured in degrees in accordance with Thomas test. The subject was in supine and one lower limb was flexed at both hip and knee passively to bring the knee to the chest. Then the subject was holding the knee in the same position. The raise of the straight leg from the base was measured in degree with the universal goniometer and recorded. The procedure was repeated for both the side hip flexor tightness measurement (Magee, 2006). The axis of goniometer was placed over Femoral Greater Trochanter. Fixed arm was parallel to midaxillary line of the trunk and movable arm was parallel to longitudinal axis of the femur in line with lateral femoral condyle (MacDiarmid et al., 1999). (Fig. 4.8)

Figure 4.8: Measurement of hip flexors tightness (left) by goniometre

5. **Hamstring tightness measurement** (Active knee extension test)**:**

This test is often used to measure hamstring tightness, as part of orthopaedic physical assessment (Magee, 2006).The Patient Position was in supine with one knee and hip flexed to 90 degree. The subject was instructed to extend the flexed knee as far as possible, keeping the foot relaxed and holds the position for 5seconds. At the end of the 5second of holding period the angle of knee extension was measured using goniometer. Centre of the goniometer to be positioned over the lateral knee joint line and the goniometer arms positioned along the lines was marked on the femur and fibula. Two lines drawn from centre, one is joining axis point to the centre of the greater trochanter of the femur and a second line joining the axis point to the apex of the lateral malleolus. The goniometer measurement was taken at the end range of knee extension. Reliability for this test is ICC of 0.761(Norris et al, 2005). (Fig. 4.9)

Figure 4.9: Measurement of left knee flexors tightness by active knee extension test method.

6. Hip Internal Rotation range of motion measurement (Piriformis tightness)**:**

The subject was in prone lying position, with hip in neutral position and knee flexed to 90 degree, the internal rotation range was measured using a standard goniometer. The axis of the goniometer was the tibial tuberosity. The movable arm of the goniometer was aligned with the shaft of the tibia and fixed arm was relative to the vertical axis, perpendicular to the ground. Reliability for this test is ICC 0.08 (Roach et al., 2013). (Fig. 4.10)

Fig. 4.10: Measurement of left hip internal rotation range of motion.

7. Lumbar spine flexibility measurement (Modified Schober's Test):

The subject was in erect standing position over a firm base. L4 was palpated corresponding to the iliac crest on the lower back, a point 10 cm above L4 and a point 5 cm below L4 was marked using a marker.A total of 15 cm from lowest point was noted. Subject was then asked to flex the spine from lumbar region. Again the point was noted from the lowest point, following flexion. The differences in the 2 points were finally noted. This measured of lumbar spine flexion range. Reliability for this is ICC=0.95 (Tousignant M et al, 2005). (Fig. 4.11)

Fig.4.11 mesurement of lumbar flexion by modified Schober's test

3.7 DATA COLLECTION

A standardized questionnaire was used to collect the demographic data and find the prevalence of low back pain in them. Subject's lumbar lordosis angle measured at T-12, S-2 spinous process, strength of transverse abdominis, flexibility of Lumbar spine ,tightness hip flexors(both left & right),tightness of knee flexors (both left & right), hip internal rotation range of motion (both left and right) objectively measured amongst 150 swimmers.

3.8 STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 20.0. Student's t-test was applied for the mean value of different variables and Pearson's correlation test was applied to find out the correlation between different variables and pain and no pain groups. P value was set at 0.05 for statistical analysis. The data were also described by descriptive statistics to find the associated factors for occurrence of low back pain among swimmers.

3.9 FORMULAS USED ARE AS FOLLOWS:

1. Sample size calculation formula:

$$N = \frac{2\times [(z\alpha - z\,(1-\beta)\,(\sigma)]^2}{d}$$

zα= 2 tailed variant (0.05=1.96)

z (1-β)= power of the test(0.09= -1.282)

δ= standard deviation of the normal value of that group i.e. from mean pre value.

d= mean difference value expected

2. Descriptive Statistics:

The mean, standard deviation and standard error were calculated to describe the data.

Arithmetic Mean$(\overline{X})$: It gives the average value of the whole

$$\bar{X} = \frac{\sum X}{N}$$

Where

$\bar{X}$= Arithmetic Mean

N= Total Number of Individuals

ΣX= Sum of all variables

Standard Deviation (S. D.): It gives the degree of dispersion or deviation of the recorded data from the mean. It is given by the formula:

$$\text{S. D.} = \frac{\sqrt{\Sigma(X-\overline{X})^2}}{N}$$

Where

X= Individual variable

N= Total Number of variables

S.D. = Standard Deviations

$X - \bar{X} =$ Deviation of variables from the mean

Standard Error (S.E.):

It enables the measurement of magnitude of the sampling error. It is calculated by using the following formula:

S.E. = S.D / √N

Where

S.E. = Standard error

S.D. = Standard deviation

N= Total number of variables

3. Student's 't' test:

It gives the difference between the two independent random samples of size N1 and N2 with mean X1 and X2 and S.E. of X1 and S. E. of X2. It is calculated by the following formula:

$$t = \sqrt{\frac{\bar{X}_1 - \bar{X}_2}{(SE_{X1})^2 + (SE_{X2}{}^2)}}$$

Where,

t='t' test

X_1= mean of 1st variable

X_2= mean of 2nd variable

SE_{X1}= SE of 1st variable

SE_{X2}= SE of 2nd variable

4. Pearson correlation coefficient formula:

The Pearson Correlation Coefficient is a very helpful statistical formula that, measures the strength between variables and relationships. In the field of statistics, this formula is often referred to as the Pearson **'**r' test. When conducting a statistical test between two variables, it is a good idea to conduct a Pearson Correlation Coefficient value to determine just how strong that relationship is between those two variables. In order to determine how strong the relationship is between two variables, a formula must be followed to produce what is referred to as the coefficient value. The coefficient value can range between -1.00 and 1.00. If the coefficient value is in the negative range, then that means the relationship between the variables is negatively correlated or as one value increases, the other decreases. If the value is in the positive range, then that means the relationship between the variables is positively correlated or both values increase or decrease together. Pearson correlation coefficient for sample data is denoted by 'r'. The formula for Pearson correlation coefficient r is given by:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Where,

r = Pearson correlation coefficient

x = Values in first set of data

y = Values in second set of data

n = Total number of values.

4.RESULTS AND ANALYSIS

Table 4.1: Comparisons of Low Back Pain Parameters in Pain and No Pain Group

Variables	No pain (n=85) Mean±sd	Pain (n=65) mean±sd	t	p
Lumbar Lordosis (deg)	31.35±14.41	28.92±15.72	-.984	0.327
Tr A strength (Sec)	46.22±13.10	38.91±12.27	-3.483	**0.001**(S)**
Hip Flex Tightness Rt (Deg)	3.29±6.79	5.63±8.47	1.874	0.063(NS)
Hip Flex Tightness Lt(Deg)	2.59±6.97	4.02±8.46	1.132	0.259(NS)
Knee Flex Tightness rt(Deg)	4.06±9.46	5.32±9.03	.827	0.41(NS)
Knee Flex tightness Lt(Deg)	3.14±8.70	3.85±9.67	.468	0.64(NS)
Hip Int Rot ROM Rt (Deg)	24.53±9.31	22.63±9.40	-1.233	0.22(NS)
Hip Int Rot ROM Lt(Deg)	11.65±12.9	13.22±13.54	.720	0.473(NS)
Modified Schober's Test(cm)	6.51±3.58	5.10±2.51	-2.715	**0.007**(S)**

*p<0.05, **p<0.01, ***p<0.001

Table 4.1 shows there is statistically very highly significant relation found for the variable Transverse Abdominis (t value -3.483, p value 0.001) and highly significant relation found for the modified Schober's test (t value -2.715, p value 0.007). There is no significant relation found among other variables in comparison between pain and no pain group.

Table 4.2: Comparisons of Low Back Pain Parameters in Male and Female Group of No Pain Category

Variables	No pain (n=85)		T	p
	Male (n=43)	Female (n=42)		
Lumbar Lordosis (Deg)	34.21±14.20	28.43±14.19	1.877	0.064(NS)
Tr A strength (Sec)	43.40±13.70	49.12±11.93	-2.052	**0.043*(S)**
Hip Flex Tightness Rt (Deg)	4.88±8.56	1.67±3.77	2.252	**0.028*(S)**
Hip Flex Tightness Lt (Deg)	3.26±6.98	1.90±6.98	.892	0.375
Knee Flex Tightness Rt (Deg)	7.33±12.26	.71±2.61	3.456	**0.001**(S)**
Knee Flex Tightness Lt (Deg)	6.21±11.49	-	3.545	**0.001**(S)**
Hip Int Rot Rt ROM (Deg)	20.23±10.35	28.93±5.36	-4.881	**0.000***(S)**
Hip Int Rot Lt ROM (Deg)	10.93±12.83	12.38±13.26	-.513	0.61(NS)
Modified Schober's Test(cm)	5.63±2.88	7.41±4.02	-2.344	**0.021*(S)**

*p<0.05, **p<0.01, *** p< 0.001

Table 4.2 shows there is statistically very highly significant relation found between the variable Hip Int Rot Rt (t value -4.881,p value 0.000), highly significant relation found between Knee Flex Rt (t value 3.456, p value 0.001), Knee Flex Lt (t value 3.545, p value 0.001) and significant relation for Tr A strength (t value -2.052, p value 0.043), Hip Flex Tightness Rt (t value 2.252, p value 0.028).

Table 4.3: Comparisons of Low Back Pain Parameters in between Male and Female of Pain group

Variables	Pain (n=65)		t	p
	Male (n=40)	**Female (n=25)**		
Lumbar Lordosis (Deg)	29.95±16.83	27.28±13.93	.663	0.51(NS)
Tr A strength (Sec)	39.58±12.70	37.84±11.72	.552	0.583(NS)
Hip Flex Tightness Rt (Deg)	7.15±9.89	3.20±4.76	2.158	**0.035***
Hip Flex Tightness Lt (Deg)	5.15±9.26	2.20±6.78	1.478	0.145(NS)
Knee Flex Tightness Rt (Deg)	7.28±10.65	2.20±4.10	2.709	**0.009****
Knee Flex Tightness Lt (Deg)	6.00±11.78	.40±2.00	2.940	**0.005****
Hip Int Rot ROM Rt (Deg)	19.03±8.93	28.40±7.03	-4.451	**0.000*****
Hip Int Rot ROM Lt (Deg)	12.00±13.05	15.16±14.34	-.914	0.364(NS)
Modified Schober's Test(cm)	4.68±2.76	5.77±1.92	-1.878	0.065(NS)

*p<0.05, **p<0.01, *** p< 0.001

Table 4.3 shows that there is statistically very highly significant relation found for the variable Hip Int Rot ROM Rt(t value -4.451,p value 0.000), highly significant relation for Knee Flex Lt (t value 2.940,p value 0.005), Knee Flex Tightness rt (t value 2.709,p value 0.009) and significant relation for Hip Flex Tightness Rt (t value 2.158,p value 0.035).There were no significant difference seen with other variables.

Table 4.4: Comparisons of Low Back Pain Parameters in Male of Pain & no pain group

Variables	No pain (n=85)	Pain (n=65)	t	p
	Male (n=43)	Male (n=40)		
Lumbar Lordosis (Deg)	34.21±14.20	29.95±16.83	1.249	0.215 (NS)
Tr A strength (Sec)	43.40±13.70	39.58±12.70	1.315	0.192 (NS)
Hip Flex Tightness Rt (Deg)	4.88±8.56	7.15±9.89	-1.119	0.266(NS)
Hip Flex Tightness lt (Deg)	3.26±6.98	5.15±9.26	-1.046	0.299 (NS)
Knee Flex Tightness rt (Deg)	7.33±12.26	7.28±10.65	0.020	0.984 (NS)
Knee Flex Tightness Lt (Deg)	6.21±11.49	6.00±11.78	0.082	0.935 (NS)
Hip Int Rot ROM Rt (Deg)	20.23±10.35	19.03±8.93	0.567	0.572 (NS)
Hip Int Rot Lt ROM (Deg)	10.93±12.83	12.00±13.05	-0.376	0.708 (NS)
Modified Schober's Test(cm)	5.63±2.88	4.68±2.76	1.546	0.126 (NS)

Table 4.4 shows there is no significant difference seen with all variables.

Table 4.5: Comparisons of Low Back Pain Parameters In female category of no Pain & pain group

Variables	No pain (n=85)	Pain (n=65)	t	p
	Female (n=42)	Female (n=25)		
Lumbar Lordosis (deg)	28.43±14.19	27.28±13.93	0.323	0.748(NS)
Tr A strength (Sec)	49.12±11.93	37.84±11.72	3.767	**0.000***(S)**
Hip Flex Tightness Rt (Deg)	1.67±3.77	3.20±4.76	-1.374	0.177(NS)
Hip Flex Tightness Lt (Deg)	1.90±6.98	2.20±6.78	-0.169	0.866(NS)
Knee Flex Tightness Rt (Deg)	0.71±2.61	2.20±4.10	-1.626	0.113(NS)
Knee Flex Tightness Lt (Deg)	-	0.40±2.00	-1.000	0.327(NS)
Hip Int Rot ROM Rt (Deg)	28.93±5.36	28.40±7.03	0.324	0.748(NS)
Hip Int Rot ROM Lt (Deg)	12.38±13.26	15.16±14.34	-0.805	0.424(NS)
Modified Schober's Test (cm)	7.41±4.02	5.77±1.92	2.250	**0.028*(S)**

*p<0.05, *** p< 0.001

Table 4.5 shows that there is statistically very highly significant relation found for the variable Tr A strength (t value 3.767, p value 0.000) and significant for Modified Schober's Test (t value 2.250, p value 0.028). There was no significant difference seen with all variables.

Table 4.6: Distributions of male and female swimmers based on pain and no pain group according to the different level of participation

Groups			Level					
			University		State		National	
			Count	Column N %	Count	Column N %	Count	Column N %
SEX	MALE	NO PAIN	8	53.33	13	54.17	22	50
		PAIN	7	46.67	11	45.83	22	50
		Total	15	100	24	100	44	100
	FEMALE	NO PAIN	5	62.5	18	62.07	19	63.33
		PAIN	3	37.5	11	37.93	11	36.67
		Total	8	100	29	100	30	100

Table 4.6 summarises the prevalence of low back pain in both male and female according the different levels of participation at university, state and national level. It shows in case of male the prevalence of pain in more at national level (50%) and where as in case of female the pain prevalence is more at state level (37.93%).

Table 4.7: Comparison of different strokes with pain and no pain group based on VAS

Strokes	No Pain		Pain	
	Count	N %	Count	N %
BUTTERFLY	6	7.06	15	23.08
BREAST STROKE	10	11.76	15	23.08
BACK STROKE	20	23.53	12	18.46
FREE STROKE	43	50.59	19	29.23
MEDLEY STROKE	6	7.06	4	6.15

Table 4.7 shows the distribution of pain in different types of strokes. It states that free style swimmers shows more prevalence of pain (29.23%), followed by the butterfly stroke(23.08%) and breast stroke(23.08%) swimmers, with the medley (6.15%) shows least occurrence of low back pain.

Table 4.8: Correlation between different variables in pain group among both male and female

VARIBALES	Lumbar Lordosis (deg)	Tr A strength (Sec)	Hip Flex Tightness Rt (Deg)	Hip Flex Tightness (lt)	Knee Flex Tightness (rt)	Knee Flex Tightness (Lt)	Hip Int Rot Rt (deg)	Hip Int Rot Lt(deg)	Modified Schober Test(cm)	Level	Strokes
Lumbar Lordosis (deg)	1	-0.091	**0.311****	**0.367****	0.059	0.188	**-0.374****	-0.178	0.075	-0.019	-0.102
Tr A strength (Sec)	-0.091	1	**-0.271***	-0.224	-0.236	**-0.320****	0.270	-0.01	0.230	0.064	**0.257***
Hip Flex Tightness Rt (Deg)	**0.311****	**-0.271***	1	**0.795****	**0.532****	**0.499****	**-0.743****	-0.167	**-0.333****	0.199	**-0.342****
Hip Flex Tightness (lt)	**0.367****	-0.224	**0.795****	1	**0.500****	**0.471****	**-0.684****	-0.129	-0.313	0.235	**-0.355****
Knee Flex Tightness (rt)	0.059	-0.236	**0.532****	**0.500****	1	**0.830****	**-0.468****	-0.095	**-0.255***	-0.033	**-0.363****
Knee Flex Tightness (Lt)	0.188	**-0.32****	**0.499****	**0.471****	**0.830***	1	**-0.486****	-0.019	**-0.346****	0.001	**-0.383****
Hip Int Rot Rt (deg)	**-0.374****	**0.270***	**-0.743****	**-0.684****	**-0.468****	**-0.486****	1	**0.338****	**0.286***	-0.037	**-0.404****
Hip Int Rot Lt(deg)	-0.178	-0.01	-0.167	-0.129	-0.950	-0.019	**0.338****	1	-0.050	-0.043	0.209
Modified Schober Test(cm)	0.075	0.23	**-0.333****	-0.213	**-0.255***	**-0.346****	**0.286***	-0.050	1	-0.119	0.056
Levels	-0.019	0.064	0.119	0.235	-0.033	0.001	-0.037	-0.043	-0.119	1	-0.127
Strokes	-0.102	**0.257***	**-0.342****	**-0.355****	**-0.363****	**-0.383****	**0.404****	0.209	0.056	0.318	1

Table 4.8: Positive correlation was found between, Rt hip flexors (r = 0.311, p<0.05), Lt hip flexors(r = 0.367, p<) and negative correlation with right hip internal rotation (r = 0.374, p<0.01). A negative correlation was found between Tr A strength and Rt hip flexors tightness (r = -0.271, p<0.05) and left knee flexors tightness (r = -0.320, p<0.01) and a positive correlation found with Rt hip int Rotation (r = 0.270, p<0.05) and swimming strokes (r =0.257, p<0.05). A positive correlation found between Rt hip flexor tightness and LL (r =0.311, p<0.01), Lt hip flex tightness (r =0.795, p<0.001), Rt knee flex tightness (r =0.532, p<0.001), Lt knee flex tightness (r = 0.499, p<0.001). A negative corelation found with Tr A strength (r = -0.243, p<0.05), Rt hip int rot (r = -0.743, p<0.001), Mod Schober's (r = -0.333, p<0.01) and swimming stokes (r = -0.342, p<0.01). A positive correlation was found between Lt Hip tightness and LL (r = 0.367, p<0.01), Rt hip flex tight (r = 0.795, p<0.0001), Rt knee flex tightness (r = 0.500, p<0.0001), Lt knee flex tightness (r = 0.471, p<0.0001). Negative correlation found between Rt hip int rot (r = -0.684, p<0.0001) and swimming strokes (r = -0.355, p<0.01). A positive correlation was found between Rt knee flex tightness and Rt hip flex tightness (r = 0.532, p<0.0001), Lt hip flex tightness (r=0.500,p<0.0001), Lt knee flex tightness (r = 0.830, p<0.0001). Negative correlation was found with Rt hip int rot (r = -0.468, p<0.0001), Mod schober's test (r = -0.255, p<0.05) and swimming strokes (r= -0.363, p<0.01). A positive correlation was found between Lt Knee flex tightness and right hip flex tightness (r = 0.499, p<0.0001), lt hip flex tightness (r = 0.471, p<0.001), Rt knee flex tightness (r = 0.830, p<0.001). Negative correlation was found with Tr A strength (r = -0.320, p<0.01), Rt hip int rotation (r = -0.486, p<0.0001), Mod Schober's test (r = -0.346, p<0.01) and swimming strokes (r = -0.383, p<0.01). A positive correlation was found between Rt hip int rotation and Lt hip int rotation (r = 0.338, p<0.01), Mod Schober's (r = 0.286, p<0.05) and swimming strokes (r = 0.404, p<0.001). Negative correlation was found with LL (r = -0.374, p<0.01), Rt hip flex (r = -0.743, p<0.0001), Lt Hip flex tightness (r = -0.684, p<0.001), Rt knee flex (r = -0.468, p<0.0001) and Lt knee flex tightness (r = -0.486, p<0.0001).

Table 4.9: showing correlation between different variables in no pain group among both male and female

VARIBALES	Lumbar Lordosis (deg)	Tr A strength (Sec)	Hip Flex Tightness Rt (Deg)	Hip Flex Tightness Lt (Deg)	Knee Flex Tightness Rt (Deg)	Knee Flex Tightness Lt (Deg)	Hip Int Rot ROM Rt (Deg)	Hip Int Rot ROM Lt (Deg)	Modified Schober's Test(cm)	Level	Strokes
Lumbar Lordosis (Deg)	1	-0.023	0.199	**0.294****	**0.239***	**0.240***	**-0.426****	0.024	**-0.220***	0.019	0.104
Tr A strength (Sec)	-0.023	1	**-0.219***	-0.012	**-0.219***	-0.15	0.164	0.117	**0.254***	0.056	0.098
Hip Flex Tightness Rt (Deg)	0.199	**-0.219***	1	**0.620****	**0.756****	**0.754****	**-0.490****	-0.84	**-0.349****	0.032	-0.035
Hip Flex Tightness Lt (Deg)	**0.294****	-0.012	**0.620****	1	**0.547****	**0.601****	**-0.381****	-0.024	**-0.381****	0.051	0.021
Knee Flex Tightness Rt (Deg)	**0.239***	**-0.219***	**0.756****	**0.547****	1	**0.931****	**-0.648****	-149	**-0.403****	-0.043	0.15
Knee Flex Tightness Lt (Deg)	**0.240***	-0.15	**0.754****	**0.601****	**0.931****	1	**-0.677****	-0.171	**-0.419****	-0.098	0.16
Hip Int Rot Rt (Deg)	**-0.426****	0.164	**-0.490****	**-0.381****	**-0.648****	**-0.677****	1	0.095	**0.329****	0.141	-0.113
Hip Int Rot Lt (Deg)	0.024	0.117	-0.084	-0.024	-0.149	-0.171	0.095	1	0.072	0.122	0.075
Modified Schober's Test (cm)	**-0.220***	**0.254***	**-0.349****	**-0.381****	**-0.043****	**-0.419****	**0.329****	0.072	1	0.117	0.073
Level	0.019	0.056	0.032	0.051	-0.043	-0.098	0.141	0.122	0.117	1	**-0.214***
Strokes	0.104	0.098	-0.035	0.021	0.15	0.16	-0.113	0.075	0.073	**-0.214***	1

Table 4.9: A positive correlation was found between LL and Lt Hip flex tightness (r = 0.294, p<0.01), Rt knee flex tightness (r = 0.239, p<0.05), Lt knee flex tightness (r = 0.240, p<0.05). Negative correlation was found with Rt hip int rotation (r = -0.426, p<0.0001) and Mod Schober's (r = -0.220, p<0.05). A positive correlation was found between Tr A and Mod Schber's (r = 0.254, p<0.01). Negative correlation was found with Rt hip tightness (r = -0.219, p<0.0.05) and Lt knee flex tightness (r = -0.219, p<0.05). A positive correlation was found between Rt hip flex tightness and Lt hip tightness (r=0.620, p<0.0001), Rt knee flex tightness (r=0.756, p<0.0001), Lt knee flex tightness (r=0.754, p<0.0001). Negative correlation was found between Tr A (r = -0.219, p<0.05), Rt hip int (r = -0.490, p<0.0001), Mod Schober's (r = -0.3490, p<0.001). A positive correlation was found between Lt Hip flex and LL (r = 0.294, p<0.01), Rt hip flex tightness (r = 0.620, p<0.0001), Rt knee flex tightness (r=0547, p<0.0001), Lt knee flex tightness (r = 0.601, p<0.0001). Negative correlation was found with Rt hip int rotn (r = -0.381, p<0.0001) and Mod Schober's (r = -0.381, p<0.0001). A positive correlation was found between Rt knee flex tightness and LL (r = 0.239, p<0.05), Rt Hip Flex (r = 0.756, p<0.0001), Lt hip flex tightness (r = 0.547, p<0.0001), lt knee flex tightness (r = 0.931, p<0.0001).Negative correlation was found with Tr A strength (r = -0.219, p<0.05), Rt hip int rot ROM (r = -0.648, p<0.0001), Mod Scober's (r = -0.043, p<0.0001). A positive correlation was found between Lt knee flex tightness and LL (r=0.240, p<0.05), Rt Hip Flex Tightness (r = 0.754, p<0.0001), Lt hip flex tightness (r = 0.601, p<0.0001), Rt knee flex tightness (r = 0.931, p<0.0001). Negative correlation was found with Rt hip int (r = -0.677, p<0.0001), Mod Scober's test (r = -0.419, p<0.0001). A positive correlation was found between Rt hip int rot and Mod Schober's (r = 0.329, p<0.01). Negative correlation was found with LL (r = -0.426, p<0.0001), Rt Hip Flex Tightness (r = -0.490, p<0.0001), Lt Hip flex tightness (r = -0.381, p<0.0001), Rt knee flex tightness (r = -0.684, p<0.0001 and Lt knee flex tightness (r = -0.677, p<0.0001).

Fig. 4.12: Mean value of different variables between no pain and pain group in male and female

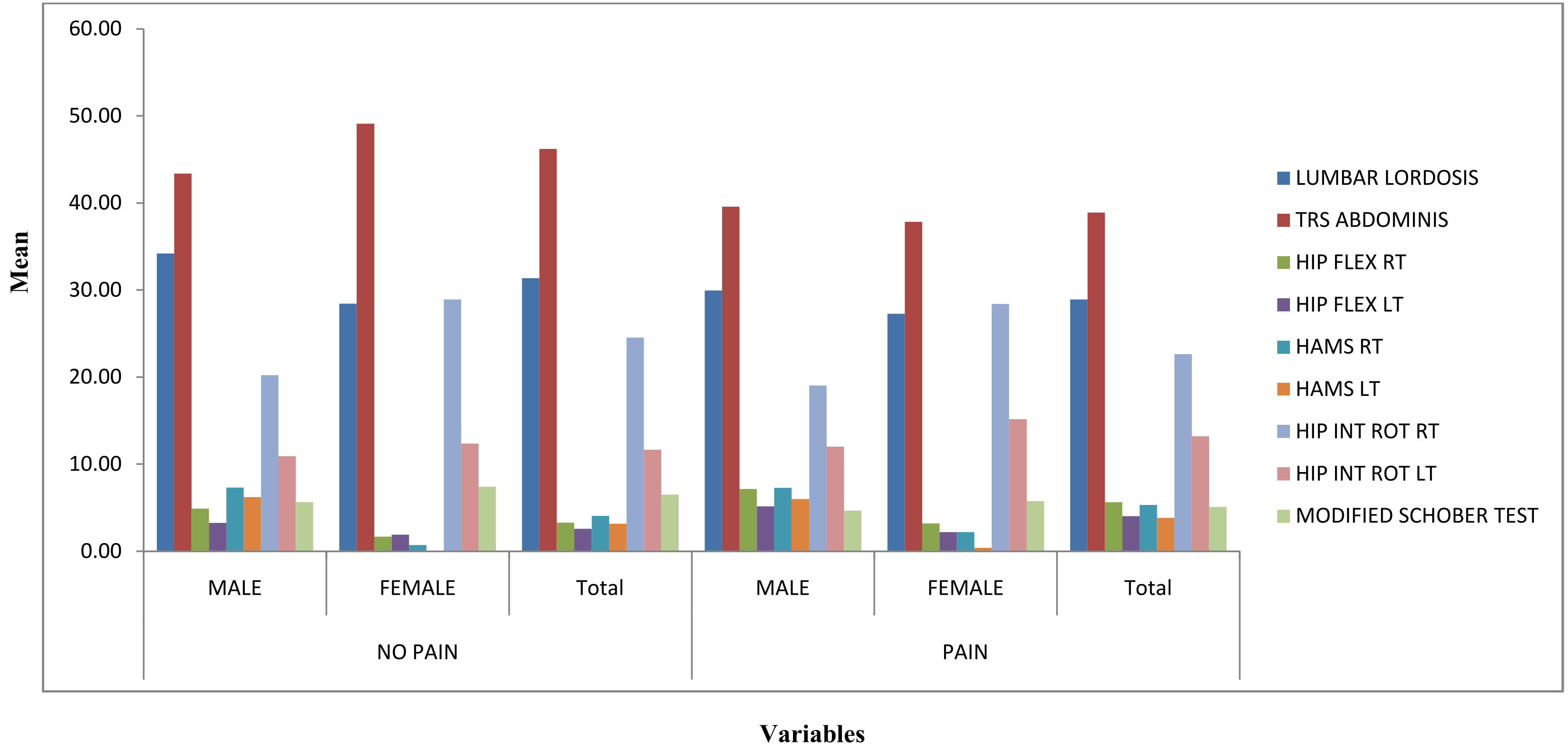


Fig.4.13: Stratification of Males and Females with respect to Pain and No Pain Group and Total Group (T: single piston error bar)

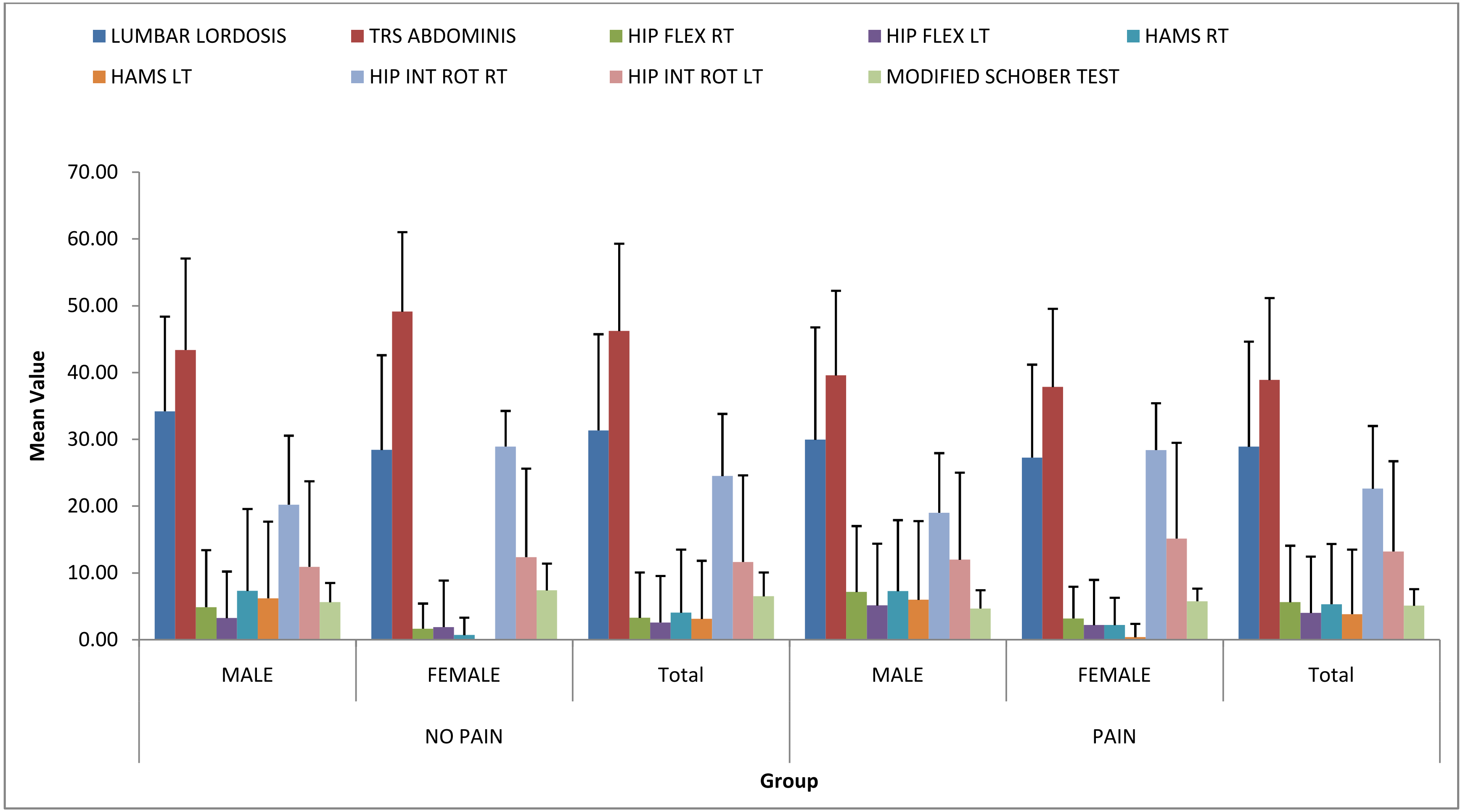


Fig. 4.16: Distribution of Male and Female in Pain and No Pain Group according to the level of participation, at National, State and University level.

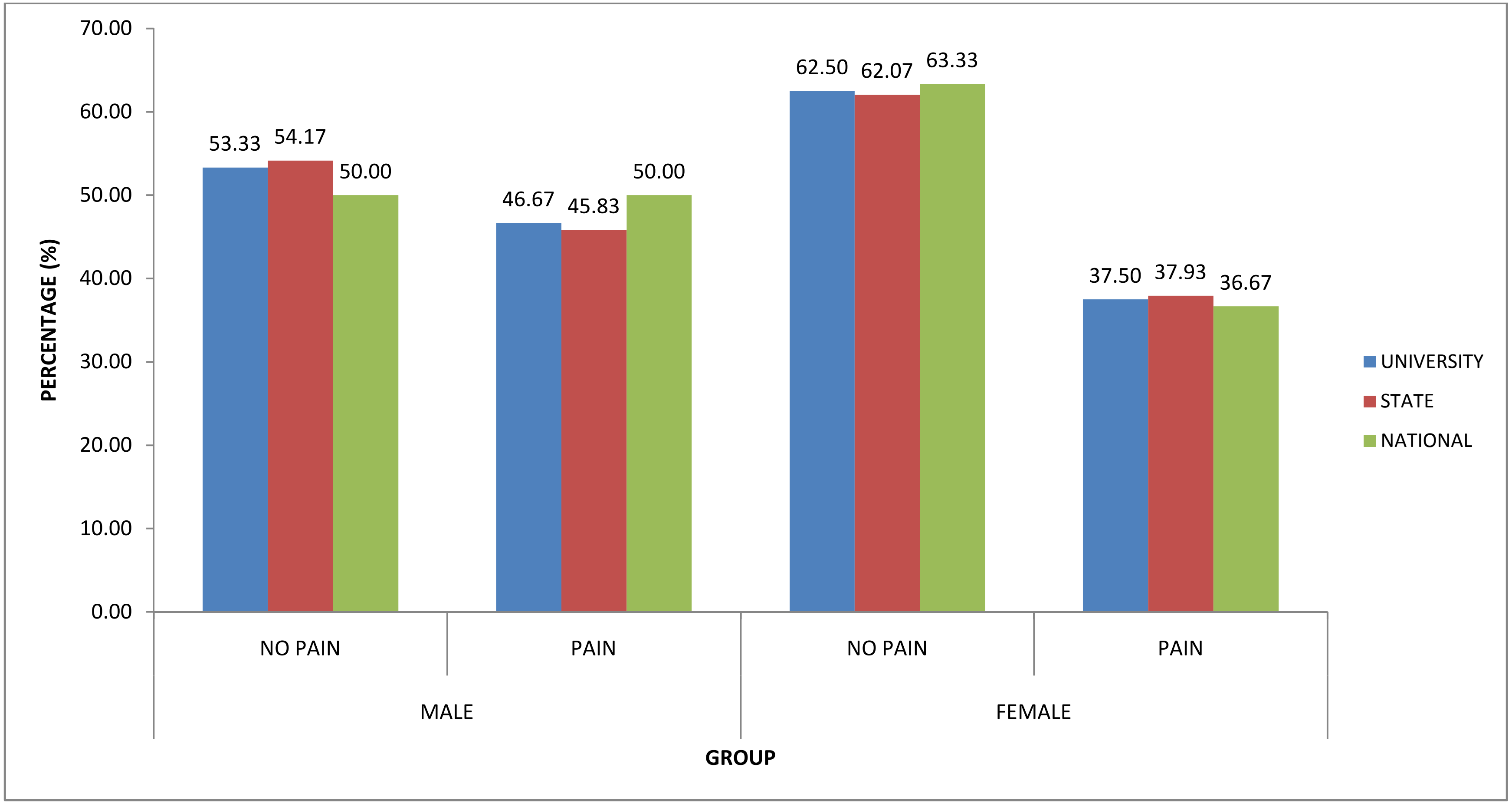
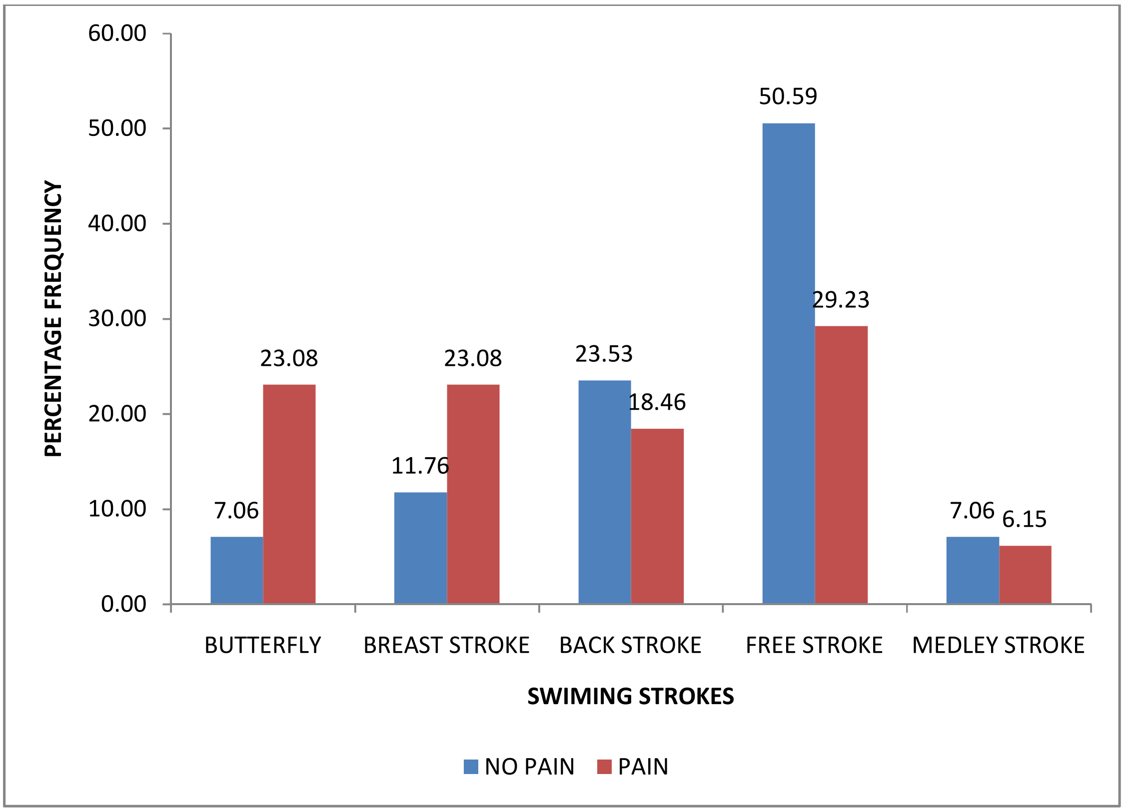


Fig.4. 17: Percent frequency of pain and no pain in different swimming strokes



5.DISCUSSION

In the present study 150 voluntary subjects were taken randomly, among them 83 were male and 67 were female swimmers, in the age group between 18 to 27 years. Each subject was given questionnaire containing 50 questions, including information about presence of low back pain or not, different levels of participations like university level, state level and national level. It also collected the information about different strokes of swimming performance like butterfly, backstroke, freestyle, breast stroke and medley. Then one time reading for different parameters related to the cause of low back pain was taken. The parameters includes the angle of lumbar lordosis, strength of transverse abdominis muscle, tightness of hip flexors, knee flexors and hip internal rotation range of motion for both left and right side. The collected data are discussed below.

5.1 PAIN PREVELANCE:

1. For total sample:

The results of present study showed that, the incidence of low back pain was 43.3% (N=65) out of 150 swimmers (Table 4.3). Present study results are closely supported by the previous studies, which reported that the incidence of low back pain among swimmers of all age group ranges from 4 to 37% (Micheli et al., 2014). Several studies reported that, there was lower incidence rate of low back in swimmers was 17% (Venancio et al., 2012), 27.5% (Ristolainen et al., 2010), 18.4% (N=7) out of 38 swimmers (Capaci et al., 2002). The difference in incidence rate may be due to individual variation among the subjects.

2. **According to gender difference:**

Present study results shows greater incidence of low back, which includes male 61.5% (N=40) and female 38.5 %(N=25) in the pain group. Current study results showed that, male swimmers were developed higher incidence (61.5%) than female (38.5 %) swimmers. Several studies reported that, female swimmers had a higher incidence rate than of male swimmers (Kerr et al., 2014; Sallis et al., 2001). Another study results showed no significant difference between gender (Kaneoka and Marks, 2010). Unequal distribution of gender difference in the prevalence low back may be due to higher number of male subject in the present study.

3. **According to the level of participation:**

According to the level of participation, the incidence of low back pain at university level was 43.4% (male 46.6 % out of 15, female 37.5% out of 8), at state level 41.5% (male 46% out of 24, female 38% out of 29), at national level 45.2% (male 50% out of 44, female 36.6% out of 30) (table 4.6). National level swimmers showed greater percentage of pain when compared to other level. Our result is consistence with the previous study, who reported that, based on level of participation the percentage of swimmers complained pain were regional level(50%), state level (77%), national level (80%), international (100%). National and international level swimmers had a greater incidence than regional level (Venancio et al., 2012). It may be due to higher intensity and frequency of training that may lead to greater stress on the low back (Kaneoka and Marks, 2010).

4. **According to the swimming strokes:**

The result of the present study found that, the freestyle strokes had a greater incidence of pain 29.2% (N=19) out of 62, butterfly 23% (N=15 out of 21) and breast strokes 23% (N=15 out of 25) both equally showed second highest pain incidence, followed by back stroke 18.4%(N=12 out of 32) where as medley stroke 6% (N=4 out of 10) swimmers showed the lowest number of incidence. Venancio et al., 2012 compared the percentage of pain in the swimmers according to the swimming style practiced by swimmers. They reported that medley strokes swimmers developed higher percentage of pain 100% (N=14 out of 14), followed by butterfly 77.8% (N=14 out of 18), freestyle 71%(N=35 out of 49), back stroke 50% (N=9 out of 18) and breast stroke 79% (N=19 out of 24) and concluded that backstroke ($p>0.05$) was not significantly associated with low back pain as compared to other strokes ($p<0.001$). Another study reported that 50% of low back pain seen in butterfly swimmers and 45 % for breast stroke swimmers (Drori et al., 1996). Another two studies concluded that, 33% butterfly swimmers and 22% breast stroke swimmers experienced low back pain during their carrier (Capaci et al., 2002 and Mutoch, 1978). But present study showed that, free style swimmers developed greater incidence of pain and medley stroke swimmers developed lowest number of incidence. It may be due to individual differences and inequality in distribution of subjects in different strokes. Another two studies by Bak et al., (1989) and Kaneoka et al., 2007, reported that there was no significant difference ($p>0.05$) between the risk of injury and swimming strokes pattern. But there was a tendency to develop overuse injuries with butterfly and breast stroke.

5. **According to the factors for low back pain:**

Transverse abdominis muscle strength: The results of the present study showed that the mean value of transverse abdominis (46.22±13.10) was significantly ($p<0.001$) higher in no pain group as compare to mean values of transverse abdominis strength (38.91±12.27) in pain group (Table 4.1). Current study results is in accordance with previous study, who evaluated the relationship between the transverse abdominis, sacroiliac joint mechanism in low back pain subjects and they found that, there was laxity of SI joint due to weakness of transverse abdominis. They observed that decrease laxity of sacroiliac joint decreases severity of low back pain (Richardon et al., 2002).

There was no significance difference seen between male and female in pain group (39.58±12.70 and 37.84±11.72) in relation to Transverse abdominis strength but there was a significant difference ($p <0.05$) seen in between male and female (43.40±13.70 and 49.12±11.93) in no pain group in relation to Transverse abdominis strength. This indicates the mean values of Transverse abdominis strength was higher in both male and female no pain group as compared to mean values of Transverse abdominis strength in both male and female pain group. But we didn't find significant difference between male and female pain group may be due to difference in sample size in no pain group in male(N=43) and female (N=42), which is almost equal ,where as in pain group in male (N=40) and female (N=25) (Table 4.2 & 4.3).

Lumbar flexibility: The mean value of Modified schober's test (6.51±3.58) in no pain group was significantly ($p<0.01$) higher (1.2folds) as compare to mean values (5.10±2.51) of Modified Schober's test in pain group (table 4.1)**.** The results were consistent with previous studies, who worked on association between measures of spinal mobility and low back pain. They measured right and left lateral flexion, standing extension and Modified Schober test, finger to floor distance, right and left knee extension in both no pain and pain groups. They found the significance difference between normal and low back pain the spinal mobility was restricted in low back pain (Elanie et al., 1998). Modified Schober's Test and standing extension and left knee extension were highly significant difference between low back pain and normal subjects. There was no significant difference seen in both male and female pain group in relation to Modified Schober's test, at the same time there was a significant difference ($p<0.05$) seen in both male and female in no pain group in relation to modified Schober test, but the mean value (5.63 ±2.88 and 7.41±4.02) of Modified Schober's test for both male and female in no pain group were higher as compare to both male and female pain groups (4.68±2.76 and 5.77±1.92) (table 4.3).

Lumbar lordosis: There was no significant difference seen in both pain and no pain group ,but the mean values of lumbar lordosis(31.35±14.41) in no pain group was higher as compare to mean values of lumbar lordosis (28.92±15.72) in pain group(table 4.1). The lumbar lordosis mean value (29.95±16.83) was higher in pain male group as compare to mean value (27.28±13.93) of female pain group, but there was no significant ($p>0.05$) difference the groups (Table 4.3). Present study results in consistent with previous study which was done using standard x-ray technique reported that, there was no association of lumbar lordosis with low back pain (Hansson et al., 1984).

Hip flexors tightness and hip internal rotation range of motion: Present study results showed that, there were no significant difference seen in both pain and no pain group in relation to hip flexor (right and left) tightness and hip internal rotation range of motion (Right and left). The results are in agreement with Wong et al., (2004), who reported that, there was no significant difference with hip movements in those with and without low back pain. There is currently no information about the effects of back pain on the correlation between the movements of the lumbar spine and hips in frontal and horizontal planes. There was a significant difference seen between male and female pain group in relation to right hip flexors tightness. The current study results consistent with the previous study who reported that, asymmetry was observed in case of length of hip flexors in both the sides (Sanders, 2011). At the same time, there was a significance difference seen in both male and female in no pain group and pain group in relation to right hip internal rotation. Present study results consistent with Kouyoumdjian et al., (2011), who reported that there was significant difference with right and left hip internal rotation, when they measured in both the genders and observed 39% presented with asymmetric hip rotation ROM the two hips.

Knee flexors tightness: Present study results shows that, there was no significant ($p>0.05$) difference in both pain and no pain group in association with right and left hamstring flexibility but the mean values of Rt and Lt knee flexors (5.32±9.30 and 3.85± 9.67) in pain group was higher than mean values of right and left knee flexors(4.06±9.46 and 3.14±8.70) in no pain group (table 4.1).This result is agreement with previous study, who reported there was no association between hamstring flexibility and low back pain (Stutchfield and Coleman, 2006). One explanation for the lack of association may relate to the point at which the hamstring muscles influence pelvic position. That is the hamstring muscles may only influence the lumbar spine, when the trunk is maximally flexed and the hamstrings are under tension. The lack of association between hamstring flexibility and lumbar flexion in the present study may be due to with this explanation. In another study who found that, lumbar flexion was influenced by hamstring inflexibility during maximum trunk flexion but it had no effect while standing position (Gajdosik et al., 1992). Importantly, during the rowing the trunk is never maximally flexed. This could suggest that the hamstring muscles have little influence on pelvic tilt during the rowing stroke and therefore may not be involved in the generation of low back pain in rowers (Redgrave, 1995). Previous research involving non-rowers clearly demonstrated that reduced hamstring flexibility was in association with low back pain (Biering-Sorensen, 1984; Halbertsma et al., 2001; Pope et al., 1985).Literature regarding the association between hamstring flexibility and low back pain was contradictory. At the same time there was a significant difference in both male and female of no pain group ($p<0.01$) and both male and female of pain group ($p<0.05$) in relation to hamstring flexibility.

The present study results are in agreement with several previous studies, who reported that there was a significance difference in both male and female group in relation to hamstring flexibility. This indicates that male athletes had shown lack of hamstring flexibility that may lead to greater percentage of hamstring strain in male athletes as compare to female athletes (Heidi, 2013**,** Marshall and Siegler,2014; Johnson, 2012). In another study, who reported no significant difference seen in hamstring flexibility between young adult male and female (Kumar, 2012).

6.CONCLUSION AND SUGESTIONS

6.1CONCLUSION

- Prevalence of low back pain in swimmers is 43%.
- Occurrence of low back pain in male swimmers in higher than that of female swimmers.
- National level swimmers showed highest rate of prevalence of low back pain as compare to state and university level swimmers.
- Highest prevalence of low back pain was seen in freestyle swimmers followed by butterfly and breast stroke swimmers.
- Strength of transverse abdominis and lumbar flexibility was better in no pain group of swimmers both in male and female.

6.2 SUGGESTIONS

- In the present study sample size was less. So the future study needs to be conduct on larger sample size.
- Our study shows higher prevalence of low back pain in male swimmer (61.5%).it may be due to unequal distribution of male and female swimmers in the present study. So the future study should be done on equal number of subjects from both the genders.
- In the present study there was unequal number of subjects from each stroke like freestyle, butterfly, backstroke, breast stroke and medley. So, the futures study should be conducted among equal number of subjects from each stroke of swimming.

- There was unequal number of subjects according to level of participation like national, state and university. So, in the future study there should be equal number of subjects from different level of participation.
- In the present study the training volume like duration of swimming per week was not included, which is a factor for low back pain. So, in the further study the volume of swimming needs to taken into consideration for analysis of low back pain.
- The intensity of swimming like sprint, middle distance and long distance swimming was not taken into consideration in the present study. So, in future study the intensity of swimming needs to be considered.
- There is very few published studies related to swimmers in India especially on low back pain in swimmers.

6.3 LIMITATIONS

- Present study was conducted on smaller sample size.
- There was unequal distribution of subjects according to the gender differences in the present study.
- The time duration for the present study was less.

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APPENDIX –I

INFORMED CONSENT

Research topic: Prevalence and analysis of risk factors for occurrence of low back pain in swimmers.

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This is to inform that, participation in this study is strictly voluntary. Anyone who decides to discontinue their participation can do so at any time. No incentive or financial assistance will be given to the participants. Nature & intent of the study has been explained to them.

I___________________________________, son/daughter of _____________________ agree to take part in the study entitled **"Prevalence and analysis of risk factors for occurrence of low back pain in swimmers"**.

I have read & understood the above information and I have answered to my satisfaction. It has explained to me that all the records/ data of the study will be kept confidential.

I agree to participate in this research without coercion.

Name of the participant: Signature:

Place: Date:

APPENDIX –II

QUESTIONNAIRE

1. Name:
2. Age:
3. Gender:
4. Height:
5. Weight:
6. Education:
7. Occupation:
8. Socio-economic status: a)LIG b)MIG c)HIG
9. Contact details:
10. Numbers of years of swimming:
11. Have you ever had to miss the training or competition because of LBP?
    (a) Yes (If yes, then for how many days?) (b) No
12. What is stroke?
    (a) Butterfly
    (b) Freestyle
    (c) Back stroke
    (d) Breast stroke
    (e) Medley
13. You are a
    (a) Sprinter
    (b) Middle-distance swimmer
    (c) Distance swimmer
14. Level of participation
    (a) District
    (b) State
    (c) National
    (d) International

(e) University

15. Participation in any other sports or cross-training ?(yes/no)

    If yes, Name of sport:

    Level of participation:

16. How many months in a year do you swim actively?
17. How many days in a week do you swim actively?
18. How many sessions in a day do you swim actively? a))Morning b)Evening
19. What is the average duration of 1 session/day?

    a) During practice b)During competition

20. Weekly training volume?......................hours
21. Weekly training millage?......................meters
22. Do you use any of the following while swimming?

    (a) hand paddles

    (b) floats

    (c) tubing

    (d) Kickboard if yes, how often?

23. Do you change the stroke frequently? (a)yes (b)no
24. Do you pay attention to modify strokes when low back pain occurs?
25. How do you progress through a swimming session?

    (a) easy to hard (b)hard to easy (c)constant throughout

26. Do you warm-up before every swimming session?

    (a) Always

    (b) Sometimes

    (c) Never

    (d) Only during competition

27. What do you include in your warm-up exercise?

    (a) Running/jogging

    (b) Stretching

    (c) Swimming related activity

    (d) All

28. Do you do cool down? (a)yes (b)no

29. Details of strengthening programme:

(a) Exercise with weight

(b) Exercise without weight

30. Stretching exercises are performed by :

(a) Self

(b) By other players

(c) Both

31. Who taught you the stretching exercises?

(a) Self

(b) Coach

(c) Physiotherapist

HISTORY OF PREVIOUS INJURY & TREATMENT PROFILE

1. Have you ever experienced low back pain? : a)yes b)no
2. Have you ever been admitted to hospital because of LBP? :(yes/no)
3. Have you ever undergone surgery because of LBP? (If yes what type of surgery?)
4. Have you ever experienced pain in low back? (a)yes (b)no
5. When did it occur? ....
6. How did it occur?

   (a) at its own

   (b) following injury
7. With regards to swimming how this pain affected you?

   (none/mild/moderate/severe)

   a) Endurance b) speed c) accuracy d) agility
8. Did you ever seek medical attention? a) Yes b) no

   If yes, which treatment?

   a)medication b)Physiotherapy c)others……………………………….

   If Physiotherapy taken, what kind of treatment was performed?

   a) Machines b) manually c) exercises d) others
9. Did you improve? a) Yes b) no

PRESENT PAIN EVALUATION

1. Do you feel low back pain now?
2. Nature of pain: a)sudden onset b)gradual onset
3. If sudden onset following injury, was it a)on ground b) off ground
4. Severity of pain: a) pain during swimming
   b) Pain during & after swimming
   c) Pain with daily living activities & effecting swimming
5. What do you do to relief the pain?
   a) Search for medical & physiotherapy guidance
   b) Self-medication
   c) Rest until pain subsides
   d) Apply ice
   e) Do not do anything
   f) Others………………..

APPENDIX –III

Table. 4.10: CLINICAL EVALUATION FORM:

Sl No.	Lumbar Lordosis (Deg)	Tr A strength (Sec)	Hip Flex Tightness Rt (Deg)	Hip Flex Tightness (lt)	Knee Flex Tightness (rt)	Knee Flex Tightness (Lt)	Hip Int Rot Rt ROM (Deg)	Hip Int Rot Lt ROM Lt(Deg)	Modified Schober's Test (cm)	Level	Strokes

MASTER CHART

SNO	AGE	SEX	LUMBAR LORDOSIS (DEG)	TR A (SECONDS)	HIP FLEX RT(DEGREE)	HIP FLEX LT (DEGREE)	KNEE FLEX RT (DEGREE)	KNEE FLEX LT(DEGREE)	HIP INT ROT RT (DEGREE)	HIP INT ROT LT (DEGREE)	MODIFIED SCHOBER TEST (CENTIMETRE)	VAS	LEVEL	STROKE
1	18	2	56	15	10	10	5	10	15	10	3	4	2	1
2	21	1	44	16	10	8	30	50	21	25	1	2	3	1
3	19	2	40	30	10	15	0	0	15	9	6	3	3	1
4	20	1	36	26	16	13	21	10	10	20	0	4	3	1
5	22	1	88	20	20	20	20	15	0	0	0	0	2	4
6	26	1	40	45	0	10	30	30	0	0	2.5	0	2	4
7	24	1	36	46	20	20	15	25	0	0	3.5	0	1	4
8	20	1	48	32	10	5	30	25	0	0	5.5	0	1	4
9	23	1	36	16	20	30	5	5	0	0	7	5	3	1
10	26	1	36	32	30	20	20	15	0	0	3	6	3	1
11	23	1	36	35	15	10	30	25	0	0	1	0	3	4
12	19	1	40	41	15	15	30	30	5	0	2	0	3	4
13	21	1	44	30	25	25	20	20	5	15	2	3	3	1
14	23	1	20	30	20	15	40	45	10	10	0.5	6	2	2
15	18	1	36	35	30	25	25	25	15	20	3	0	2	4
16	20	1	28	43	25	15	35	30	5	5	0	0	2	4
17	18	1	38	33	25	15	10	15	5	5	1.5	3	2	1
18	26	1	45	41	30	20	15	10	0	5	4	4	3	1
19	20	1	28	32	20	20	20	15	15	10	1	5	3	1
20	24	1	40	51	30	20	45	40	20	15	3	0	3	4
21	18	1	80	42	25	30	15	15	0	0	6	2	2	1
22	18	1	48	62	0	0	5	7	0	0	3.5	0	2	4
23	20	1	60	51	0	0	0	0	25	0	7.7	3	2	1
24	20	1	48	58	0	0	0	0	20	30	10	0	2	4
25	22	1	24	55	0	0	0	0	25	20	7.8	0	2	4
26	19	1	24	45	10	0	0	0	25	0	2	1	2	1
27	24	1	44	63	0	0	0	0	25	15	8	1	3	1
28	26	1	24	26	0	0	0	0	25	30	7.5	3	3	1
29	20	1	1	56	0	0	10	0	30	0	6	7	3	1
30	18	1	40	63	0	0	0	0	20	25	9.9	0	3	4
31	26	1	28	62	0	0	0	0	25	20	7.2	2	3	1
32	22	1	48	45	0	0	0	0	30	0	7	0	3	4
33	24	1	32	33	10	0	0	0	15	0	6	5	3	1
34	25	1	32	55	0	0	10	0	20	0	5	0	3	4
35	25	1	28	40	0	0	0	0	30	0	7	0	3	4
36	27	1	24	45	0	0	0	0	30	0	5	0	3	4

SNO	AGE	SEX	LUMBAR LORDOSIS (DEG)	TR A (SECONDS)	HIP FLEX RT(DEGREE)	HIP FLEX LT (DEGREE)	KNEE FLEX RT (DEGREE)	KNEE FLEX LT(DEGREE)	HIP INT ROT RT (DEGREE)	HIP INT ROT LT (DEGREE)	MODIFIED SCHOBER TEST (CENTIMETRE)	VAS	LEVEL	STROKE
37	26	1	24	23	0	0	10	0	30	0	9	0	3	4
38	18	1	24	33	0	0	10	0	25	0	7	2	1	1
39	25	1	16	23	0	0	0	0	30	0	7	0	1	4
40	26	1	16	23	0	0	35	20	20	0	8	7	1	1
41	25	1	16	55	0	0	10	20	15	35	6.5	5	1	1
42	22	1	40	40	0	0	0	0	20	15	6	0	1	4
43	23	1	43	32	0	0	0	0	20	20	6	0	2	4
44	24	1	50	46	0	10	0	0	20	0	6	0`	2	4
45	24	1	24	23	5	0	0	0	25	20	6	0	3	4
46	26	1	28	26	5	0	0	0	25	0	8	0	3	4
47	24	1	24	33	5	0	0	0	30	25	5.5	5	1	2
48	29	2	20	58	0	0	0	0	20	0	12.5	0	1	4
49	27	2	40	43	0	0	0	0	20	0	2	0	1	4
50	19	2	8	56	0	0	0	0	35	0	1	0	2	4
51	25	2	46	10	0	0	0	0	30	35	0.5	0	2	4
52	20	2	16	43	0	0	0	0	30	0	12.5	0	2	4
53	23	2	26	20	0	0	0	0	35	30	1.5	5	2	2
54	24	2	16	15	10	0	0	0	35	30	6	7	2	
55	23	2	40	40	10	0	0	0	20	30	10.3	0	3	4
56	22	2	18	40	0	0	10	0	35	30	6.5	7	3	2
57	24	2	8	56	0	0	0	0	35	20	8.5	0	2	4
58	23	2	16	40	0	0	0	0	35	0	6.5	2	3	2
59	23	2	20	68	0	0	0	0	30	35	0.5	0	3	4
60	25	2	40	46	0	0	0	0	30	0	12.5	0	3	4
61	22	2	18	56	10	0	10	0	30	35	6	2	2	2
62	22	2	20	26	0	0	10	0	30	25	0.5	0	2	4
63	21	2	32	56	0	0	10	0	30	25	8.5	0	1	4
64	18	2	20	58	0	0	0	0	30	0	12.5	0	1	4
65	19	2	40	66	0	0	0	0	25	35	12.5	0	3	4
66	20	2	16	40	0	0	0	0	35	35	7.6	6	3	2
67	22	2	20	60	0	0	0	0	20	35	12.5	0	3	4
68	18	2	40	58	0	0	0	0	30	0	12.5	0	3	4
69	19	2	20	53	0	0	0	0	35	0	12.5	0	3	4
70	20	2	20	56	0	0	0	0	35	0	15.5	0	2	4
71	22	2	16	45	0	0	0	0	35	0	4	4	2	2
72	21	2	40	53	0	0	0	0	35	20	6.5	0	2	4
73	18	2	8	43	0	0	0	0	30	0	6.5	0	2	4
74	18	2	32	60	0	0	0	0	25	20	6	0	3	4
75	18	2	20	48	0	0	0	0	35	0	8	0	3	4

SNO	AGE	SEX	LUMBAR LORDOSIS (DEG)	TR A (SECONDS)	HIP FLEX RT(DEGREE)	HIP FLEX LT (DEGREE)	KNEE FLEX RT (DEGREE)	KNEE FLEX LT(DEGREE)	HIP INT ROT RT (DEGREE)	HIP INT ROT LT (DEGREE)	MODIFIED SCHOBER TEST (CENTIMETRE)	VAS	LEVEL	STROKE
76	22	2	20	61	0	0	0	0	30	0	7	5	3	2
77	23	2	60	58	0	0	0	0	20	0	4.6	0	2	4
78	26	2	40	43	0	0	0	0	25	20	6.5	0	2	4
79	25	2	20	40	0	0	0	0	20	25	8	0	2	4
80	20	2	8	38	0	0	0	0	30	20	6.5	4	2	2
81	22	2	28	25	0	0	0	0	35	35	7.6	3	2	2
82	23	2	40	45	10	0	10	0	20	0	4.2	5	2	2
83	20	2	16	31	0	0	0	0	20	0	4.5	5	3	2
84	20	2	40	45	0	0	0	0	35	0	8.5	0	3	4
85	19	2	40	48	0	0	0	0	35	0	9.5	3	3	2
86	13	2	20	35	0	0	0	0	35	20	4	5	3	2
87	12	2	24	36	0	0	0	0	25	20	5.5	0	3	4
88	21	1	8	45	0	0	0	0	20	0	1	7	3	2
89	22	1	16	35	0	0	0	0	20	0	0.5	5	3	3
90	25	1	20	40	10	0	0	0	25	15	1	5	3	3
91	26	1	40	65	0	0	0	0	25	30	4.5	0	3	4
92	27	1	16	43	0	0	10	0	20	0	4.5	8	3	3
93	26	1	8	30	0	0	0	0	20	0	3.5	5	3	3
94	23	1	24	30	10	0	0	0	15	0	1.5	6	1	3
95	24	1	24	33	0	0	10	0	20	25	3	8	1	3
96	22	1	32	48	0	0	0	0	20	30	4.5	0	1	3
97	21	1	28	61	0	0	0	0	20	25	4	7	1	3
98	19	2	24	45	0	0	0	0	35	20	5.2	0	1	3
99	20	2	40	36	0	0	0	0	20	20	4	5	2	3
100	22	2	40	35	10	0	10	0	20	0	9.5	3	2	3
101	18	2	16	48	0	0	0	0	35	25	8.5	0	3	3
102	21	2	28	45	0	0	0	0	30	35	4.5	5	3	3
103	23	2	8	31	0	0	0	0	30	20	4.2	5	1	3
104	22	2	20	45	0	0	0	0	20	0	7.6	3	1	3
105	20	2	40	31	0	0	0	0	25	0	6.5	4	1	4
106	19	2	60	45	0	0	0	0	20	0	8	0	2	3
107	21	2	20	25	10	0	10	0	30	20	6.5	0	2	3
108	22	2	20	38	0	0	0	0	20	0	4.6	0	2	3
109	20	2	32	40	10	0	0	0	25	20	7	5	2	4
110	22	1	60	40	0	0	0	0	25	0	6.5	2	2	4
111	23	1	48	46	10	0	10	0	20	20	8.5	0	3	3
112	22	1	24	40	0	0	0	0	25	35	6.5	6	3	4
113	24	1	24	56	0	0	0	0	25	30	10.3	0	2	3
114	20	1	44	26	0	0	0	5	30	30	6	0	3	3

SNO	AGE	SEX	LUMBAR LORDOSIS (DEG)	TR A (SECONDS)	HIP FLEX RT(DEGREE)	HIP FLEX LT (DEGREE)	KNEE FLEX RT (DEGREE)	KNEE FLEX LT(DEGREE)	HIP INT ROT RT (DEGREE)	HIP INT ROT LT (DEGREE)	MODIFIED SCHOBER TEST (CENTIMETRE)	VAS	LEVEL	STROKE
115	22	1	4	40	10	0	0	0	20	35	1.5	7	3	4
116	24	1	40	68	0	0	0	0	35	0	7.2	0	3	3
117	22	1	48	46	0	0	0	0	30	35	0.5	5	2	4
118	21	1	16	56	0	0	0	0	25	0	6.5	0	2	3
119	23	1	40	43	0	0	0	10	30	0	1	0	1	3
120	22	1	28	58	0	0	0	0	30	0	2	0	1	3
121	24	1	24	33	0	0	0	0	15	25	6.5	0	3	3
122	20	2	60	68	0	30	0	0	30	30	0.5	0	3	3
123	18	2	20	46	0	25	0	0	30	25	12.5	0	3	3
124	19	2	20	56	10	30	10	0	30	30	6	2	3	4
125	20	2	32	58	10	25	0	0	30	0	0.5	0	3	3
126	18	2	8	66	10	0	0	0	30	0	8.5	0	2	3
127	20	2	40	43	10	0	0	0	30	15	8.5	0	2	3
128	21	1	16	26	0	0	0	0	30	0	9.2	0	2	3
129	23	1	48	28	0	0	0	0	20	25	7.2	2	2	4
130	22	1	40	63	0	0	0	0	25	30	9.9	0	3	5
131	22	1	4	56	0	0	10	0	30	0	6	7	3	4
132	20	1	24	26	0	0	0	0	25	30	7	3	3	4
133	24	1	44	63	0	0	0	0	25	15	8	1	2	5
134	23	1	24	45	10	0	0	0	25	0	8	1	2	5
135	22	1	24	55	0	0	0	0	25	20	7	0	2	5
136	20	1	48	58	0	0	0	0	20	30	10	0	2	5
137	22	2	40	53	0	0	0	0	35	0	5	0	2	5
138	18	2	8	43	0	0	0	0	35	0	6	0	2	5
139	20	2	32	60	0	0	0	0	35	20	6.5	0	3	2
140	21	2	20	48	0	0	0	0	30	0	8	0	3	2
141	20	2	20	58	10	0	0	0	25	20	7	0	3	2
142	18	2	60	43	0	0	0	0	35	0	4.5	5	3	5
143	18	2	40	40	10	0	0	0	30	0	8	0	3	2
144	20	1	48	23	5	0	10	0	20	0	5	0	3	2
145	22	1	4	26	5	0	0	0	25	20	3	0	3	2
146	22	1	28	33	5	0	0	0	25	0	2.5	0	3	2
147	24	1	24	58	0	0	0	0	30	25	1.5	5	3	5
148	20	1	20	43	0	0	0	0	20	0	8.2	0	3	2
149	24	1	40	56	0	0	0	0	20	0	7.5	0	3	2
150	20	1	8	46	10	0	10	0	35	35	5.3	0	1	5