Editor's Page

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Editor's Page

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SJIF Scientific Journal Impact Factor

Impact Factor for Journal of Exercise Science & Physiotherapy, JESP

Year	Impact Factor
2011	2.035
2012	3.217
2013	4.652

I am glad that the **Volume 10, No. 1 issue** of **Journal of Exercise Science and Physiotherapy** ***(JESP)*** is ready for circulation. An important milestone has been achieved during the year 2013 with the indexing of the JESP in the sciencecentral.com, InnoSpace - Scientific Journal Master List database beside Indmed. InnoSpace has announced that JESP was positively evaluated in the SJIF Journals Master List evaluation process, which resulted in a score given **SJIF 2013 = 4.652** (Scientific Journal Impact Factor Value for 2013). The organization has reported steady improvement in the SJIF scores calculated for 2011 (2.035) & 2012 (3.217). More and more commonly used rating is the criteria of citation which has also a great impact on gaining the Impact Factor rating. Building citation rating is long-lasting processes which require strict strategy which is consistently inculcated. All the contributors, reviewers and editorial board members deserve congratulations for their efforts in maintaining the quality of there publications and rigorous review processes and dealing with all this efficiently and in a timebound manner for maintaining the timely release of the journal. The improvement in the SJIF impact factor will help to gain better scores in different kind of evaluations and especially in gaining better citation results. The editorial committee members are busy with their effort to get the journal indexed in more and more databases to further improve the citation of the research published in the JESP. This issue of JESP contains ten original research articles and two case reports on the different aspects of exercise science from different countries of the world. I am sure you will enjoy the same and strengthen our hands to futher improve the position of the journal in the international market.

S.K. Verma

Efficacy of Muscle Energy Technique on Functional Ability of Shoulder in Adhesive Capsulitis

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Abstract

Adhesive Capsulitis is a very painful condition of the shoulder characterized by pain, severe stiffness and movement restriction usually present in the sixth decade of life. Onset before age 40yr is uncommon. The non dominant shoulder is slightly more likely to be affected. Muscle energy (MET) technique is very much beneficial in this condition. Muscle energy techniques are class of soft tissue osteopathic manipulation consisting of isometric contraction design to improve musculoskeletal function and reduce pain. Method:-30 patients of Adhesive Capsulitis were included in the study using convenient random sampling divided into 2 groups, Group A (Experimental) and Group B (Control). Each group was divided into 15 patients. 40 - 60 year old patients of both genders were included in the study. Control group was treated with conventional physiotherapy treatment. The Experimental group was treated with MET for shoulder Flexion, Abduction, and External rotation along with Conventional treatment. Result: Both Groups showed significant difference and improvement after treatment. There is significant difference in Post test scoring of both the groups; with lower SPADI scoring

Group A of experimental group shows better results then Group B of control group. *Conclusion:* Muscle energy technique is very much effective on functional ability of shoulder in adhesive Capsulitis.

Key Words: Frozen Shoulder, Codmen Exercise, Hot Packs.

Introduction

Adhesive capsulitis is a condition of the shoulder of unknown etiology. It is characterized by pain and restriction of both passive and active range of motion (ROM). Duplay referred to Adhesive capsulitis in 1872 as "Scapulohumeral Periarthritis," a disorder he believed resulted from subacromial bursitis *(Post, 1978; Neviaser, 1980; Bruckner & Nye, 1981; Jayson, 1981; Kessel et al, 1981; Rizk & Pinals, 1982; Loyd & Loyd, 1983;* Griggs *et al, 2000; Patil et al, 2010, Day & Nitz, 2012).* In 1934, Codman coined the term "frozen shoulder" but used it in association with tendinitis of the rotator cuff (*Kessel et al, 1981).*

Neviaser (1983) introduced the concept of adhesive capsulitis when he discovered that the capsule was tight, thickened, and stuck to the humerus in such a manner that it could be peeled off like "adhesive plaster from the skin (*Post, 1978; Jayson, 1981; Loyd & Loyd, 1983; Rizk et al, 1983; Schenk et al, 1997; Sandy et al, 2006; Steples et al, 2010; Stephanie et al, 2011; Srikanth et al, 2013). Loyd and Loyd (1983)* suggested that secondary frozen shoulder develops when painful spasm limits activity and creates dependency of the arm.

Adhesive capsulitis is a commonly recognized but poorly understood cause of a painful and stiff shoulder. Although most orthopaedic literature supports treatment with physical therapy and stretching exercises, some studies have demonstrated late pain and functional deficits. The purpose of these studies was to evaluate the outcome of patients with adhesive capsulitis who were treated with a stretching-exercise program as reported by *Griggs et al, (2000)*. *Staples et al (2010)* concluded that the shoulder pain and disability index (SPADI) is superior responsiveness when compared to the Disability arm, shoulder, hand (DASH) in patient with adhesive capsulitis.

Muscle energy techniques (MET) are a class of soft tissue osteopathic manipulation methods that incorporate precisely directed and controlled patient initiated, isometric contractions, designed to improve musculoskeletal function and reduce pain. *Schenk et al, (1997)* modelled this study found that lumbar extension was significantly increased after treatment, supporting MET as an appropriate therapy for restoring lumbar extension ROM. The authors recommended further MET efficacy studies be undertaken focussing on the thoracic and sacroiliac regions. *Stephanie et al (2011)* conducted a study to compare the muscle energy technique for the glenohumral joint external rotators to improve glenohumeral joint range of motion in baseball players. Their result showed that single application of and Muscle energy technique (MET) for the Glenohumeral joint horizontal abductors provided immediate improvement in both GHJ horizontal adduction and internal rotation ROM in asymptomatic collegiate baseball players. *Srikanth et al (2013)* did a study to compare the effectiveness of anterior versus posterior glide mobilization techniques and improving functional activity of the shoulder in patient with adhesive capsulitis. *Patel et al (2010)*; conducted the study to compare the effectiveness of MET on quadratus lumborum in acute low back using a randomized control trial. They studied a total number of 40 subjects (21 male and 19 female) and the result of the study concluded that MET on quadrates lumborum combined with interferential therapy is more effective in reduction of disability and increasing spinal range of motion than interferential therapy alone in patients with acute low back pain. The aim of the present study was to study the effectivity of MET on functional ability of shoulder in Adhesive Capsulitis.

Materials and Methods

30 patients of Adhesive Capsulitis were included in the study using convenient random sampling from Delhi NCR and further divided into 2 groups, Group A (Experimental) and Group B (Control). Each group was divided into 15 patients. 40 - 60 year old patients of both genders were included in the study. Patients with Rotator cuff tear, any systemic disorder any neurological disorder or fracture in and around shoulder were excluded. Control group was treated with conventional physiotherapy treatment which consisted of Ultrasound Therapy, Hot pack, Codman's exercises, Pulley exercises and active assisted exercises. The Experimental group was treated with MET for shoulder Flexion, Abduction, and External rotation along with Conventional treatment. The protocol for MET to shoulder joint included 3 repetitions per set, 1 session per day and thrice a week for 5 weeks.

Results & Discussion

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Statistical comparison of the two groups, Experimental (group A) and Control (group B) reveal no significant differences in the mean age of both groups. Statistics were performed by using SPSS 13. Results were calculated by using 0.05 level of significance.

Table 1: Statistical comparison of mean scores of Shoulder pain and disability index before and after the treatment in the experimental group

Experimental Group	MEAN	±SD	T	P
Pre	56.53	15.96	9.22	< 0.05
Post	37.53	11.74		

Table 2: Statistical comparison of mean scores of Shoulder pain and disability index before and after the treatment in the control group

Control Group	MEAN	±SD	T	P
Pre	63.07	10.60	11.82	< 0.05
Post	46.87	10.46		

Group A was given MET with Conventional treatment. The Pre treatment scoring of SPADI is 56.53 ± 15.96 and Post 37.53± 11.74. Group B was given Conventional treatment. The Pre treatment scoring of SPADI is 63.07± 10.60 and Post was 46.87±10.46.

Both the groups showed significant difference and improvement after treatment. However, greater magnitude of % improvement was observed in the Group A i.e. the experimental group than the Group B of control group.

Discussion-

The purpose of this study was to see the Efficacy of Muscle energy technique on Functional ability of Shoulder in Adhesive Capsulitis. In this study age distribution showed no significant difference in both groups. The comparison of mean value of age in Group A is 50.80±6.48yrs and Group B is 51.13±5.77yrs. Group A showed significant changes may be due to the application of MET that relaxes and improve biomechanics and thus results in improved functional ability. Group B also showed mild changes due to the relaxation effect of conventional treatment. It was evident from the mean score that both the groups showed improvement in SPADI score because of treatments. Between groups analysis revealed that percentage of improvement in SPADI score was more in shoulder MET group which further showed more improvement than the conventional treatment Group.

The data analysis and statistic inference have brought to check the effectiveness of MET and conventional treatment on the variables of the study which are pain, functional ability and ROM . The MET has an effect in reducing pain, increase ROM and functional ability in patient with adhesive Capsulitis. This is also supported by the study of *Patil et al (2010).* They took 40 subjects (21 males and 19 females) diagnosed with acute low back pain. Subjects were randomly assigned to two groups of 20 each. The control group received interferential therapy while interventional group received MET on quadratus lumborum combined with interferential therapy. MET on quadratus lumborum combined with IFT demonstrated a statistically significant difference ($p<0.001$) showing decrease in disability and increase in spinal range of motion than IFT alone. In the present study Muscle energy technique along with conventional treatment is found to be relatively more effective on pain, disability and ROM than the conventional treatment alone. The study of *Day et al (2012)* also supports the results of the present study.

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Low back pain is the most common type of pain reported by adults in the United States. A variety of manual therapy techniques are being used in the management of low back pain to reduce pain, improve function, and reduce disability. Muscle energy techniques have been increasingly used in clinics to treat low back pain *Day et al (2012).*

Akbari et al (2012) reported a study in which thirty patients with trigger points in the upper trapezius and levator scapula were randomly assigned to one of the three groups in equal number. In the laser group a low level Ga- As laser was applied with pulse duration of 200 ns and 60 j/cm2 dosages by contrast in the muscle energy group, in the present study used stretching following Post isometric relaxation and in the placebo group used low level laser without an output. The result showed that low level laser and muscle energy technique are both equally effective in decreasing the neck and shoulder pain and disability in patients with myofascial trigger points in trapezius and levator scapula muscle (*Akbari et al, 2012).* There effect was reported to be beneficial because these exercises spread synovial fluid stimulate tonically depressed joint mechanoreceptors, alleviate pain secondary to muscle ischemia or prevent collagen cross bridging. These results of study are also supported by the study *Schenk et al (1997)* in their study on physical therapy management of the shoulder. Subject in the present study have similar baseline values of all dependent variables suggesting that both groups had similar distribution of patients. Statistical analysis reveals that there are significant changes in all the base values. These include decrease in pain, improvement in the Disability score, increase in ROM. Group A demonstrated significant changes that may be ascribed to the usage of the MET that relaxes and improve biomechanics and thus may result in increase in ROM, decrease in pain and improvement in the functional ability. Group B also showed some significant changes may be due to the relaxation effect of conventional treatment that may have caused improvement in ROM, SPADI and VAS. Between the groups analysis revealed that percentage of improvement in pain in Group A was greater than Group B.

Our data supported alternate hypothesis that shoulder Muscle energy technique along with conventional treatment for functional ability in adhesive capsulitis was more effective than the shoulder conventional treatment for functional ability in Adhesive capsulitis.

Conclusion: Muscle energy technique is very much effective on functional ability of shoulder in adhesive Capsulitis.

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Musculoskeletal Disorders among Medical Laboratory Professionals-A Prevalence Study

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Abstract

Background: Work –related musculoskeletal disorders (WRMSD) have been reported very often in various occupations. Laboratory personnel are also exposed to many ergonomic risk factors due to the nature of their work. As their work demands awkward and static postures, high repetition, excessive force, excessive reaching, compression or contact stress, forceful or static exertions, lifting and pinch grip lifting, and repetitive motions, they may be at increased risk for work related musculoskeletal disorder which is often ignored. So the study was aimed at estimating the prevalence of work related musculoskeletal disorders among laboratory professionals. *Methods:* It was a cross sectional study done on 250 laboratory professionals (lab technicians, pathologists, microbiologists, biochemistry technologist) in Udupi district of Karnataka state and validated questionnaire was used to screen for the symptoms. Data were analyzed using descriptive statistics. *Results:* Prevalence of musculoskeletal symptoms among laboratory professionals was found to be 21.2%. The neck and lower back are observed to be the most affected with symptoms of pain and discomfort with prevalence of 8% and 6.8% respectively. *Conclusion:* Medical laboratory professionals are at high risk for the development of MSDs related to cumulative trauma. Thus, laboratory professionals are strongly encouraged to adopt preventive measures before symptoms develop.

Keywords: Work related musculoskeletal disorders; Occupational; Health Risk; Cumulative trauma, Laboratory professional

Introduction

Musculoskeletal disorders (MSDs) are an increasing health problem in workplaces. These disorders are a major cause of concern for several reasons: the health problem leading to workers' disability and the lost time from work *(WHO, 2003)*. Work-related Musculoskeletal Disorders (WMSDs) are the musculoskeletal disorders to which the work environment and the performance of work contribute significantly *(Wolf et al, 2006)*.

Hospitals are large, organizationally complex, system driven institutions employing large numbers of workers from different professional streams. They are also potentially hazardous workplace and

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expose their workers to a wide range of physical, chemical, biological, ergonomical and psychological hazards. Oftentimes, healthcare workers experience musculoskeletal disorders (MSDs) as well as respiratory symptoms at a rate exceeding the rate of workers involved in construction, mining, and manufacturing sectors *(Howells & Knight, 1981).*

Stricoff, and Walters, (1995) reported that healthcare workers, including pathologists, microbiologists, and technicians are exposed to a number of risk factors in the workplace for musculoskeletal disorders such as back and shoulder injuries and even other joints and muscles exertion, which are aggravated or prolonged by their work conditions. The primary functions of the hospital laboratory in the hospital are to perform analytic tests and procedures on body fluids and tissues taken from patients and to provide the results of these tests to physicians in order to confirm diagnosis determine prognosis or ascertain or assess the patient's treatment. The laboratory medical staff functions in an atmosphere of continual pressure from the responsibility of providing accurate and precise information with vitually no margin of error. Results must be carefully checked and rechecked by them since the responsibility for treatment of the patient depends on the reports issued from the laboratory *(Stricoff and Walters, 1995)*

Along with the risk of working daily with hazardous substances, laboratory personnel are also exposed to many ergonomic risk factors due to the nature of their work and the research they conduct (*Thomas, 2011*). Ergonomic risk factors for laboratory staff causing MSD consist of awkward and static postures, high repetition, excessive force, excessive reaching, compression or contact stress, Forceful or static exertions, lifting and pinch grip lifting, and repetitive motions affecting the comfort and productivity (*Wahlstro¨m, 2005).*

The laboratory workers are considered to be sedentary workers and often a time the stress involved with this job that can affect their musculoskeletal system causing its function to decline if ignored. The literature on medical laboratory hazards has largely centered on infections, this is partly because laboratory acquired infections tends to be more easily remembered than the hazardous events *(Skinhoj, 1974; Harrington, 1982),* its impact on musculoskeletal system are often ignored.

So, the aim of the study was to estimate the prevalence of work related musculoskeletal disorders among laboratory professionals.

Materials & Methods

The Manipal University ethical committee clearance was obtained before the study. The study conducted is a cross sectional survey of laboratory professionals (lab technicians, pathologists, microbiologists, biochemistry technologist) belonging to the Udupi district. The target sample size was the whole community of laboratory professionals in the selected district. Participants that were in the age group ranging in age from 19 to 60 years and having minimum experience of one year were included in the study. The subjects having history of unhealed fractures, recent dislocations, inflammatory arthritis, tumors, diagnosed psychiatric illness, recent traumatic soft tissue injuries,

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diagnosed disc lesion were excluded from the study.

A validated questionnaire pertaining to symptoms related to different body parts (neck, upper back, lower back, shoulder, elbow, wrist /hand, hip/thigh, knees, ankle/feet), demographic data and Occupational history was used to screen for symptoms.

Procedure: After identification of the subjects, informed consent was obtained following which**,** interviews were carried out using validated questionnaire to screen for the musculoskeletal symptoms during the previous 12 months in nine body regions (head/neck, shoulders, elbows, wrists/hands, upper back, low back, hips, knees and ankles/feet)**.** Demographic data, occupational case history like years of experience, number of hours at work etc. were also taken. All the data collected were analyzed by SPSS version 16 software and descriptive statistics was used to summarize the data.

Results & Discussion:

260 subjects were screened of which 10 were excluded (6- due to less than one year experience, 4- due to the diagnosed disc lesion).

Table 1: Demographic characteristic of the participants

Variables	Mean (SD)
Age, years	30.64 ± 9.89
No. of hours in a day at work	6 (median) 9 (interquartile range)
Duration of experience, yrs	8.13 ± 1.88 (mean±SD)
Gender	Female 73.6% Male 26.4 %
Involvement in Physical activity	No-78.4% Yes-21.6%
Perception of their general health	Good-85.2% Fair-13.6% Poor-1.2%

A total of 250 subjects participated in the study. Table 1 shows the details of demographic characteristics of the participants.

Looking at the prevalence among 250 subjects, it was found that 21.2% participants were observed to suffer from musculoskeletal symptoms in various regions of the body. Further analysis revealed that 8% of the subjects reported neck pain and 6.8% of the subjects suffered from lower back complain indicating relatively greater prevalence of symptoms in neck and upper back region. Tables 2 and 3 enlist the prevalence rates of symptoms in various body regions as well as distribution based on type of laboratory profession.

Table 2:

Laboratory profession	Number of subjects with musculoskeletal complaints
Laboratory technician	44
pathologist	6
Microbiologist	1
Biochemistry profession	2

62.2% of the subjects reported, work to be the prime reason for their complaint as they had to use the microscope as well computer to document the report for maximum number of time in their working hours. Regarding the nature of complain 45.2% of the subjects labelled their discomfort as stiffness around the respective body region. 98% of subjects had been on sick leave during the previous year for a median of 4 (mean = 6) days. The change in their ability to work because of specific musculoskeletal complaint graded on 0-10 point scale, where 0 is no change

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and 10 is the extreme change, 66% of subjects with musculoskeletal complain graded their ability to work between 1 to 3 which is indicative of minimal change in the ability.

In the present study although maximum subjects (85.2%) perceived their general health to be good, 21.2% of the participants had reported musculoskeletal symptoms. The mean age of the participants in the present study was 30.64±9.8 yrs which show that this problem is being experienced by many young technicians. This observation is similar to the findings of *Florian et al (2012)* who argued against a mere aging effect of this disorder, and also underlines the importance of addressing this problem not only on middle aged to older employees but in the younger ones, at an early stage in their career. Similar to the study reported by *Florian et al (2012)*, female gender was predominant in our study, 83% of the subjects with musculoskeletal complaint were observed to be females. It was further observed that, average number of hours they were involved in their work were 8.13±1.8 which itself could be a major contributing factor in getting musculoskeletal symptoms in this population. More so 78.4% of the participants were not involved in any kind of physical activity. Lack of physical activity may have had an impact on their fitness level which might have contributed to the cause of complaints among this population.

In the present investigation prevalence of neck complaint was found to be 8%. The main reason for neck symptoms could be the static posture adopted by neck during laboratory work which is support the view expressed by *George (2010)* in a study stating strong evidence that high levels of static contraction, prolonged static loads, and awkward postures involving the neck and shoulder muscles were associated with an increased risk for MSDs. Many studies linking static postures/static loads with "tension-neck syndrome" were cited by him (odds ratios were greater than 3.0 and statistically significant). Emphasis therefore must be placed on the term static because most of us do not intuitively associate sitting in a chair for prolonged intervals with tissue injury.

Lower back complaint also found with 6.8% prevalence in the present study. The neck and back muscles truly are involved while sitting down and viewing slides at the microscope or staring at a computer; this has been confirmed by surface electromyography *(Falla, 2004).* This could be the reason for observing higher percentage of symptoms in neck and lower back in the present study. Further 83.01% subjects were laboratory technicians who reported musculoskeletal complaints. This can be explained by the fact that they are mainly involved in clinical work and most of the clinical load is borne by them unlike the pathologist or microbiologist who are involved in teaching also. 66% of subjects with musculoskeletal symptoms in our study graded their ability to work between 1 and 3 which is indicative of minimal change in their ability. As this study was questionare interview based, during interview many subjects might have perceived these symptoms as part of their daily work pattern and were trying to ignore it, the reason could be lack of awareness about serious impact of these musculoskeletal symptoms on their health.

Strength and Limitation of the study: As the study adopted face to face interview

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method for collecting data so it is more reliable which can be considered as the strength of the study. As analysis of the perceived load and stress based on the various tasks and time spent in various tasks during work that might have thrown light on to the specific posture or activity predisposing to symptoms so further detail evaluation of these components are indicated in future research.

Conclusion; This study noted that prevalence of work related musculoskeletal disorder among medical laboratory professionals is 21.2%. The results suggest that practicing medical laboratory professionals are at high risk for the development of MSDs related to cumulative trauma. Thus, it is recommended that there exist the need for evaluation of laboratory professionals. Also, laboratory professionals are strongly encouraged to adopt preventive measures before symptoms develop as well as physical activity promotion.

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Effect of Fatigue on Kinesthetic Acuity of Healthy Ankle

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Abstract

The purpose of this study was to determine the effect of fatigue on kinesthetic acuity of (Ankle) the gastrocnemius through a dynamic fatiguing protocol in dorsiflexion and plantar flexion of the ankle. Participants: 100 healthy college students volunteered for the study. Subjects meeting any of the following exclusion criteria were excluded from the study: (1) prior history of multiple ankle sprains, (2) an ankle sprain or ankle injury within the last six months, (3) any knee or ankle surgery within the past year, (4) any neurological or central nervous system deficits (5) taking any medication which might affect the nervous system. Main Outcome Measures: The researchers expected that there would be a significant difference in absolute error between the non-fatigued and fatigued condition at both 10º of dorsiflexion and 20º of plantar flexion. Results: There was significant main effect of fatigue on kinesthetic of healthy ankle. Conclusion: The results of this study indicated that there was significant difference between the non-fatigued and fatigued conditions at 10º of dorsiflexion and 20º of plantar flexion measurements.

Key Words: Kinesthetic Acuity; Fatigue; Ankle; Dorsiflexion; Planter flexion

Introduction

Kinesthetic acuity is defined as ability of perception of one's own body part, weight and movement or the ability of a person to sense by which position, weight and movement are perceived *(Mosby, 2009).* Proprioception is defined as the awareness of posture, movement, and changes in equilibrium and the knowledge of position, weight and resistance of objects in relation to the body. It is derived from a complex array of information arriving at the brain from several different sources including the muscle spindle, joint capsule, joint ligaments, skin, fat pads, and possibly the joint cartilage and/or subchondral bone. The individual contributions of the various components of proprioception are not well understood, although historically the joint capsule and ligaments were thought to be the major contributors. If indeed the joint capsule and ligaments are the principle contributors to proprioceptive input, it might be expected that persons with damage to their joint capsules or ligaments might have proprioceptive deficits. Joint position sense is a vital component of proprioception. Joint position sense is the body's conscious awareness of joint position and movement resulting from the proprioceptive input to the central nervous system *(Docherty et al, 1999).* Joint position sense is determined by muscle spindles and skin receptors (*Forestier et al, 2002).* There have been numerous studies

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measuring joint position sense in the lower *(Hertel et al, 1996; Bernier & Perrin, 1998; Forestier et al, 2002)* and upper extremity *(Johnston et al, 1998; Hertel, 2000)* using a dynamometer. These studies have indicated that joint position sense may be affected by anesthetic injection (*Bernier & Perrin, 1998)* and muscle fatigue in the lower *(Forestier et al, 2002)* and upper *(Myers et al, 1999)* extremities. Fatigue can be defined as undergoing both a metabolic and a neuromotor process. The neuromuscular component of fatigue is dependent on many factors, including stimulation parameters such as frequency, duty cycle, and activation pattern *(Ding et al, 2002)*. There are two types of neuromotor fatigue, central fatigue and peripheral fatigue *(Bernier & Perrin, 1998. Ding et al, 2002)*. Central fatigue is associated with reduced recruitment of new motor units or decreased firing frequency of the active units, or both *(Bernier & Perrin, 1998. Ding et al, 2002)*. Peripheral fatigue results from a decrease in the efficiency of the contractile units of the muscle Neuromuscular fatigue may involve a decrease in motoneuron output or desensitization of type III and type IV muscular afferents *(Yaggie & McGregor, 2002).*

Materials & Methods

A convenient sample was taken from Prem Institute of Medical Sciences, Panipat. 100 subjects were taken which were equally divided into two groups with 50 males and 50 females in each group which were young group of non sports activity. The subjects were explained about the procedure (fatigue protocol) and then allowed a practice for time of 5 minutes. Both groups followed the same procedure. During the practice time, as in the test time, subjects removed their shoes and socks. The dominant leg was determined by asking the subject which leg they preferred to kick a soccer ball as done in many earlier studies *(Ochsendorf et al, 2000; Sekizawa et al, 2001; Forestier et al, 2002)*. The subjects were then tested for degrees of movement using Baseline Electric goniometer at 20° of plantar flexion and 10° of dorsiflexion in the non-fatigued state. Intermediate range of motion for plantar flexion and dorsiflexion were selected rather than the end range of motion. For our study Golgi Tendon Organs and muscle mechanoreceptors, which are activated at the intermediate range of motion, are of more concern rather than the articular receptors which are activated at the end ranges of motion. Subjects were then allowed a five-minute break prior to starting the fatiguing protocol in which the subjects were allowed to stretch their gastrocnemius if they so desired. The subjects were then asked to stand on their tiptoes until they could no longer hold such a position. When fatigue was reached the subjects underwent a fatigued state kinesthetic acuity test using the same test angles in the same order. The amount of time from the end of the fatigue protocol to the beginning of joint position sense measurement was not greater than 60 seconds. Each test angle was tested only once in the fatigued and non-fatigued state.

Results & Discussion

The results demonstrate that there is significant effect of fatigue on kinesthetic acuity of healthy ankle. There is a significant effect of fatigue on kinesthetic acuity of healthy ankle in the Female group

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which demonstrated a change in dorsiflexion and plantar flexion range of motion after fatigue protocol i.e. non fatigue ankle dorsiflexion range of motion was 9.26 and fatigue ankle dorsiflexion range of motion was 9.28 whereas Non fatigue ankle plantar-flexion range of motion was observed to be 20.00 and fatigue ankle plantar flexion range of motion was 20.00. There was also a significant effect of fatigue on kinesthetic acuity of healthy ankle in the Male group which demonstrated a change in dorsiflexion and plantar flexion range of motion after fatigue protocol i.e. non fatigue ankle dorsiflexion range of motion was found to be 9.86 and fatigue ankle dorsiflexion range of motion was 9.88 whereas Non fatigue ankle plantar-flexion range of motion was 20.00 and fatigue ankle plantar flexion range of motion was 20.00. It was further found that there was greater magnitude of significant effect of fatigue on kinesthetic acuity in males as compared to females i.e. fatigue dorsiflexion range of motion of ankle of males is 9.88 and fatigue dorsiflexion range of motion of ankle of females is 9.28.

Groups	Mean +_ SD	t-value	P value
Non Fatigue Ankle DF	**9.26+-1.07**	**-1.00**	**<0.05**
Fatigue Ankle DF	**9.28+_0.83**		
Non Fatigue Ankle DF	**9.86+-0.34**	**-1.00**	**<0.05**
Fatigue Ankle DF	**9.88+-0.34**		

Yaggie & McGregor (2002) used a Cybex dynamometer in their protocol and fatigued the ankle in all four directions, inversion, eversion, plantar flexion and dorsiflexion. They were observing the effects of isokinetic ankle fatigue on the maintenance of balance and postural limits. The speed was set at 60° per second and fatigue was achieved when three consecutive repetitions fell below 50% of maximum joint torque *(Wilkerson & Nitz, 1994)*. It was concluded that isokinetic fatigue of ankle plantar flexors and dorsi flexors significantly influences sway parameters and ranges of postural control in healthy young men. These perturbations are transient, and recovery occurs within 20 minutes *(Wilkerson & Nitz, 1994)*. *Forestier, et al (2002)* used a dynamometer and subjects hold at least 70% of their maximum voluntary contraction for 40 seconds followed by 40 seconds rest. Subjects were considered fatigued when they could no longer produce 70% of their maximum voluntary contraction for 15 seconds or more. In this study the results indicated that the acuity of the position sense at the ankle is reduced subsequent to a fatigue protocol. With fatigue, subjects produced ankle movements characterized by greater absolute errors for movements of large amplitude in dorsiflexion and for movements of small amplitude in plantarflexion.

Groups	Mean +_ SD	t-value	P value
Non Fatigue Ankle PF	**20.00+-000**	**0.00**	**<0.05**
Fatigue Ankle PF	**20.00+-000**		
Non Fatigue Ankle PF	**20.00+-000**	**0.00**	**<0.05**
Fatigue Ankle PF	**20.00+-000**		

However, in our study fatigue was determined by the subjects. Therefore, a perceived fatigue may have occurred and not an actual fatigue. The technique, when performed correctly, was reliable in inducing a real state of fatigue. In previous

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studies using this protocol it was stated that in order to ensure a real fatigued state the testing protocol must begin within one minute of fatigue *(Vuillerme et al, 2001; 2002)*. In the protocol actually took place in under 40 seconds of fatigue. However, not all subjects may have been experiencing a real state of fatigue. Some may have perceived that they were fatigued, when in fact they might have only been experiencing minor discomfort. Previous studies have indicated the use of repeated bouts of this protocol due to multiple trials of their testing procedure *(Vuillerme et al, 2001; 2002)*. The subjects in this study only performed one trial of this fatiguing protocol based on our procedures perhaps the protocol did induce a real state of fatigue, but since subjects were healthy one can only speculate that the muscle mechanoreceptors were not affected. The angles that were tested may play an important role in determining significance. The angles of 10º of dorsiflexion and 20º of plantar flexion were near the midpoint of the normal physiological ranges of motion for the ankle. Using angles that are at the mid-range or just past the mid-range may yield significant results. The mechanoreceptors that are located in the muscles and tendons have shown to be most effective at determining conscious awareness of joint position sense at the mid-range of motion *(Wilkerson & Nitz, 1994; Luttgens & Hamilton, 1997; Vuillerme et al, 2002)*. It has been reported that there is no evidence that articulator (joint) receptors of any joint are important in the conscious awareness of joint position sense *(Wilkerson & Nitz, 1994)*. Muscle spindles are believed to be the best suited for conveying conscious awareness of joint position sense. Therefore, if the angles selected were closer to the mid ranges of motion it may be assumed that significant results may have been found. The failure of anesthesia of the joint and cutaneous afferents disrupting conscious kinesthesia and joint position sense provides further support for the importance of muscle receptors in conscious proprioception (*(Wilkerson & Nitz, 1994)*. In this study the mid ranges of motion were tested to eliminate the cutaneous receptors that are activated at the beginning ranges of motion. Through testing the intermediate range of motion proprioceptive input from type III and IV joint receptors, that detect joint movement and joint position sense at the end range of motion, was eliminated (*Luttgens & Hamilton, 1997)*. We further eliminated cutaneous receptor activity by covering the foot with an elastic foam strap *(Docherty et al, 1999)*.

Conclusion: The study was on the effect of fatigue on kinesthetic acuity on the healthy ankle the results of our study conclude that there is significant change in absolute error in an active angle reproduction test at 10º of dorsiflexion a non-fatigued and fatigued condition but there is no significant change in absolute error in an angle reproduction test at 20° of plantar flexion. There are many other variables that can affect joint position sense in the lower extremity. Those subjects with chronic ankle instability have impaired joint position sense due to the disruption of joint mechanoreceptors while healthy subjects have no such impairment. In our study only the mid-range of the physiological range of motion was tested. This is the range of motion in which joint position sense is detected by muscle mechanoreceptors.

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The Impact of Open Patella Knee Cap and Designed Off-Loader Valgus Knee Brace on Muscle Activity Patterns and Joint Loading during Walk In Normal Adult – A Pilot Study

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Abstract

Objective: To assess the biomechanical impacts of open patella knee cap/sleeve and designed polycentric off-loader knee brace on knee joint movement during gait in normal adult. *Method:* Quantitative assessment for the pressure changes of strain gauges of muscles around the knee joint during normal gait with & without knee cap & brace are recorded in MATLAB and further analyzed. *Results:* The application of open patella knee cap reduces co-contractions in magnitude of lateral hamstring pair and increases those of medial hamstring pair. Contrary to it when exposed to offloader valgus knee brace same subjects had significantly vastus lateralis -lateral hamstring co-contractions greater in magnitude than those of vastus Medialis-medial hamstring. *Conclusion:* The application of open patella knee cap/sleeve without hinge joint and designed offloader knee brace attempt to redistribute the load laterally or medially respectively as needed in context to demand in normal adult.

Key words: Offloader brace, Knee Sleeve, Strain gauge sensor, Muscular loading, Gait

Introduction

The concept of unloading the affected compartment by bracing aims to correct the mechanical axis deviation. American *Academy of Orthopaedic Surgeons (1999)* classified knee braces into prophylactic, functional and rehabilitative categories. According to *Burger (1995)* the prophylactic knee braces protect or reduce severity of knee injuries from valgus stress to protect medial collateral ligaments. *Wojtys (1996)* identified that functional knee brace provide stability for ligamentous knees instability and control some degree of external knee rotation & AP joint translation. Rehabilitative braces allow protected & controlled movements in injured knees. Patello-femoral braces improve patellar tracking moderately and thereby relieve anterior knee pain (*Maurer et al, 1995; Paluska & McKeag, 2000*). They also found that unloader / offloader braces provide pain relief in osteoarthritis (OA) knees.

Harrington (1983) study indicated that varum deformity knees had a predictable loading pattern or location of centre of pressure than valgum deformity knees and hence is easily compensated. The study also found that valgus braces reduce medial compartmental loading, pain and improve the performance in subjects. The

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little change in alignment shortens the moment arm and hence lowers the external adduction and varus moment. The compressive load is shifted away from medial compartment and thus redistributes compressive load over joint surfaces. This assists to alleviate mechanical stress on the medial compartment of knee joint (*Cole & Harner, 1999*).

In off loader/unloader brace, additional valgus forces were generated by the subjects' muscles through the helical straps of the brace from one anatomical plane to another. This reaction forces on subjects leg create a resistance in flexion plane and significantly prevents full extension. The restriction in flexion motion, unload subjects' medial compartment. *Davidson et al (1997)* study showed that the dynamic forces of the hinges in the brace contribute to internal rotation of shank of tibia during extension and external rotation during knee flexion. In a similar study, it was observed that dynamic straps of an unloader brace shares the load at the knee joint. *Pollo et al (2002)* study calculated using a mathematical/computer model and reported the decreased stress in the medial knee compartment with an unloader brace.

The unloader brace improves knee stability, decreases co-contraction of thigh and leg muscles and relieves pain. It reduces compressive forces across the joint rather than direct compartment off-loading (*Ramsey et al, 2007*). The off-load shelf prophylactic knee braces provide 20-30% greater knee ligament protection (*Mortaza, 2012*).

In the normal structural abnormalities of genu varum or genu valgum, quadriceps femoris muscle especially vastus medialis oblique function is affected that limit ability to provide dynamic postural stability. According to *Nyland (2002)* study patello-femoral pain is common in those with extreme patellar tilt and lateral shift &; *Moller et al* (*1987*) stated that activation of vastus medialis obliqus is delayed compare with other quadriceps muscles and this reduces the lateral force by 25% in patellar pain syndrome patient.

The muscle response in gastrocnemius, hamstrings and quadriceps femoris are slowed significantly after fatigue. In physically demanding sports the muscle fatigue is commonly seen to alter the neuromuscular response to anterior tibial translation. The average increase of 32.5% in anterior tibial translation is seen after fatigue (*Wosjys et al 1996*) & this affects the dynamic stability of the knee. Thus, fatigue plays important role in knee injuries and its patho-mechanism.

Mediation of muscles for even distribution of load across the joint is needed for normal gait biomechanics (*Shakoor & Moisio, 2004*). So, the measurement of the muscle activation pattern and dynamic joint loading patterns helps to evaluate the extent of abnormal joint loading and alterations in the neuromuscular system in OA knee subjects (*Childs et al, 2004*).

The neuromuscular system is not effectively challenged in static positions compared to dynamic condition during the activities of daily living and sports. Majority of dynamic sport activities precisely assess single limb activities as landing force movement. The different studies (*Colby et al, 1999; Webster & Gibble, 2010 &; Yayaei-Rad et al, 2013*) showed that during dynamic task the genu-varum increases dynamic postural stability index and decreases the dynamic balance. Moreover strength, stability and balance

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are essential for protection and prevention of joint health.

During normal ambulation the force transmitted on the medial and lateral compartments of the knee is different. *Kuroyangi et al* (*2007*) study indicates that the loads on the medial compartment are 2.5 times more than the lateral compartment of the knee. There are more other studies indicating the similar concept. Also, the study found that the healthy subjects transmit 71% to 91% of total knee force through tibio-femoral compartment compared to 100% in OA. Thus, force augmentation may be a contributing factor in the development of knee OA (*Esrafilian et al, 2012*).

Published studies on the use of knee braces in OA, report biomechanical outcomes relating changes in the joint movement and posture, however a few reporting patient-derived outcomes. In summary, unloading braces may be a valid option for selected patients.

Materials & Method

The subjects were asked to walk on a level surface with and without open patella knee cap and offloader valgus knee brace to investigate the influence of orthosis on the knee alignment. Ethical approval was taken from Institute Ethical Committee, Banaras Hindu University before starting the data collection. The subjects were asked to sign a consent form and were familiarized with the study procedure.

Thirty active normal adult males participated in the pilot study. Normal male Subjects demographics are provided as (Age, 24.73±1.85 yrs; Height, 169.66±3.97 cm; Weight, 66.07±2.89 kg and BMI, 23.08±0.74) based on their grouped knee alignment, normal knee (n=14) , genu varum (n=10) and genu valgum (n=6). The knee angle was measured using a goniometry.

Exclusion criteria of study were sport injury/traumatic knee, inflammatory arthritis and metabolic disorders; along with any vestibular, proprioceptive or visual impairment.

Each subject was exposed to two interventions: (1st) Open patella knee cap and (2nd) Designed polycentric knee brace. Assessment variables have been six muscles around the knee joint (see data collection procedure below).

Our designed polycentric unloader knee brace had a modular structure to change the alignment based on the patient's need and could reduce the pressure at knee joint, which could be corrected to 10^0 valgus and more according to the need. Steel alloy was used instead of regular aluminum material, so that if molding is needed subject can correct according to abduction/ adduction pressure changes. This helped to have subject franchise custom made orthosis as tailor made one and does not have to wait for an orthotic's to rectify it.

Data collection procedure:

The muscular loading was assessed using strain guage sensor; with and without knee sleeve and offloader valgus knee brace of specific muscles viz. vastus-medialis (VM), vastus-lateralis (VL), semi-membranosus/ tendinosus (SS/ST), bicep femoris (BF), gastro-soleus (GS) and tibialis anterior (TA) muscles in a three minutes level walk.

Mechanical design incorporated a spring steel strip of length 10cm x 1cm to which strain gauges were fixed and the tip of strip acted as a mechanical pressure transducer to transfer the muscular loading to the system. The pressure changes of

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strain gauges in volts were captured by the differential amplifiers, which were then fed to the ADC (Analogue digital convertor) of the PIC 18F4550 microcontroller. It was finally transferred to the system via USB interface of PIC18F4550. These digital values from ADC's were received by MATLAB. The final signal processing was finally done in MATLAB. These values were recorded further and analyzed. (Data of Tables 1 & 2 shown as graph in Matlab *(Figs.1 & 2)* of same patient respectively).

Table 1: Comparative data of specific muscles of an individual subject with and without knee sleeve

Muscle variables	With knee sleeve (mean in volts)	Without knee sleeve (mean in volts)
Gasrocnemius-Soleus(GS)	11.06	9.81
Lateral Hamstrings (LH)	7.28	7.48
Medial Hamstrings (MH)	7.63	7.48
Vastus Laterals (VL)	4.38	4.50
Vastus Medialis (VM)	4.70	4.50
Tibialis Anterior (TA)	1.30	1.31

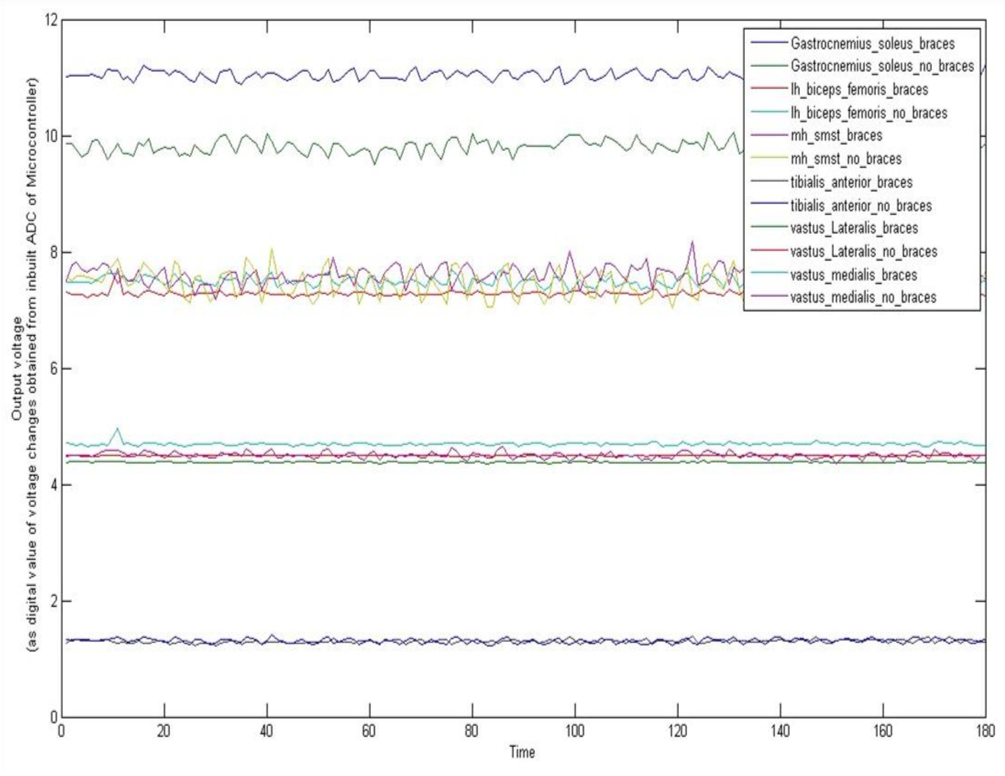

Figure 1: Comparative picture of specific muscles of an individual subject with and without knee sleeve

Table 2: Comparative data of specific muscles of same subject with and without off-loader knee brace

Muscle variables	With knee Brace (mean in volts)	Without knee brace (mean in volts)
Gasrocnemius-Soleus (GS)	11.63	10.42
Lateral Hamstrings (LH)	7.16	7.50
Medial Hamstrings (MH)	7.86	7.51

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Vastus Laterals (VL)	4.27	4.50
Vastus Medialis (VM)	4.71	4.50
Tibialis Anterior (TA)	1.04	1.06

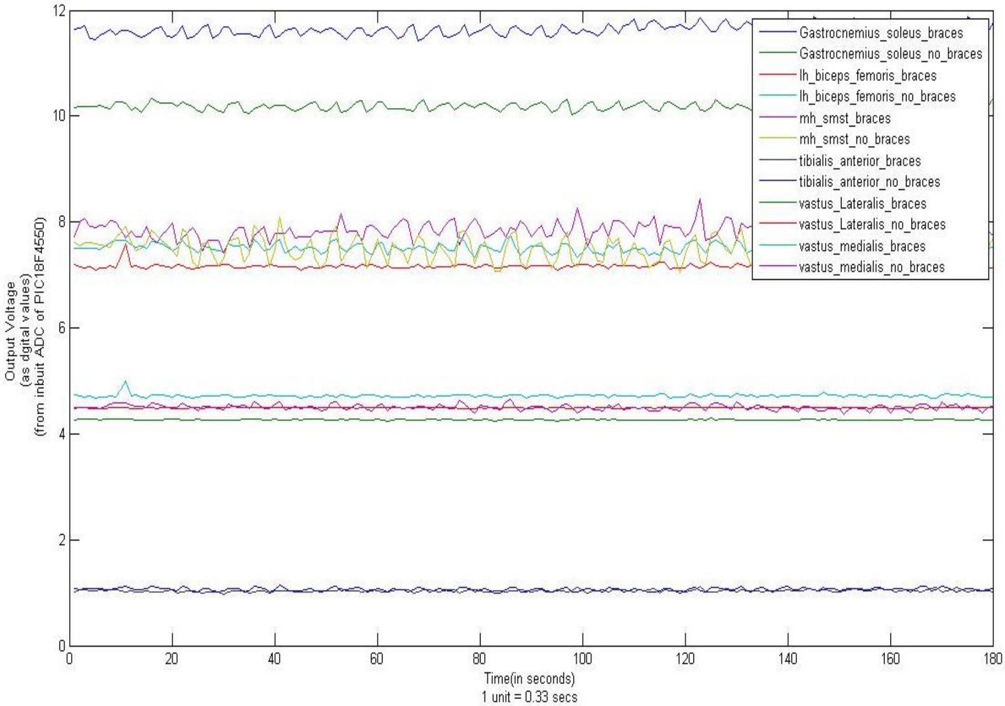

Figure 2: Comparative picture of specific muscles of same subject with and without off-loader knee brace

Table 3: Comparative efficacy of knee sleeve and valgus knee brace among loading muscles around the knee joint of normal adults (in volts)

Loading Muscles	With open patella knee cap (A) (mean±SD)	Without knee cap (A1) (mean±SD)	Paired T-test (A-A1)	With valgus knee Brace (B) (mean±SD)	Without Brace (B1) (mean±SD)	Paired T-test (B-B1)
Gasrocnemius (GS)	11.02 ±0.45	9.98 ±0.14	*15.76	11.30±0.25	10.04 ±0.09	*35.21
Lateral Hamstrings, (LH)	7.23 ±0.10	7.50 ±0.03	-*16.26	7.50±0.01	7.12 ±0.06	*40.69
Medial Hamstrings (MH)	7.78±0.05	7.51±0.03	*26.85	7.50±0.02	7.90 ±0.06	-*41.11
Vastus Laterals (VL)	4.37±0.04	4.50±0.01	-*16.39	4.50±0.01	4.27 ±0.02	*58.98
Vastus Medialis (VM)	4.65±0.05	4.50±0.01	*16.52	4.50±0.01	4.73 ±0.02	-*52.50
Tibialis Anterior (TA)	1.10±0.10	1.12±0.10	-*8.59	1.25±0.28	1.28 ±0.29	-*9.06

*Note: Significance (2 tailed): *P<0.005*

Table 4: Independent T-test of muscle variables with and without knee sleeve and valgus knee brace

Variables	Group	Mean ± SD	T- test	Significance
GSNB	Knee sleeve	9.98±0.14	1.835	0.072
	Knee valgus brace	10.04±0.09		

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GSB	**Knee sleeve**	**11.02±0.45**	**3.027**	**0.004**
	Knee valgus brace	**11.30±0.25**		
LHNB	**Knee sleeve**	**7.50±0.03**	**34.135**	**0.000**
	Knee valgus brace	**7.12±0.06**		
LHB	**Knee sleeve**	**7.23±0.10**	**15.369**	**0.000**
	Knee valgus brace	**7.50±0.01**		
MHNB	**Knee sleeve**	**7.51±0.03**	**34.656**	**0.000**
	Knee valgus brace	**7.90±0.06**		
MHB	**Knee sleeve**	**7.78±0.05**	**26.430**	**0.000**
	Knee valgus brace	**7.50±0.02**		
VLNB	**Knee sleeve**	**4.50±0.01**	**60.685**	**0.000**
	Knee valgus brace	**4.27±0.02**		
VLB	**Knee sleeve**	**4.37±0.04**	**18.205**	**0.000**
	Knee valgus brace	**4.50±0.01**		
VMNB	**Knee sleeve**	**4.50±0.01**	**50.238**	**0.000**
	Knee valgus brace	**4.73±0.02**		
VMB	**Knee sleeve**	**4.65±0.05**	**15.968**	**0.000**
	Knee valgus brace	**4.50±0.01**		
TANB	**Knee sleeve**	**1.12±0.10**	**2.798**	**0.007**
	Knee valgus brace	**1.28±0.29**		
TAB	**Knee sleeve**	**1.10±0.10**	**2.763**	**0.008**
	Knee valgus brace	**1.25±0.28**		

Note: NB (no brace); B (brace)

Data decoding and Statistical analysis: MATLAB (ver. 6.1, Math Works Inc.) was used to process data. Data was organized in Excel sheet (2002, Microsoft Corp.) and the statistics were conducted using SPSS (ver. 16.0, SPSS Inc.). A paired T-test was done to examine the difference between the mean values of muscular loading between without and with bracing in normal adults. A significance level of < 0.05 was considered for this analysis. Independent T- test was also done to examine the efficacy of open patella knee cap and offloader valgus knee brace. Comparative efficacy of knee sleeve and valgus knee brace among loading muscles around the knee joint of normal adults (in volts) is presented in Table-3. The application of knee sleeve in the study revealed GS, MH and VM increased while LH, VL and TA decreased. Thus, VL-lateral hamstring co-contractions were lesser in magnitude than those of VM-medial hamstring pair. This represents an attempt to redistribute the load medially (A & A1). On the contrary the application of offloader knee brace revealed that GS, LH and VL increased while MH, VM and TA decreased. Thus, the study indicates that vastus medialis-medial hamstring co-contraction was found to be of lesser in magnitude than those of vastus lateralis-lateral hamstring pair. It improvises loading on medial compartment of knee (B & B1). A paired t test indicates 2 tailed significance of each 6 variables with and without knee brace/ cap at P<0.005 level.

Independent t-test of different variables between two interventions i.e. knee sleeve and offloader valgus knee brace (with and without) was found to be highly significant except values of Gastrocnemius without knee sleeve and brace which have been insignificant (Table 4).

Discussion

A few researchers have assessed the effect of brace on muscle activity. The evidence suggested that off-loading braces may influence antagonist muscle co-

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contractions. In the study by *Ramsey et al* (*2007*), sixteen subjects with radiographic evidence of knee malalignment and medial compartment OA were recruited and fitted with a custom Generation II unloader brace, found that VL-lateral hamstring co-contractions were greater in magnitude than those of VM-medial hamstring. Also, *Andriacchi (1994) & Schipplein et al (1991)* studies stated that the VL greater contraction attempt to redistribute the load laterally. In *Ramsey et al* (2007) study, during neutral and valgus brace settings the co-contraction of VL-lateral hamstrings was reported to be significantly reduced from baseline in both the neutral ($p = 0.014$) and valgus conditions ($p = 0.023$); which resulted in decreased joint compression. In the present study, the subjects being non impaired adults, VL-lateral hamstring co-contractions were lesser in magnitude than those of VM-medial hamstring. Though the difference of both pairing being meager; the application of open patella knee sleeve may represent an attempt to redistribute the load medially and reflective of more stability and strength. This is in consistency with the findings of *Maurer et al* (*1995*). In the present study, the same subjects when exposed to offloader valgus knee brace had VL-lateral hamstring co-contractions greater in magnitude than those of VM-medial hamstring. This expresses an effort to re-distribute loading on the medial compartment of the knee. It will help to protect genu varum aligned normal adults as prophylactic measure and can be advocated for medial compartment OA knee persons. This study is an attempt to investigate clinical application of knee braces as indicated in a study by *Hinmann et al (2007)* which reveals that knee braces that realign knee joint in varus (our result of open patella knee brace) are opposed to those that realign in valgus direction (offloader knee brace). This is the main consistent to this study.

Polycentric offloader knee brace designed by us is 5^0-10^0 valgus and hence influence moment applied on the knee joint i.e. the magnitude of the medio-lateral force and moment arm. The resultant adduction moment applied on the knee joint decreases significantly, as that in the study by *Esrafiliaan et al* (*2012*). Few researchers (*Beynnon, 1992; Ott & Clancy, 1993; Wojtys, 1996*) observed that unloader brace compensate a portion of external load and AP joint rendition. Improvement in the medio-lateral force and the knee joint alignment decreased following use of the knee orthosis is important finding of this study. *Divine & Hewett* (*2005*) also informed that orthosis improve the knee stability in knee OA patient. However, *Niyousha et al* (*2013*) *& Singer* (*2008*) studies found that the examined functional knee brace/ sleeves had no significant effect on the knee muscle performance. *Beaudreui et al* (*2009*) study revealed that flexion and extension torques of knee and other joints of the lower limb were not significantly different between brace and non-braced conditions. In addition to this, there were no statistically significant differences between the brace and sleeve. They also, reported that knee sleeves decreases pain but can’t be effective for knee disability.

Pollo et al (*2002*) using strain gauges and buckle transducers affixed on the custom braces in 4-8^0 valgus setting on eleven patients using three-dimensional gait analysis & reported the compressive load reduction in the medial compartment

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significantly by as much as 20% at 8^0 adjusting valgus angulation from normal 4^0 to 8^0. Even normal 4° valgus alignment via the adjustable hinge reduces medial compartment load than increasing tension of straps. Measurement of medial compartment load reduction has been estimated indirectly. The net varus moments were reduced using valgus brace by 11% (7.1 N-m) and load reduction was 17% on the medial side during stance phase of the gait in normal 4^0 valgus setting. The mean maximum value of the orthotic valgus moment was 0.053 Nm/kg, which represents approximately 10% of the external genu varus moment without the brace. This outcome may explain the pain relief reported by patients using such braces in clinical studies.

Anderson et al (*2003*) study using pressure transducer inserted on the medial compartment of OA knee of 11 subjects measured unloading during walk using valgus unloader knee brace but could not found unloading although there were large variations in force output, as a consequence of transducer shifted position.

Studies on the knee brace suggest full benefits are achieved between 1-2 months and doubtful beyond 6months. *Matsuno et al* (*1997*) recommended knee bracing up to 12months for subjects awaiting knee surgery and those with pharmacological risks.

Conclusion: The results of this study, suggest that knee sleeve may redistribute the load medially while polycentric offloader knee brace laterally thus, provide unloading knee in frontal plane and may decrease or increase respectively dynamic balance during sport activity as needed in context to demand in normal adult. The subjects without it might be at risk of injury during sport activity due to the reduced balance deficit.

The offloader valgus knee brace will help to protect genu varum aligned normal adults while knee sleeve will provide support to genu valgum and sport persons. The selected prophylactic brace in this study significantly inhibit athletic performance which might verify that their structure and design have caused limitation in the normal function of the knee joint but for a trance phase and enhance capability for better sports. The biomechanical indication and limitation of the off loader knee brace should be confirmed by a larger study as prophylactic measure and can be advocated for medial compartment OA knee persons.

Limitation of this study was that we have only assessed the effects of knee sleeve and offloader valgus brace on the knee joint load bearing function in normal adults. Further studies with off loader brace may be helpful to investigate the interaction and compensation of the knee joint during aging process and age related compensation in larger study group.

Better insights into normal and abnormal joint mechanics will continue to play a critical role in improved orthotic therapy and conservative treatment modalities more effective in the near future for prolonging the life of the natural knee joint.

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A Study of Anaerobic Power and Capacity of Football Players

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Abstract

The purpose of this study was to observe and report anaerobic power and capacity of football players. The design of this study required participants to perform six sprints each of 35 meter. Thirty six (N=36) male football players between the ages of 17 and 28 years volunteered for this study. The mean age, height and weight of football players was 21±2year, 172±6.81cm and 67.50±9.94Kg respectively. The mean sprint time of 1st,2nd,3rd,4th,5th and 6th sprint of football players was 5.50±0.39 seconds, 5.50±0.55 seconds, 5.57±0.56 seconds, 5.78±0.55 seconds, 5.83±0.59 seconds and 5.88±0.62 seconds respectively. The mean power generated during the 1st,2nd,3rd,4th,5th and 6th sprints by football players was 506.94±119.65 watts, 522.58±165.63 watts, 490.64±134.88 watts, 443.72±137.38 watts, 438.17±132.76 watts and 422.22±130.16 watts respectively. The maximum power, minimum power, average power and fatigue index of football players was 579.94±147.78watts, 376.00±111.66watts, 470.78±114.76watts and 6.00±3.45 respectively. It was concluded from the results of this study that sprint time increased, power declined with a high fatigue index, the football players may need to focus on improving lactate tolerance and this could be a focus of their training programme.

Key Words: Sprint time, Power, Anaerobic, Fatigue index

Introduction

However, often we think of football as a chiefly aerobic sport but in reality, it is the contrary *(Derek Arsenault, 2007).* When the sport of football activity is critically analysed, it can be understood that the game is played by the players performing at varying speeds and intensities; jogging, walking and sprinting. The greater part of play is in intervals and the motion does not last for long periods of time (e.g. chasing a lose ball, making a run into space etc.). This is the most significant factor to consider when doing football conditioning. There certainly is a need for aerobic conditioning as well, due to the fact that the intervals mentioned are repeated at various intensities and durations over the course of a ninety minute match. On the other hand, because of the nature of the sport, anaerobic conditioning should take up the majority of the cardiovascular conditioning *(Derek Arsenault, 2007).* The high level of the anaerobic capacities in football players enable them to carry out high-speed runs, which in the end may have a very important impact on match results *(Luhtanen, 1994).* Elite football players are capable of performing more high-intensity running than moderate professional football players. The players spend 1–11% of the game sprinting *(Bangsbo et al., 1991; Bangsbo 1992),* which represents 0.5–3.0% of effective time with ball in

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play *(Bangsbo, 1992; O'Donoghue, 2001).* For this reason, it is very important to incorporate anaerobic training into overall conditioning training protocols. Because the repeated sprint ability field tests show high reliability and validity *(Metaxas et al., 2005; Psotta et al., 2005),* high reproducibility, and sensitivity *(Krustrup et al., 2003),* they may represent a valid measure of anaerobic football performance. Sprint running times have been shown to be well correlated to peak and mean power output *(Patton & Duggan, 1987; Tharp et al., 1985).* The purpose of this study was to report the anaerobic power and capacity (i.e. speed, power and fatigue index) of Punjabi football players.

Materials and Methods:

Thirty six (N=36) male Punjabi football players between the age of 17 and 28 years volunteered for this study and each participant was required to perform six sprints each of 35 meter. A rest of 10 second was given to the participants between each sprint. *Draper and Whyte (1997)* developed the Running-based Anaerobic Sprint Test (RAST) to test a runner's anaerobic performance. RAST provides researchers/coaches with measurements on peak power, average power and minimum power along with a fatigue index. Participants were refrained from participating in any heavy physical activity (except activity of daily living) within 24 hours of the testing day. Little effort has been made in the literature to evaluate the effects of the training of sprint style in male football players. Hence, due to the lack of referring literature, this study utilized only male football players as participants. Table 1 shows the number and percent distribution of football players according to their playing positions in the present study. As per the playing positions of the football players, 44.4% (N=16) were back, 27.8% (N=10) forward, 25% (N=9) center and 2.8% (N=1) goalkeeper.

Table 1: Sample composition with respect to the playing position of footballers

Playing Position	N	Percentage
Forward	10	27.8
Centre	9	25.0
Back	16	44.4
Goalkeeper	1	2.8
Total	36	100.0

Statistical Analysis: Statistical analysis was performed with SPSS version 16.0 (free trial, SPSS Inc, Chicago). Results are shown as Mean and Standard Deviation. The alpha level for the data analysis was determined at $p<0.05$.

Results & Discussion

Thirty six healthy male football players (mean age 21± 2year) from Mata Gujri College, Sri Fatehgarh Sahib (Punjab) participated in the study. The mean height and weight of thirty six football players was 172.00±6.81 cm and 67.50±9.94Kg respectively (Table 2). The mean values of the time of -1st, 2nd, 3rd, 4th, 5th & 6th sprints of football players was 5.50±0.39 seconds, 5.50±0.55 seconds, 5.57±0.56 seconds, 5.78±0.55 seconds, 5.83±0.59 seconds and 5.88 ±0.62 seconds respectively (Table 2). From the six sprint times of 35 m sprint each, the power for each sprint run was calculated and then maximum power (highest value), minimum power (lowest value) and average power (sum of all six values ÷ 6) were determined The power was calculated using the equation: Power = Weight × Distance^2 ÷ Time^3 *(Draper and Whyte, 1997).* The mean values of power of the -1st, 2nd, 3rd, 4th, 5th & 6th sprints in case of football players was

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506.94±119.65W, 522.58±165.63W, 490.64±134.88W, 443.72±137.38W, 438.17±132.76W and 422.22±130.16 W respectively. In addition, the maximum power, minimum power and average power of football players was 579.94±147.78watts, 376.00±111.66 watts, and 470.78±114.76 watts respectively (Table 2). The Fatigue Index was calculated using the equation: (Maximum power - Minimum power) ÷ Total time for the 6 sprints *(Draper and Whyte, 1997).* The mean fatigue index of football players was 6.00 ± 3.45 (Table 2).

Table 2. Descriptive Statistics of male football players

Variables (N=36)	Mean	Std. Deviation
Age, year	**21**	**02**
Height, cm	**172.00**	**6.81**
Weight, kg	**67.50**	**9.94**
Sprint time-1,seconds	**5.50**	**0.39**
Sprint time-2,seconds	**5.50**	**0.55**
Sprint time-3,seconds	**5.57**	**0.56**
Sprint time-4,seconds	**5.78**	**0.55**
Sprint time-5,seconds	**5.83**	**0.59**
Sprint time-6,seconds	**5.88**	**0.62**
Power-1,watts	**506.94**	**119.65**
Power-2,watts	**522.58**	**165.63**
Power-3,watts	**490.64**	**134.88**
Power-4,watts	**443.72**	**137.38**
Power-5,watts	**438.17**	**132.76**
Power-6,watts	**422.22**	**130.16**
Maximum power, watts	**579.94**	**147.78**
Minimum power, watts	**376.00**	**111.66**
Average power, watts	**470.78**	**114.76**
Fatigue index	**6.00**	**3.45**

Table 3 shows the absolute and percent increase in time among six different sprint times. It was found that the maximum absolute and percent increase value of sprint time was 0.38 seconds & 6.90% (sprint time-1 vs. sprint time-6 and sprint time-2 vs. sprint time-6) followed by 0.33 seconds & 6.00% (sprint time-1 vs. sprint time-5 and sprint time-2 vs. sprint time-5), 0.31 seconds & 5.56% (sprint time-3 vs. sprint time-6), 0.28 seconds & 5.09 % (sprint time-1 vs. sprint time-4 and sprint time-2 vs. sprint time-4), 0.26 seconds & 4.66 % (sprint time-3 vs. sprint time-5), 0.21 seconds 3.77 % (sprint time-3 vs. sprint time-4), 0.10 seconds & 1.73 % (sprint time-4 vs. sprint time-6), 0.07 seconds 1.27 % (sprint time-1 vs. sprint time-3 and sprint time-2 vs. sprint time-3) and 0.05 seconds 0.86% (sprint time-4 vs. sprint time-5 and sprint time-5 vs. sprint time-6). Thus, it was observed that the time taken by the subjects for the completion of sprint-1 and 2 was minimum (5.50±0.39 seconds and 5.50±0.55 seconds) then there was an increase in the value of time for the subsequent sprint-3 (5.57±0.56 seconds), sprint-4 (5.78±0.55 seconds), sprint-5 (5.83±0.59 seconds) and sprint-6 (5.88±0.62 seconds). This may be due to more blood lactate production in the subsequent sprints in the football players that might have lead to fatigue in them.

Table 3.Mean ±SD of absolute & percent change in time for different sprints

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Variables	Mean±SD	Absolute	%percent
Sprint time-1 vs. time-2	**5.50±0.39 vs. 5.50±0.55**	**0.00**	**0.00**
Sprint time-1 vs. time-3	**5.57±0.56**	**0.07**	**1.27**
Sprint time-1 vs. time-4	**5.78±0.55**	**0.28**	**5.09**
Sprint time-1 vs. time-5	**5.83±0.59**	**0.33**	**6.00**
Sprint time-1 vs. time-6	**5.88±0.62**	**0.38**	**6.90**
Sprint time-2 vs. time-3	**5.50±0.55 vs. 5.57±0.56**	**0.07**	**1.27**
Sprint time-2 vs. time-4	**5.78±0.55**	**0.28**	**5.09**
Sprint time-2 vs. time-5	**5.83±0.59**	**0.33**	**6.00**
Sprint time-2 vs. time-6	**5.88±0.62**	**0.38**	**6.90**
Sprint time-3 vs. time-4	**5.57±0.56 5.78±0.55**	**0.21**	**3.77**
Sprint time-3 vs. time-5	**5.83±0.59**	**0.26**	**4.66**
Sprint time-3 vs. time-6	**5.88±0.62**	**0.31**	**5.56**
Sprint time-4 vs. time-5	**5.78±0.55 5.83±0.59**	**0.05**	**0.86**
Sprint time-4 vs. time-6	**5.88±0.62**	**0.10**	**1.73**
Sprint time-5 vs. time-6	**5.83±0.59 5.88±0.62**	**0.05**	**0.85**

Table 4. Mean ±SD of absolute & percent change in Power for different sprints

Variables	Mean±SD	Absolute	%percent
Power-1 vs. Power-2	**506.94±119.65 vs. 522.58±165.63**	**15.64**	**3.08**
vs. Power-3	**490.64±134.88**	**-16.3**	**-3.21**
vs. Power-4	**443.72±137.38**	**-63.22**	**-12.47**
vs. Power-5	**438.17±132.76**	**-68.77**	**-13.56**
vs. Power-6	**422.22±130.16**	**-84.72**	**-16.71**
Power-2 vs. Power-3	**522.58±165.63 vs. 490.64±134.88**	**-31.94**	**-6.11**
vs. Power-4	**vs. 443.72±137.38**	**-78.86**	**-15.09**
vs. Power-5	**vs. 438.17±132.76**	**-84.41**	**-16.15**
vs. Power-6	**vs. 422.22±130.16**	**-100.36**	**-19.20**
Power-3 vs. Power-4	**490.64±134.88 vs. 443.72±137.38**	**-46.92**	**-9.56**
vs. Power-5	**vs. 438.17±132.76**	**-52.47**	**-10.69**
vs. Power-6	**vs. 422.22±130.16**	**-68.42**	**-13.94**
Power-4 vs. Power-5	**443.72±137.38 vs. 438.17±132.76**	**-5.55**	**-1.25**
vs. Power-6	**vs. 422.22±130.16**	**-21.5**	**-4.84**
Power-5 vs. Power-6	**438.17±132.76 vs. 422.22±130.16**	**-15.95**	**-3.64**

Table 4 shows absolute and percent change in power for six different sprints of football players. It was found that the maximum absolute and percent increase value of power was 15.64 watts & 3.08% (Power-1 vs. Power-2). But it was found that the maximum absolute and percent decrease value of power was -100.36 watts & -19.20% (Power-2 vs. Power-6) followed by -84.72 watts & -16.71% (Power-1 vs. Power-6), -84.41 watts & -16.15% (Power-2 vs. Power-5), -78.86 watts & -15.09% (Power-2 vs. Power-4), -68.77watts -13.56% (Power-1 vs. Power-5), -68.42 watts & -13.94% (Power-3 vs. Power-6), -52.47 watts & -10.69% (Power-3 vs. Power-5), -46.92 watts & -9.56%

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(Power-3 vs. Power-4), -31.94watts & -6.11% (Power-2 vs. Power-4) -21.05watts & -4.84% (Power-4 vs. Power-6), -16.3watts & -3.21% (Power-1 vs. Power-3), -15.95watts & -3.64% (Power-5 vs. Power-6) and -5.55watts & -1.25% (Power-4 vs. Power-5). Thus, it was observed that the maximum value of power was 522.58±165.63watts for power-2 (i.e. during sprint-2) then there was a decrease in the value of power for the sprints i.e. power-1 (506.94±119.65watts), power-3(490.64±134.88watts), power-4 (443.72±137.38 watts), power-5(438.17±132.76 watts) and power-6(422.22±130.16watts). This may be due to more blood lactate production in the subsequent sprints in the football players that might have lead to fatigue in them.

The different repeated sprint ability (RSA) tests which have been performed in earlier studies involved 6x40 m sprints departing every 30 s *(Dawson et al., 1993).* These studies recorded mean performance decrements of 5.6% and 5.3%, respectively. The present study also provides a comparable mean performance decrement (i.e. sprint time) of 1.27%, 5.09%, 6.00% and 6.90% respectively. A greater depletion of creatine phosphate (CP) stores will be observed during a 40 m sprint as compared with a 20 m sprint *(Hirvonen et al., 1987).* During 6x40 m sprints departing every 30 s, approximately 2-3s of additional sprinting is performed for each sprint. This would be anticipated to deplete the creatine phosphate stores during each sprint to a greater extent than the protocol used in the present study. However, these previous repeated sprint ability test protocols also provide an additional 7- 8s of recovery. These longer recovery periods may counteract the additional 2-3s of sprinting and allow for similar proportions of phosphagen depletion and resynthesis when compared with the sprint protocol used in this study. For single high intensity efforts, of less than 5-10s duration, the largest contribution to the energy demands is made by the phosphagen energy system *(Hirvonen et al., 1987; Tesch et al., 1989; Gaitanos et al., 1993). Hirvonen et al., (1987)* found runners of higher sprinting ability were able to deplete a greater proportion of creatine phosphate stores when compared with runners of lower sprinting ability. Other studies that have used a repeated sprint protocol have also revealed similar findings as observed in the present study. *Holmyard et al., (1988)* found individuals producing the highest peak power output during repeated 6s sprinting efforts on a non-motorized treadmill had the greatest decreases in mean power output. Consequently, subjects who could produce higher peak power outputs and better sprint times are most likely able to do so due to their ability to utilize a greater proportion of their creatine phosphate stores. With short recovery periods, these subjects would have lower creatine phosphate stores prior to the next sprint and are therefore likely to fatigue more over a series of repeated sprints. *Balsom et al., (1992)* have observed no significant increase in plasma hypoxanthine or uric acid concentrations during a repeated sprint ability test involving 40x 15 m sprints with 30 s recovery. Sprinting time was also not observed to vary much during these 40 sprints. An increase in these purines during exercise would be indicative of a net degradation of adenosine 5'-triphosphate (ATP) in the muscle. Their finding

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suggests that the phosphagen system coped with these energy demands and was adequately resynthesised during the recovery periods. The repeated sprint ability protocol in the present study is similar in sprint length and therefore likely to rely predominantly on the phosphagen system. The present study also involves shorter recovery periods which are less than the half life of creatine phosphate resynthesis *(Harris et al., 1976).* The creatine phosphate stores will not be adequately replenished during the repeated sprint ability test and a progressive decline in creatine phosphate stores and a slowing of the 35 m sprint times have ensued. Even though anaerobic glycolysis provides a significant contribution to the initial stages of the sprint test, its contribution appears to diminish over the latter stages of a repeated sprint test. *Gaitanos et al., (1993)* measured the change in muscle creatine phosphate, ATP, lactate and pyruvate during 10×6 s maximal sprints on a cycle ergometer. They estimated that during the first sprint, anaerobic glycolysis was contributing approximately 50% to anaerobic ATP production. However, by the last sprint, anaerobic glycolysis was only contributing approximately 20 % to anaerobic ATP production. Based on these findings, *Gaitanos et al., (1993)* also suggested that it was likely aerobic metabolism increased its contribution during these last sprints. These studies suggest that the phosphagen system is the major anaerobic energy system during 3-5s of maximal sprinting and its importance appears to increase over the latter stages of a series of repeated sprinting efforts.

Conclusion; It was concluded from the results of this study that sprint time increased, power declined with a high fatigue index, the football players may need to focus on improving lactate tolerance and this could be a focus of their training programme.

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Minimum Muscular Fitness and Ventilatory Function in South Indian School Children

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Abstract

Emerging society has considered physical fitness as one of the important indicators of health. Muscular fitness and ventilatory functions are the important domains of physical fitness. The present study was designed to evaluate minimum muscular fitness and ventilatory functions in South Indian Children. Three hundred and fifty two healthy school children of both genders in age range of 10- 16 years who attended Yoga based Personality Development Camp were recruited for the study. Sample consisted of 203 boys and 149 females with a mean age of 12.90 years (SD=1.55). Anthropometric measurements, Kraus-Weber (KW) minimum muscular fitness test and PEFR were recorded. Out of 352 subjects tested 251 (71.31%) subjects failed in completing the test successfully. The overall failure rate in boys was 71.9% while in girls it was 70.5% with non significant differences between the two genders. The observation that the group of students who succeeded on minimum muscular fitness had significantly higher PEFR, points to a positive relationship between muscle fitness and lung functions. A failure rate of 71% on KW test in urban children (10-16years) of both genders points to an urgent need of physical fitness training programs for the enhancement of the strength in areas that shape their physical fitness.

KEY WORDS: physical fitness, muscular fitness, ventilatory function, Kraus-Weber, PEFR

Introduction

Emerging society has considered physical fitness as one of the important indicators of health. Physical fitness is the ability to perform physical activity, and makes reference to a full range of physiological and psychological qualities *(Ortega et al, 2008).* Being physically fit has been defined as "the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies" *(PCPFS, 1952).* Physical fitness during adolescence is related to a healthy cardiovascular disease risk profile in adults *(Twisk et al, 2002).* Fitness refers to the maximum capacity that people have or achieve while they perform physical activity that can be measured as the level of strength and flexibility of the muscular groups in different body parts. After two decades of clinical experience, Kraus and Hirschland prepared six tests of minimum muscular fitness for children called Kraus-Weber test (KW). The battery evaluates strength and flexibility of trunk and leg muscles.

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Studies have shown that this test represents minimum muscular fitness, and that falling below the normative level in this test predisposes to orthopedic and emotional difficulties *(Kraus & Hirschland, 1953).*

Studies show wide variations in the children fitness levels as measured on KW test. Initial studies on American and European children from comparable urban and suburban communities showed that 57.9% of the 4264 American students while only 8.7% of the 2870 European students failed to pass the test *(Kraus & Hirschland, 1954).* In the first Indian survey in the year 1975 on minimum muscular fitness in 375 school children in Lonavla, Maharashtra, the failures reported was 40.3% with multiple failures to the extent of 63.9 per cent *(Gharote & Ganguly, 1975).* Further, a recent study in year 2000 by the same group revealed that 20.8 per cent boys failed in the tests *(Gharote, 2000)* and this improved performance was attributed to better training through sports and physical activities promotions in the school. Multiple failures were 4.8 percent while flexibility failures alone were 11.6 percent.

Measurement of ventilatory functions is another useful measure to assess physical fitness in children and adults *(Petty, 2006).* Peak expiratory flow rate (PEFR) which is the maximum flow achieved during rapid exhalation delivered with maximal force starting from the level of maximal lung inflation is an essential measure of ventilatory function *(Pedersen, 1997).* PEFR is a simple quantitative and reproducible measure of resistance and severity of airflow obstruction *(Holcroft et al, 2003).* The purpose of this study was to evaluate the present status of muscular fitness and ventilatory function using Kraus-Weber Test and mini peak expiratory flow meter in healthy South Indian Children.

Methods

Participants: Three hundred and fifty two healthy school children of both genders in age range of 10- 16 years who attended yoga based Personality Development Camp in summer holidays in the serene campus of SVYASA University, Bengaluru, were randomly selected from a pool of 540 children. Children with a history of asthma, a recent history of respiratory infection with or without persistent cough within the past two weeks and those with any major disability or illness were excluded from the study.

*Consent and ethical clearance**:*** Signed informed consent was obtained from the parent or guardian of the child at the time of registration after they had read the proposal of the study. All procedures were reviewed and accepted by the institutional ethical committee. The children were explained in detail about the nature of the study and the voluntary nature of participation and were not provided with any incentives for their participation.

Methods: All the children were the participants of a ten day residential yoga based personality development camp organized during summer holidays in the month of April. The testing was performed in a spacious room during the morning hours between 9 to 11 AM on 2^{nd} day of the camp after the child had acclimatized to the camp life. The children were taken in batches of five to the room situated adjacent to the hall. After documenting the demographic data, PEFR followed by Kraus Weber test was recorded.

Measurements

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Kraus-Weber test: The Kraus-Weber test is composed of five strength items and one flexibility item *(Kraus & Hirschland, 1953).* Failure of any one of the six items means a failure of the total test.

1. The first test item measured the strength in abdominal and psoas (hip flexor) muscles. The subject was instructed to lie supine with the hands behind the neck. The feet were held by the examiner. On command the subject rolled up into a sitting position.

2. In the second test item the subject was asked to lie supine, hands behind neck and knees bent. The feet were held. On command the subject tried to roll up into a sitting position. This is a test of abdominal muscles without using the psoas muscle.

3. This is a test item for the strength of lower abdominal muscles. During this test, the subject lies flat on his back with his hands behind his neck. He was then instructed to lift the legs straight off the floor about 10 inches and to hold the position for 10 seconds.

4. The upper back muscles were tested during the 4th test item. The subject was asked to lie prone with a pillow under the abdomen but far enough down to give a seesaw effect. While lying on the stomach, the subject was asked to lift the head, shoulders, and chest off the floor and hold for 10 seconds.

5. In the fifth test, the position was the same as in the 4th test. The subject was instructed to lie prone over the pillow and place his hands in front and rest his head on them. The examiner held the chest down and asked the subject to lift his legs up without bending the knees and maintain this position for 10 seconds. The lower back muscles were tested with this.

6. In the sixth test item, the subject was tested for the flexibility of back and ability to stretch the hamstring muscle. The subject was asked to stand erect with his hands at sides and feet together. On command he was instructed to lean down slowly to touch the floor with his fingertips. The knees were kept straight and the leaning down position was asked to be maintained for 10 seconds. No bouncing was allowed to touch the floor.

PEFR Measurement: A mini PEFR meter (Clement Clarke) was used to check the PEFR of the children. The purpose and technique of performing PEFR was explained along with a demonstration of the correct manner of performing the test. When subjects had understood the method and were able to perform correctly, they were made to give the test in the standing position. They were closely observed to ensure that they maintained an airtight seal between their lips and the mouthpiece of the instrument *(Holcroft et al, 2003).* The highest value of the three readings was recorded as the final PEFR value.

Physical characteristics:

The weight (Kg) was recorded using a standard electronic weighing scale. The participants were asked to remove as much outerwear as possible. Further they were asked to remove the shoes and step up onto the weighing scale and stand still over the center of the scale with body weight evenly distributed between both the feet. Standing height (cm) was measured without shoes and without traction using a standard scale.

Data analysis: All the statistical analyses were performed using the Statistical Package for Social Sciences (version 16.0). Descriptive statistics was used to examine the frequency and percentage to compare successes and failures in Kraus-

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Weber Test items based on age and gender. Independent-samples t-tests were performed to determine the significance of the observed differences in physical characteristics of the subjects according to success and failure.

Results & Discussion

A total of 352 students (203-boys, 149-girls) were enrolled in the study. Participants' age ranged from 9 to 16 years with a mean age of 12.90 years (SD=1.55). Table I shows physical characteristics and frequency distribution of children's performance on the two tests i.e. PEFR & Kraus Weber tests.

Table I: Frequency distribution of children on KW test and PEFR

age groups	Gender	N	Weight		Height		PEFR		KW test	
			Mean	SD	Mean	SD	Mean	SD	Success N (%)	Failure N(%)
	Girls	13	32.52	6.54	135.04	10.47	226.92	64.47	1(7.7)	12(92.3)
	Boys	14	37.89	7.26	138.14	6.68	239.29	37.31	2(14.3)	12(85.7)
10	Total	27	35.3	7.32	136.64	8.68	233.33	51.52	3(11)	24(89)
	Girls	16	33.6	5.94	141.69	6.38	250.63	39.58	4(25)	(75)
	Boys	26	36.66	7.17	140.84	6.99	266.54	52.07	9(34.6)	17(65.4)
11	Total	42	35.5	6.82	141.16	6.7	260.48	47.83	13(29.8)	29(70.2)
	Girls	26	37.93	8.53	143.35	10.34	238.85	48.36	4(15.4)	22(84.6)
	Boys	42	40.86	9.04	146.88	8.86	285.76	45.37	11(26.2)	31(73.8)
12	Total	68	39.74	8.9	145.53	9.53	267.82	51.58	15(20.8)	53(79.2)
	Girls	33	45.11	7.19	152.17	7.32	297.88	52.78	13(39.4)	20(60.6)
	Boys	56	46.83	12.07	151.93	9.78	293.39	52.23	15(26.8)	41(73.2)
13	Total	89	46.19	10.52	152.02	8.9	295.06	52.18	28(33.1)	61(66.9)
	Girls	29	49.02	9.2	155.83	6.92	304.14	42.8	12(41.4)	17(58.6)
	Boys	39	46.08	9.84	156.96	8.39	324.87	57.35	8(20.5)	31(79.5)
14	Total	68	47.33	9.62	156.48	7.76	316.03	52.32	20(30.9)	48(69.1)
	Girls	27	49.81	6.84	156.1	7.09	312.22	47.9	8(29.6)	19(70.4)
	Boys	18	54.72	6.39	170.21	7.78	381.67	62.43	9(50)	9(50)
15	Total	45	51.77	7.03	161.74	10.1	340	63.6	17(39.8)	28(60.2)
	Girls	5	48.22	10.8	155.4	5.04	308	50.7	2(40)	3(60)
	Boys	8	49.59	7.95	161.75	2.83	336.25	63.23	3(37.5)	5(62.5)
16	Total	13	49.06	8.73	159.31	4.85	325.38	58.25	5(38.8)	8(61.3)
	Girls	149	43.24	9.95	149.54	10.56	280.47	57.89	44(29.5)	105(70.5)
10-16	Boys	203	44.34	10.76	151.49	11.92	300.21	62.38	57(28.1)	146(71.9)
	Total	352	43.87	10.43	150.66	11.39	291.85	61.22	101(28.7)	151(71.3)

PEFR= Peak expiratory flow rate.
Note: Total failure percentage is 71.31

KW test: Out of 352 subjects tested a total of 251 (71.31%) subjects failed to complete the test successfully. The overall failure rate in boys was 71.9 while in girls it was 70.5 with non significant difference between the two genders. Further 25.85% of students failed in one of the items of the test. It is observed that the failure rates that ranged from 89% dropped to 50% as the age advanced in both girls and boys; the maximum failure rate of 89% was observed in the age group of 10 years and the dropped to 60.2% in the boys of 15 years of age. Table 2 presents the analysis of success and failures in the number of items of the Kraus-Weber test. Table 3 presents the success and failures in Individual items of the Kraus-Weber test. The maximum number of students failed in the test item meant for Strength of Upper Back muscles where the failure rate was observed to be 93.8%. Physical

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characteristics of the subjects who were successful or failed in the KW test items are summarized in Table 4. Successful group of subjects have shown significantly higher PEFR as compared to the failure group.

Table 2:–Analysis of Failure rates in the different Items in the Kraus-Weber Test (N-356)

KW test	Number of items failed 5	4	3	2	1	Total
N	8	28	48	76	91	251
%	2.27	7.95	13.64	21.59	25.85	71.31

Table 3: Performance On Individual Items Of KW Test

Items	Success N	Success %	Failures N	Failures %
Abdominals Plus Psoas	44	12.5	308	87.5
Abdominals Minus Psoas	86	24.4	266	75.6
Psoas & Lower abdominals	99	28.1	253	71.9
Upper Back muscles	22	6.3	330	93.8
Lower Back muscles.	167	47.4	185	52.6
flexibility and strength back and hamstrings	121	34.4	231	65.6

Table 4: Comparison Of Physical Characteristics and KW Test

Physical parameters	KW result	N	Mean	SD	t	p
Weight	Successes	101	43.6	10.686	-0.36	0.716
	Failures	251	44.0	10.34		
Height	Successes	101	151.8	11.96	1.19	0.235
	Failures	251	150.2	11.14		
PEFR	Successes	101	309.6	64.12	3.51	0.001
	Failures	251	284.7	58.64		

In the current study, overall 71.3% failure rate was observed in any one of the six test items in Kraus-Weber test. The failure percentage observed in this study has been second highest reported so far in India. This seems to be in line with a recent study in India which has concluded that basic levels of health-related fitness are low among school children and reasons attributed to this trend were increasing affluence, and academic competitiveness, which forces the child to devote very little time to physical activity *(Gupta et al, 2014).* In the current decade the television and video game use has become the most popular leisure activity. As 'couch potato' hypothesis states time spent with these media activities result in deleterious affects on the physical activity and the diet *(Vandewater et al, 2004).* Although in the current study their basic physical activity level, hours of television viewing and video game activity were not measured, this may be responsible for the increased failure rate in minimum physical fitness. Maximum failure percentage was seen in test item 4 that measures the upper back muscles (93.8%) and test item 1 (Strength of abdominal plus psoas muscles) (87.5%). This result is in contrast to a previous study which has shown that the test item number 6 that measures the flexibility of Back and Hamstrings as the weak areas *(Gharote & Ganguly, 1975).* The overall failure rate in boys was 71.9 % while in girls it was 70.5% with no significant difference between the two genders. This result is in contrast to a previous study from India which reported higher failure rates in females than males *(Gharote, 2000).* The observation that the group of students who succeeded on minimum muscular fitness had significantly higher PEFR, points to a positive relationship between muscle fitness and lung functions.

Limitations: Potential limitations of this research must also be considered. The sample included was healthy young children in a yoga camp environment which may be difficult to generalize for all children and adults. Secondly, we have used only PEFR using a mini PEFR instrument; it would have been ideal to compare all measures of lung function

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using a spirometer. To our knowledge, this is the first study that has looked at both minimum muscular fitness and PEFR in south Indian children. The benefits of physical fitness are widely acknowledged and extend across many domains of wellness and health. Previous findings have shown a positive relationship between physical fitness, during adolescence and arterial properties later in life *(Twisk et al, 2002).* Further reports have shown consistent positive relationship between physical fitness and academic achievement *(Chomitz et al., 2009).* Furthermore, results support the possible link between physical fitness and improved emotionality *(Folkins, 1981).* Physical fitness can be enhanced by training. One of the effective strategies for enhancement of physical fitness is yoga practice. Many earlier studies have shown positive effects of Yoga training in reducing the failure rate in K-W tests *(Gharote, 1975).* Studies have also shown that yoga based breathing practices can increase pulmonary function *(Vedala et al, 2014).*

Conclusion: A failure rate of 71% on KW test in urban children (10-16years) of both genders points to an urgent need of physical fitness training programs for the enhancement of the strength in areas that shape their physical fitness.

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The Relationship between Creatine Kinase and Cortisol Level of Young Indian Male Athletes

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Abstract

Serum concentration of creatine kinase is used widely as an index of skeletal muscle fibre damage in athletes. Cortisol is a steroid hormone, often called the "stress hormone" because its level rises following emotional and physical stress. Forty five (45) male athletes of three different sports disciplines namely Hockey, Wushu and Fencing having age between 14 to 17 yrs, were divided equally into three groups. The results show that no correlation exists between the creatine kinase and cortisol level of male Indian athletes of three different sports discipline.

Key words: Creatine kinase, Cortisol, Muscle fibre damage, Stress hormone

Introduction

Competitive sports impose substantial energy, mechanical, mental and emotional burdens on the athletes. This reflects, among other things, on a number of biochemical and hematological properties in blood sample collected at rest *(Lang & Wurzburg, 1982; Clarkson et al, 1992; Malczewska et al, 2000; Mayr et al, 2006).* Creatine kinase is an enzyme and present in almost all tissues but is highest in the muscle and in the brain. Creatine kinase exists in three different isoenzymes. Each Isoenzyme is a dimer composed of two protomer 'M' for muscle and 'B' for brain *(Nanji, 1983; Noakes, 1987; Nikolaidis et al, 2003).* The serum concentration of creatine kinase is used widely as an index of skeletal muscle fibre damage in sport and exercise. The serum Creatine Kinase concentration rises when an organ that contains the enzyme is damaged. The serum Creatine Kinase concentration is probably the best biochemical marker of muscle fibre damage. Creatine Kinase involved in muscle metabolism and it is believed to leak into the plasma from skeletal muscle fibers when these are damaged because of repeated and intense contraction of muscles *(Wevers et al, 1977; Tolfrey et al, 2000).* The serum concentration of Creatine Kinase peaks 1–4 days after exercise and remains elevated for several days. Thus, athletes participating in daily training have higher resting values than non-athletes, although this response to training is mitigated by the so-called repeated-bout effect. That is, the repetition of an exercise after several days or even weeks causes less muscle fibre damage than that caused by the previous exercise. Cortisol is a steroid hormone, often called the "stress hormone" because its level rises following emotional and physical stress. Its primary functions are to increase blood sugar through gluconeogenesis, suppress

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the immune system, and aid in fat, protein, and carbohydrate metabolism. It also decreases bone formation. High level of cortisol can change the body from an anabolic (muscle building) to a catabolic (muscle losing) state. Cortisol release in response to exercise appears to be altered depending on the time of day that exercise takes place (10).

The aim of the present study is to evaluate the level of serum Creatine Kinase and cortisol and find out the correlation between serum Creatine Kinase and cortisol level in Indian male athletes.

Materials & Methods

A total of forty five (N=45) male athletes, fifteen (15), each from Hockey, Wushu and Fencing sports disciplines having age between 14 to 17 years of Sports Authority of India training centre, Netaji Subhas National Institute of Sports, Patiala were the subjects of the present study. Fasting (Twelve hours) 3ml blood sample was collected from antecubital vein between 07.00am to 09.00am. Creatine kinase catalyzes the reaction between creatine phosphate and ADP to form creatine and ATP. The ATP formed along with glucose is catalysed by hexokinase to form glucose 6 phosphate. The glucose 6 phosphate reduces NADP to NADPH in the presence of glucose 6 phosphate dehydrogenase. The rate of reduction of NADP to NADPH is measured as an increase in absorbance which is proportional to the Creatine kinase activity in the sample.

Creatine kinase

$$\text{Creatine Phosphate} + \text{ADP} \xrightarrow{creatine\ kinase} creatine + \text{ATP}$$

$$\text{Glucose} + \text{ATP} \xrightarrow{Hexokinase} Glucose\ 6\ Phosphate + \text{ADP}$$

$$Glucose\ 6\ Phosphate + \text{NADP} \xrightarrow{G\ 6P\ dehydrogenase} Gluconate\ 6\ Phosphate + \text{NADPH+H}$$

Cortisol (antigen) in the sample competes with horseradish peroxidase-Cortisol (enzyme-labelled antigen) for binding onto the limited number of anticortisol (antibody) sites on the micro plates (solid phase). After incubation, the bound/free separation was performed by a simple solid-phase washing. The enzyme substrate (H_2O_2) and the TMB-substrate (TMB) were added. After an appropriate time had elapsed for maximum colour development, the enzyme reaction was stopped and the absorbencies were determined. The colour intensity was taken as inversely proportional to the Cortisol concentration in the sample.

Results & Discussion

Table 1: Mean standard deviation and r- value of creatine kinase and cortisol level of young Indian male athletes of three different sports disciplines

Groups (Sports Disciplines)	Creatine kinase (U/L), Mean±SD	Cortisol (ng/ml), Mean±SD	r-Value
Hockey (N=15)	200.3±97.29	169.00±24.22	0.129
Fencing (N=15)	138.3±69.72	162.00±20.94	0.098
Wushu (N=15)	159.1±56.62	162.67±34.32	0.281

As shown in the table no. 1 the mean value of creatine kinase (200.3 ± 97.29) & cortisol (169.00±24.22) level was observed to be highest in the athletes of Hockey group and the lowest in the Fencing group. No significant correlation was found between the two variables in the three different sports disciplines (groups).

The serum creatine kinase and cortisol activity observed can serve to verify if the training protocol is adequate. Higher serum creatine kinase and cortisol activity is believed to be associated with other clinical signals and symptoms suggestive of excessive training load and skeletal

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muscle lesion. Conversely, lower values may point inadequate training load not promoting the adaptations. In the present study, the mean values of creatine kinase and cortisol level of all the three groups are in the desirable range. But we have found that some athletes in each sports discipline have higher level of creatine kinase while the level of cortisol of all the athletes is found to be within a reference range. The serum creatine kinase and cortisol concentration serves as an index of both overexertion and adaptation of the muscular system to repeated bouts of exercise. As such, creatine kinase and cortisol is one of the top choices of athletes and coaches when requesting a biochemical profile, although the interpretation of these parameter's values is not always straightforward. A particularly important consideration relating to the use and the interpretation of creatine kinase and cortisol values in the sports sector is the dependence of this parameter on nature of the stress. Physical training is a form of stress that is applied onto the body. Chronic stress (overtraining) results in an excess of cortisol and creatine kinase, which will cause higher baseline levels.

This is for the first time that the study was carried out to find out the relationship between creatine kinase and cortisol level of athletes. Three groups of young Indian male athletes belong to Hockey, Fencing and Wushu were analyzed for creatine kinase and cortisol level. As mentioned that both the variables are good markers of physical and mental stress on athletes. In order to find out the relationship between the two variables, Karl Pearson's coefficient of correlation method was used. After applying correlation between the two variables of the three groups of athletes, we found that there is no correlation exists between creatine kinase and cortisol level of Indian male athletes.

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Efficacy of progressive core strengthening exercise on functional endurance tests and hypertrophy of multifidus, transverses abdominis in healthy female subjects with low core endurance

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Abstract

Objective: Aim of the present study was to find out the efficacy of core strengthening training on hypertrophy of core group of muscles (i.e) transverses abdominis (TA) and multifidus (MF) and on trunk flexor as well as extensor endurance tests in normal healthy low core endurance females. **Methodology: Study Design:** Single blind randomized control trail. **Sample size:** Convenient sample of 20 female college students with low core endurance. They divided into two groups. **Intervention:** Experimental group received six weeks progressive core stabilization exercise while control group received no treatment. **Out come measurement:** Pre and post reading of right and left side cross sectional area (CSA) of MF at L_4 and L_5 level and TA using ultra sound image. Flexor and extensor trunk isometric tests were too taken for functional improvement. **Statistics:** Related t- test were used to compare means within the group and unrelated t-tests were used to compare means between two unrelated groups. The significance level was set at $p \leq 0.05$. **Results:** Prior to the intervention there was no significant difference in CSA between the groups. After 6 weeks there was no significant improvement in control group. In experimental group, after six weeks on and average 35.41% improvement in CSA with MF L_4 left being most improved site (53.50%) and TA left being least improved site (9.01%). All improvements are statistically highly significant with $p<0.001$. When the experimental group post values were compared with control group post values all MF CSA values were statistically highly significant ($p<0.001$) but TA CSA were not. **Conclusion:** The present study results supports that 6 weeks progressive core stabilization can be used as prehabilitation to prevent LBP in normal healthy female students.

Key Words: **Stabilization exercise; Core training; Lumbar stabilization; Low back pain; Core endurance**

Introduction

Rapid growth in technology in the last couple of decades has lead to constant reduction in physical activity and increased sedentariness in lifestyle. This in turn has reduced the work of certain muscles that were once strong and were responsible for good posture & prevented injuries. This is especially true to the trunk and hip muscles that helped to maintain erect posture against the gravity. Balance between anterior and posterior group trunk and hip muscles is essential for normal postural alignment. However, habitual wearing of high heels by young women results in definite biomechanical and musculoskeletal changes that are manifested by reduced base of support, increased anterior pelvic tilt, increased lumbar lordosis, short hip flexor and trunk extensor, weak abdominals and gluteal muscles. The resulting decreased core stability has been suggested to contribute to the etiology of lower extremity injuries in females (*Leeton et al., 2004*).

A specific type of exercises called as core stability exercise are

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gaining rapid popularity among the clinical therapists (*McGill, 2001*). These exercises are used to target specific muscle groups (i.e) transverse abdominis (TA), internal oblique (IO), multifidus (MF), quadrates lumborum, pelvic floor muscles in the trunk so as to prevent not only the low back pain, but other injuries in lower extremity (*Heidt et al., 1999; Hewett et al., 2000; Nadler et al., 2002; Cowan et al., 2004; Ferreira et al., 2004; Akuthota and Nadler, 2004; Zazulak et al., 2007; Muthukrishnan et al., 2010; Hides et al., 2011*). Studies support the activation of TA and MF prior to the movement of shoulder and hip in order to stabilize low back (*Hodges and Richardson, 1996 and 1999*). Above mentioned muscles are attached directly to the lumbar vertebrae and are the parts of motion segment in lumbar region. So they are beleved to be responsible for providing segmental stability by controlling the lumbar segments during movement. When all these local muscles contract together they keep the spine in its most stable position (the neutral zone), so called local stability system, and aid in preventing injury (*Fredericson and Moore, 2005; Zazulak et al., 2008*). Apart from injury prevention, core stability also improve the sports performance in certain sports (*Hedrick, 2000; McGill, 2001; Nadler et al., 2002; Myer et al., 2005; Kibler et al., 2006; Marczinka, 2007*). It is also important for normal day to day physical activities such as throwing, jumping, lifting, walking and running etc.

Hicks et al., (2005) & Akuthota et al., (2008) advise the core stability exercise program to younger age population (25 to 45 years) with greater general flexibility which young women population has. Further female population with weak core is more susceptible to ACL injury and other lower limb injuries thus incorporation of core strengthening program in their life style is essential (*Leeton et al., 2004; Hewett et al., 2000*). The current literature supports the importance of core strengthening, in fact the endurance, in the injury rehabilitation (*Hides et al., 1996; Daneels et al., 2001*) and sports performance (*Hedrick, 2000 McGill, 2001; Kibler et al., 2006; Marczinka, 2007*). However, there is no study that deals with normal young women population who might have subclinical level muscular imbalance in trunk due to relative high heel foot wear usage and wider pelvis. More over, current literature lacks in consensus regarding what constitute a core strengthening program, how it differs from normal strengthening exercises, how it has to be progressively increased over the period of time, its effect on muscular cross sectional area in normal population. Thus, aim of the present study was to find out the efficacy of core strengthening training on hypertrophy of core group of muscles (i.e) TA and MF and on functional trunk endurance tests in normal healthy low core endurance females.

Materials & Methods

Study design: Present study was a single blind randomized control trial with convenient sampling technique. 20 healthy female collegiate students aged between 18-26 years were recruited after passing inclusion and exclusion criteria.

Inclusion and exclusion criteria: The inclusion criterion was female students without any regular training atleast one year before the time of intervention. They should possess low static trunk extensor

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endurance (endurance tests less than 100 sec), whereas main exclusion criteria were LBP in the last 3 months before the study and LBP that resulted medical intervention in the past, Contraindication to abdominal muscle strengthening like-glaucoma, pregnancy, hypertension, osteoporosis, spinal tumors, inflammatory diseases.

Sample characteristics: Mean (SD) of age, height and weight of the sample were 22.2 (2.21) yrs, 162.5(6.00) cm and 55.1(3.01) kg respectively.

Procedure: The sample was randomly divided into two groups, experimental & control & consisted of 10 persons each. Experimental group received 6 weeks of progressive core stabilization exercise whereas the control group received no treatment during the period of the study. Cross sectional area (CSA) of Multi Fidus (MF) and Transverse Abdominis (TA) as well as functional endurance test for both lumbar flexor and extensor groups were the out come measurements of the present study. These were measured two times with six weeks duration apart.

Ultra sound measurement- Technique: Ultrasound images were used to measure CSA of MF and TA muscles bilaterally by an independent radiologist blind to the content of the study. Ultrasound imaging assessment was conducted using Xario ultrasound imaging apparatus equipped with a 10- MHz curvilinear transducer (Toshiba, Japan).

For MF muscle thickness the subject was positioned in prone lying, with a pillow placed under the abdomen to minimize the lumbar lordosis. The MF muscle was imaged in para saggital section, as per (*Hides et al. (1992) and (1995); Stokes et al., (2005))* allowing visualization of the zygpophyseal joints, muscle bulk, and thoracolumbar fascia. The left and right MF muscle was separately imaged at the L4-5 vertebral level, then the images were saved and measurement of cross sectional area was taken.

Assessment of TA was done as per *Ferreira et al., (2004); Teyhen et al., (2005); Rankin et al., (2006); Hides et al., (2006) and Teyhen et al., (2008)*. The subject was positioned in supine lying position, and was asked to maintain relaxed position while images were taken. The center of the transducer was placed in a transverse plane just superior to the iliac crest, in line with the mid-axillary line. To standardize the location of the transducer, the hyperechoic interface between the TA and the thoracolumbar fascia was positioned in the right side of the ultrasound image, and the image was taken at the end of expiration. Images of both left and right sides were saved and measurement of thickness of TA was taken later.

Static endurance tests- measurement: To test flexor endurance test the subject was positioned in supine with the knees and hips flexed at 90° so that their torso could be flexed to 60°. The feet was secured under foot straps or held by the examiner. Subjects were asked to hold this position, 60º flexion, for as long as possible. Failure occurs when the subject's torso falls below 60°, the duration for holding the position was noted using digital stop watch (*McGill, 2002; Evans et al., 2007*).

To test the torso extensors subjects were positioned in a prone position with trunk outside the table. The pelvis hips, and knees were secured on a table. The upper body was held out straight over the end of the table. The subjects were asked to extend their back and maintain this position for as long as they could. Failure

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occurs when the upper body falls from horizontal into a flexed position, then the measurement of duration for how long they could hold this position was noted (*Moreau et al., 2001; McGill, 2002*).

*Progressive core endurance exercise-procedure: A t*otal of 6 weeks duration was divided into 3 stages with each stage lasting for 2 weeks. The segmental approach we have devised develops through three stages of segmental control, with each stage exposing the individual patient to increasing challenges to her joint protection mechanisms (*Myer et al., 2005; Richardson et al., 2005; Norris, 2008; Luque-Suárez et al., 2012*). Table 1 shows the type of exercises performed at each stage of the progression. Justifications for selection of exercises were given in our previous publication (*Kulandaivelan and Chaturvedi, 2014*). Before starting each exercise session warm up session of about 5 min in the form of jogging was given. Duration of each session was around 45-60 min in a day. Frequency of exercise was 5 times a week for 6 weeks. Subjects were allowed 2 days rest period after completion of 5 sessions of exercise in order to provide adequate rest from exercise. The abdominal drawing-in maneuver was performed in conjunction with each of the dynamic exercises because of its ability to facilitate coactivation of the TA and MF muscles when stabilizing the trunk and its clinical use as a foundational basis for lumbar stabilization exercises. In dynamic exercises each exercise was of 10 repetitions (2 sec concentric contraction with expiration, 8 sec hold with normal breathing, 3 sec eccentric contraction with inspiration with 5 sec rest) per set and 3 sets per session (total 30 repetitions). Whereas static exercises were on 10 sec hold (30-40 % of maximal voluntary contraction as intensity) followed by 5 sec rest for 10 repetitions per set and 3 sets per session (total 30 repetitions) (*Koumantakis et al., 2005*). There was a 60 sec interval between sets and 3 min rest between each exercise (*Hicks et al., 2005; Willardson, 2006; Akuthota et al., 2008; ACSM, 2009; De Salles et al. 2009*).

Table 1: Exercise Programme

Stage	Name	Static	Dynamic
Stage I	**Core Control**	1. Abdominal 'tuck in' in crook lying position 2. Abdominal 'tuck in' in sitting position with tactile cue on back 3. Abdominal 'tuck in' in quadruped position	1. Bridging on the floor without leg extension 2. Bird dog exercise in quadruped position 3. Abdominal crunches on floor (hands behind head)
Stage II	**Core stabilization**	Abdominal 'tuck in' in sitting position	1. Back bridging onswiss ball without leg rise 2. Wall squat with swiss ball 3. Abdominal crunches on swiss ball (hands over chest)
Stage III	**Core strengthening**	Abdominal 'tuck in' in standing against the wall	1. Back bridging onswiss ball with leg rise 2. Bird dog exercise on swiss ball 3. Abdominal crunches on swiss ball (hands behind head)

Statistics: Data were analyzed using SPSS version 11.5. Data is presented by mean ± Standard deviation (SD). Related t- test were used to compare means within

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the group and unrelated t-tests were used to compare means between two unrelated groups.The significance level was set at p ≤ 0.05.

Results & Discussion

Table 2 compares experimental group and control group, pre and post exercise period readings in CSA of muscle groups at different sites. There was no significant difference in pre and post readings in control group. There was a significant improvement in CSA of muscle groups at all sites in experimental group's post exercise period (p<0.001 in all but TA left which was p<0.01). However, when the post values of experimental group was compared with control group, significant difference was observed only at multifidus muscle not in TA muscles.

Table 2: Comparison of control and experimental groups' pre and post exercise period readings in CSA of muscle groups at different sites.

Sno	Side & Site	Control		Experimental		'T'$^{A(SIG)}$	'T'$^{B(SIG)}$
		Pre	Post	Pre	Post		
1.	L4 MF Left	1.210 ± 0.175	1.314 ± 0.300	1.099 ± 0.327	1.687 ± 0.313	2.718*	4.524***
2.	L4MF Right	1.212 ± 0.209	1.212 ± 0.209	1.120 ± 0.305	1.676 ± 0.255	4.452***	5.553***
3.	L5 MF Left	1.347 ± 0.180	1.349 ± 0.179	1.237 ± 0.328	1.818 ± 0.233	5.044***	5.577***
4.	L5MF Right	1.421 ± 0.160	1.422 ± 0.166	1.300 ± 0.327	1.856 ± 0.277	4.424***	5.117***
5.	TA Left	0.317 ± 0.075	0.319 ± 0.075	0.333 ± 0.061	0.363 ± 0.057	1.468^{NS}	4.616**
6.	TA Right	0.321 ± 0.066	0.324 ± 0.064	0.322 ± 0.061	0.356 ± 0.056	1.185^{NS}	7.519***

t^A, $t^B$are post control-experimental, pre control-experimental, 't' values respectively. *, **, *** means 'p' values less than 0.05, 0.01, 0.001 respectively. NS means non-significant.

Table 3: Comparison of control and experimental groups pre and post exercise period readings of flexor and extensor endurance test.

S.No	Tests	Control		Experimental		'T'$^{A(SIG)}$	'T'$^{B(SIG)}$
		Pre	Post	Pre	Post		
1.	Flexor endurance test (in sec)	41.9±17	48.4±15	57.8±23	129.2±42	6.66***	5.72***
2.	Extensor endurance test (in sec)	58.7± 25	68.6 ± 15	49.2±29	108.9±39	7.93***	3.03**

t^A, t^B are post experimental-control, experimental pre-post 't' values respectively. *, **, *** are 'p' values less than 0.05, 0.01, 0.001 respectively. NS means non-significant.

Table 3 compares control and experimental group's pre and post exercise period values in flexor and extensor endurance test. There was no significant difference in pre and post values of control groups in both tests. But experimental group showed significant improvement in trunk endurance in both tests. The same trend continued when post exercise values of control and experimental group values were compared (all values were P<0.001).

In the present study, transverse abdominis thickness pre intervention values are observed to be significantly lower than the reference value reported by *Teyhen et al., 2008* but comparable to them only in post intervention experimental group. *McGill et al., (1999)* reported higher values for both flexor as well as extensor endurance tests. The normative values reported in their study achieved only in the experimental group after intervention. This indicates that present

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study population possessed low core endurance at the beginning of the study. The results of our study are in accordance with the previous work by *Daneels et al. (2001)*, who suggested that core strengthening programs of 10 weeks duration with a frequency of 3 times a week was enough to induce hypertrophy, core strengthening program of 6 weeks as used in the present study however has also been found to induce hypertrophy to the same extent. The reason for greater improvement of hypertrophy in MF compared to TA may be explained by *Grenier and McGill (2007)* study. They found lesser hypertrophy in TA using abdominal hollowing as compared to abdominal bracing and advised others to emphasis for the later. In contrast in the present study, more emphasis for abdominal hollowing over bracing was followed, which may be the cause of poor hypertrophy of TA. *Hides et al., (1996)* demonstrated that specific exercise training involving co-contraction of transverses abdominis and lumbar multifidus over a 4 week period demonstrated an increase in cross sectional area of the atrophied multifidus due to pain.

Abdominal hollowing is performed by transverses abdominis activation; abdominal bracing is performed by co-contraction of many muscles including the transverses abdominis, external obliques, and internal obliques (*Akuthota and Nadler, 2004*). *Urquhart et al., (2005)* reported that inward movement of the lower abdominal wall result in greater TA activation than drawing in maneuver (activation of both upper and lower abdominal wall). A recent study has demonstrated that as much as 70% MVC is needed to promote strength gains in abdominal muscle (*Stevens et al., 2008*). The novice patient is more likely to contract wide groups of abdominal muscles (*Urquhart et al., 2005*). All the above points may explain lack of or lesser improvement observed in TA muscle CSA in experimental group.

Conclusions: The results of the present study show greater hypertrophy in multifidus than transverses abdominis after 6 weeks of progressive core strengthening program along with both flexor and extensor musculature endurance improvement. The results may help clinicians, physiotherapists to prescribe core strengthening exercises as prehabilitation for prevention of injuries in normal young women population with low trunk endurance.

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Role of footwear alteration along with conventional physiotherapy in Osteoarthritis knee

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Abstract

Inspite of vast array of conservative treatment interventions for medial knee osteoarthritis, their effectiveness in its management is still contentious. Numerous researchers have suggested the role of footwear modification in reducing medial knee joint space load and hence reducing pain and improving functional status. However, most of the studies were cross-sectional in nature and have not seen the alteration in compendium of factors like radiographic changes, static alignment, kinesiological factors, gait parameters and most importantly plantar pressure distribution following 6 months of footwear modification along with conservative physiotherapy. The results of the present study suggested that footwear alteration along with conventional physiotherapy was effective not only in improving clinical outcomes but also increasing medial knee joint space width, changing static alignment, improving kinesiological factors, gait parameters and plantar pressure distribution in patients of osteoarthritis knee.

Key Words: Footwear alteration; Knee; Osteoarthritis; Joint Space Width; Static alignment; Kinesiology; Gait; Plantar pressure; Pain; Functional status

Introduction

Osteoarthritis of the knee is a common painful chronic disease whose prevalence is increasing and for which there are few efficacious treatment options *(Felson et al, 2000).* The increase in rates of knee replacement for osteoarthritis has made the identification of effective nonsurgical treatments a high priority. Medial osteoarthritis is one of the most common subtypes of knee osteoarthritis *(Parkes et al, 2013).* It was directly linked with a varus deformity causing a change in the axial alignment on the knee and with the static load bearing axis transmitting through the medial side rather than the center of the knee. This change in alignment and load bearing axis of the knee will increase the loading transmitted through the medial compartment and accelerate the degeneration of the cartilage, which is believed to be one of the main causes of medial knee OA *(Mehta and Mulgaonkar, 2004).* In the light of these cross-sectional studies, the present study was carried out in a longitudinal design with an aim to not only provide symptomatic relief to OA knee patients but also address the biomechanical alterations.

Lateral wedge insoles are used for conservative treatment of OA when there is medial compartment narrowing. Although knee OA is not a foot condition, foot orthosis can alter the ground reaction forces affecting the more proximal joints,

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such as knee and therefore could be effective in treatment of knee OA *(Hennessey, 2007).* The wedge is placed under the sole of the foot and angulated so that it is thicker over lateral than medial edge transferring loading during weight bearing from medial to the lateral knee compartment. Studies have documented a modest 5% to 6% reduction in the external knee adduction moment, a measure of medial vs lateral loading *(Keating et al, 1993; Kakihana et al, 2005; Butler et al, 2007; Hinman et al, 2008).* In a study conducted by *Hinman and colleagues (2009)*, twenty people with medial compartment OA underwent gait analysis in their own shoes wearing i) no insoles and; ii) insoles wedged laterally 5 degrees, in random order. They concluded that effects of laterally wedged insoles on the adduction moment do not appear to decline after one month of continuous use, suggesting that significant wedge degradation does not occur over the short term. In an another study *(Barrios et al, 2013)*, 3- dimensional gait data were captured in an intervention group of 19 patients with symptomatic medial knee osteoarthritis wearing their prescribed laterally wedged foot orthoses at 0 and 12 months. Wedge amounts were prescribed based on symptom response to a step down test. It was observed that mechanical effectiveness of lateral wedging did not decrease over 12 months' time period. Thus both short term and long term biomechanical effectiveness of lateral wedge has been reported in the management of medial osteoarthritis knee.

Materials & Methods

This was an experimental, interventional study that was conducted at the Research Lab, Department of Physiotherapy, Punjabi University, Patiala. The data was also collected from Knee Clinic, Rotary Club (Mid Town), SST Nagar, Patiala, Physiotherapy OPD, Geriatric Centre, Patiala and Out Patient Department (OPD), Bhai Khanaiya Health Centre, Punjabi University, Patiala. Approval to conduct the research study was obtained from Institutional Ethical Committee, Punjabi University, Patiala. Thirty patients (mean age 58.33 ± 6.31 years; mean BMI 27.89 ± 3.89; 05 Males & 25 Females) with medial compartment OA (Grade – II & - III) were included in the study. 13 patients had right side involvement of medial knee OA and 17 patients had left sided involvement. The exclusion criteria were history of fracture in the area of knee joint under study or secondary OA knee; severe osteoporosis; any major lower limb surgery in the past; locomotion with assistive device; lower extremity injuries (not older than one year); Neurological disorders such as polyneuropathy, hemiplegia, parkinson disease, stroke; Grade- 4 Osteoarthritis (Osteoarthritis grading system - *Kellgren and Lawrence, (1957*); Orthostatic Hypotension and patients suffering from acute illness, systemic /infectious diseases or disorders. Informed consent was obtained from each subject before starting the assessment.

As per the study protocol, the intervention group (n=30) received conventional physiotherapy that consisted of administration of hot packs and interferential therapy followed by exercise regime along with footwear modification. Footwear modifications included application of 5 degrees of lateral wedge in their shoes and were instructed to wear them while doing activities of daily living.

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The total duration of intervention was 6 months. The evaluation of osteoarthritis knee was carried out at pre-intervention and post-intervention stages (3 months & 6 months). Clinical outcome (VAS & WOMAC), radiographic joint space narrowing (using radiographs in standing), static alignment (Q angle, Genu varum & Tibial Torsion), kinesiological factors (Quadriceps & Hamstrings strength, Quadriceps lag, Hamstrings flexibility and Knee range of motion), gait parameters (Step length, Stride length, Toe out, Cadence & Gait velocity) and plantar pressure distribution were assessed.

The role of footwear modification along with conventional physiotherapy was evaluated by comparison of outcomes at pre-intervention, in between the intervention (i.e. 3 months) and at the completion of intervention (i.e. 6 months) stages. Analysis of Variance (ANOVA) was used for this purpose followed by multiple comparisons of mean differences using Scheffe's post hoc test. The SPSS - 17.0 program was applied for analyses of data and a *p* value of 0.05 was considered as significant level.

Results and Discussion:

Table: 1 Comparison of clinical outcomes (Pain and Functional status) in osteoarthritis knee at different levels of intervention.

	Levels of Intervention				Mean difference (Scheffe's Post Hoc)		
Clinical Outcome	**Pre intervention Mean± SD**	**3 Months Post intervention Mean± SD**	**6 Months Post intervention Mean± SD**	**F-Value**	**Preintervention vs 3 Months Post intervention**	**Preintervention vs 6 Months Post intervention**	**3 Months Post intervention vs 6 Months Post intervention**
Intensity of Knee Pain (VAS score)	**7.47 ± 1.01**	**3.2 ± 1.24**	**3.13 ± 0.82**	**290.45***	**4.27***	**6.33***	**2.07***
Functional Status (WOMAC)	**80.63±10.90**	**37.13±14.23**	**14.45±10.01**	**241.40***	**43.50***	**66.18***	**22.68***

Note *p < 0.05

Table 2: Comparison of knee joint space width in osteoarthritis knee at different levels of intervention.

	Levels of Intervention				Mean difference (Scheffe's post hoc)		
Radiographic changes	**Pre intervention Mean± SD**	**3 Months Post intervention Mean± SD**	**6 Months Post intervention Mean± SD**	**F-Value**	**Pre intervention vs 3 Months Post intervention**	**Pre intervention vs 6 Months Post intervention**	**3 Months Post intervention vs 6 Months Post intervention**
Joint Space Width (mm)	**2.29 ± 1.43**	**2.96 ± 1.49**	**3.75 ± 1.36**	**7.87***	**-0.67**	**-1.47***	**-0.79**

Note *p < 0.05

It is observed from Table 2 that average knee joint space width increased from 2.29±1.43 to 2.96±1.49 following 3 months of Footwear alteration along with

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conventional physiotherapy. It was observed further to increase to 3.75±1.36 on the completion of six months of intervention. This increase in knee joint space width was statistically significant (F = 7.87, table 3). The mean difference between preintervention and 6 months postintervention was statistically significant whereas difference between other levels of interventions was found to be statistically nonsignificant. Thus the osteoarthritic patients who receive footwear alteration along with conventional physiotherapy have statistically significant improvement in the knee joint space width after the administration of six months of intervention.

Table: 3 Comparison of static alignment in osteoarthritis knee at different levels of intervention

Static alignment	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre-intervention Mean± SD	3-Months Post-intervention Mean± SD	6-Months Post-intervention Mean± SD		Pre-intervention vs 3 Months Post-intervention	Pre-intervention vs 6 Months Post-intervention	3-Months Post-intervention vs 6 Months Post-intervention
Q-Angle	10.67 ± 2.01	12.57 ± 1.74	14.13 ± 1.48	29.40*	-1.90*	-3.47*	-1.57*
Genu Varum	- 4.82 ± 2.77	- 2.33 ± 2.28	- 1.37 ± 2.11	16.46*	2.48*	3.45*	0.97
Tibial Torsion	19.43 ± 4.55	17.05 ± 4.90	15.85 ± 4.96	4.32*	2.38	3.58	1.20

Note *p < 0.05

Table: 4. Comparison of kinesiological factors in osteoarthritis knee at different levels of intervention

Kinesiological factors	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre-intervention Mean± SD	3-Months Post-intervention Mean± SD	6-Months Post-intervention Mean± SD		Pre-intervention vs 3 Months Post-intervention	Pre-intervention vs 6 Months Post-intervention	3-Months Post-intervention vs 6-Months Post-intervention
Quadriceps Strength (Kgs)	16.19 ± 3.13	18.02 ± 3.17	19.47 ± 3.35	7.84*	-1.83	-3.28*	-1.45
Hamstring Strength (Kgs)	11.97 ± 2.04	13.82 ± 2.16	15.04 ± 1.01	15.23*	-1.84*	-3.06*	-1.22
Hamstring Flexibility (cms)	13.43 ± 2.91	12.20 ± 2.37	11.93 ± 2.56	2.79	-	-	-
Quadriceps Lag (degrees)	2.70 ± 2.94	1.20 ± 1.79	0.67 ± 1.58	6.98*	1.50*	2.03*	0.53
Knee Range Of Motion (degrees)	109.93 ± 5.60	113.93 ± 4.46	116.40 ± 3.95	14.32*	-4.00*	-6.47*	-2.47

Note *p < 0.05

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Table 3, presents the mean of Q-angle (degree), Genu varum (degree) and Tibial torsion (degree) within in the group at preintervention, 3 months postintervention and 6 months postinterventions. The calculated F values for all the biomechanical factors [Q angle (29.40), Genu varum (16.46) and Tibial torsion (4.32)] were found to be statistically significant. The multiple comparisons of mean difference of static alignment by using Scheffe's post hoc showed that for Q angle mean difference is statistically significant at all levels of interventions whereas for tibial torsion, it was significant only between preintervention and 6 months postintervention stages. Additionally for genu varum mean difference is statistically significant between pre intervention and 3 months postintervention as well as preintervention and 6 months post intervention stages.

The calculated F value for Quadriceps strength (7.84), Hamstring strength (15.23), Quadriceps lag (6.98) and Knee range of motion (14.32) was found to be statistically highly significant where as the F value for Hamstring Flexibility (2.79) was found to be statistically non significant as shown in Table 4. The mean difference between pre-intervention and 6 months post-intervention was found to be statistically significant for all the kinesiological parameters. However the mean difference between pre and 3 months post-intervention as well as 6 months post-intervention stages was statistically significant only for hamstring strength, quadriceps lag and knee range of motion.

Table: 5 Comparison of gait parameters in osteoarthritis knee at different levels of intervention

Gait parameters	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre-intervention Mean± SD	3-Months Post-intervention Mean± SD	6-Months Post-intervention Mean± SD		Pre-intervention vs 3 Months Post-intervention	Pre-intervention vs 6 Months Post-intervention	3-Months Post-intervention vs 6 Months Post-intervention
Step Length (cm)	**43.63 ± 6.08**	**46.63 ± 5.22**	**48.88 ± 4.84**	**7.12**	**-3.00**	**-5.25***	**-2.25**
Stride Length (cm)	**87.33 ±12.22**	**93.08 ± 10.60**	**97.70 ± 9.75**	**6.81**	**-5.75**	**-10.37***	**-4.62**
Toe-Out (degrees)	**12.26 ± 1.79**	**10.63 ± 1.30**	**9.63 ± 0.81**	**28.50**	**1.63***	**2.63***	**1.00***
Cadence	**91.43 ± 8.05**	**99.70 ± 8.98**	**106.40 ± 7.73**	**24.64**	**-8.27***	**-14.97***	**6.70***
Velocity (cm/sec)	**75.27 ± 5.50**	**81.59 ± 5.38**	**85.95 ± 5.75**	**28.09**	**-6.32***	**-10.67***	**-4.35***

Note *p < 0.05

Table 5 presents the average step length, stride length, toe out, cadence and gait velocity at different levels of interventions in the Experimental group – I. The calculated F value for all of these parameters [step length (7.12), stride length (6.81), toe out (28.50), cadence (24.64) and gait velocity (28.09)] was found to be significant at p<0.05. the multiple comparisons carried out by using Scheffe's post hoc indicated that the mean difference of gait parameters namely toe out cadence and velocity was statistically significant at all the levels of interventions. On the other hand this difference was significant only between pre and 6 months

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post-intervention for step length and stride length.

Table 6: Comparison of plantar pressure distribution mask in Osteoarthritis knee at different levels of intervention

Plantar Pressure Distribution	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre-intervention Mean± SD	3-Months Post-intervention Mean± SD	6-Months Post-intervention Mean± SD		Pre-intervention vs 3 Months Post-intervention	Pre-intervention vs 6 Months Post-intervention	3-Months Post-intervention vs 6 Months Post-intervention
Anterior Mask (UM+UL+MM)	**41.64 ± 8.26**	**45.63 ± 7.78**	**46.41 ± 8.22**	**3.01**	-	-	-
Posterior Mask (ML + LM + LL)	**58.92 ± 7.94**	**53.78 ± 8.12**	**53.35 ± 7.97**	**4.48***	**5.13**	**5.57***	**0.44**
Medial Mask (UM + MM + LM)	**46.73 ± 5.04**	**55.31 ± 6.04**	**58.81 ± 6.53**	**33.25***	**-8.58***	**-12.08***	**-3.49**
Lateral Mask (UL + ML + LL)	**53.83 ± 5.18**	**44.11 ± 5.75**	**40.95 ± 6.22**	**41.15***	**9.72***	**12.87***	**3.16**

Note *p < 0.05

The mean values of anterior mask, posterior mask, medial mask and lateral masks of plantar pressure distribution at different levels of interventions have been illustrated in Table 6. The results of one way ANOVA suggested that the changes in plantar pressure distribution were statistically significant for posterior mask (4.48), medial mask (33.25) and lateral mask (41.15) but not for the anterior mask (3.01). The mean difference of plantar pressure distribution was found to be statistically significant from base value to 3 months post intervention as well as base value to 6 months post-intervention for both medial mask and lateral mask while it was significant only after 6 months of intervention for posterior mask.

Discussion and Conclusions

Knee Osteoarthritis is a musculoskeletal condition prevalent in adults that causes considerable pain, immobility and disability and imposes a significant economic burden on those afflicted by it *(Raja and Dewan, 2011*). Keeping this in mind, the present study was designed to decrease the biomechanical load on medial compartment of knee and thereby reduce clinical symptoms and the risk of further development of medial OA knee.

The mean varus alignment was significantly reduced by 3.4 degrees in the patients receiving footwear modification along with conservative physiotherapy. These findings are contrary to the observations of *Van Raaij et al (2010)* who demonstrated that neither the lateral wedge nor the valgus brace achieved the correction of knee varus malalignment in

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the frontal plane. In their study, the authors showed that the mean varus alignment for the insole group (6.9 degrees; SD, 3.6 degrees) was similar ($p = 0.8$) at baseline compared with when wearing the wedge (6.9 degrees; SD, 4.1 degrees). Conversely, the present findings are well in line with the results of the study conducted by *Zhang et al (2012)* who suggested that valgus knee bracing showed a significant smaller knee varus degree with a 2.90° reduction compared with control condition, meanwhile a 2.81° reduction compared with lateral wedge condition ($p < 0.05$).

It has been observed that after 6 months of intervention, hamstring and quadriceps strength has shown significant improvement. These findings can be attributed to biomechanical effectiveness that was achieved by the application of lateral wedge, as it has been reported that the muscles at the medial compartment of knee (vastus medialis, medial gastrocnemius and medial hamstrings) present with a pathological protective patterns which increase the compressive forces and moments acting on the affected compartment *(Lawek et al, 2005).* Thus only muscle strengthening without biomechanical correction in the control group was not sufficient to improve the quadriceps strength ($p = 0.09$) and hence quadriceps lag ($p = 0.53$). On the other hand quadriceps lag was significantly improved. Knee range of motion was another kinesiological parameter studied in the present investigation which has significantly improved. Several studies have demonstrated the effect of hot pack, interferential therapy and exercise therapy in reducing pain and stiffness and hence improving joint range of motion.

All the gait parameters namely Step length, stride length, toe out, cadence and velocity were improved significantly. These results differ from the previous studies that have been unable to show improvements in gait parameters either with exercise program *(Thorstensson et al, 2007)*, or lateral wedge *(Hinman et al, 2009; Zhang et al, 2012).* The difference between these previous studies and present study is that: i) there was average reduction in knee adduction moment in the study conducted by *Thorstensson et al (2007)* and ii) studies conducted by *Hinman et al (2009*) and *Zhang et al (2012)* were very short term studies. Six months administration of intervention resulted into a statistically significant improvement in pain. Similar findings have been reported by *Sattari and Ashraf (2011)* and this could be attributed to the unloading of medial compartment *(Miyazaki et al, 2002; Zhang et al, 2012)*, decrease in the knee adduction moment *(Baliunas et al, 2002; Zhang et al, 2012)* and an increase in the medial joint space *(Richard et al, 2005; Raja and Dewan, 2011).* This reduction in pain and improvement in walking ability is believed to be naturally translated into enhanced functional scores (WOMAC) of the participants ($p = 0.00$). Additionally pain and functional outcome has improved even after 3 months of intervention. These results are consistent with the many of the previous studies reported.

Hinman et al (2008) conducted a study on 40 people with medial compartment OA and demonstrated that laterally wedge insoles resulted in an immediate reduction in walking pain and knee adduction moment. The improvement in pain and physical function were reported by the cohort after 3 months of treatment with insoles. This study provides an objective

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measurement of function by analysis of gait symmetry. This was measured in 30 patients on four separate occasions: immediately before and after initial fitting and then again at three months with the brace on and off. All patients reported immediate symptomatic improvement with less pain on walking. Hence, footwear alteration along with conventional physiotherapy is found to be effective in improving clinical outcomes, radiographic joint space width, static alignment, kinesiological factors, gait parameters and plantar pressure distribution in patients of osteoarthritis knee. Thus, the results of the present study may help clinicians to find a novel way of use of lateral wedge along with conventional physiotherapy, to help patients with early medial OA knee in future.

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A Study of Haemodynamic and Aerobic Fitness Profile of Football Players

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Abstract

The purpose of this study was to observe haemodynamic and aerobic fitness profile of football players. Thirty (N=30) male college football players between the age of 17 and 28 years volunteered for this study. The mean age, height and weight of football players was 21±3years, 172.63±8.64cm and 71.56±10.75Kg respectively.The mean resting pulse rate, systolic blood pressure, diastolic blood pressure, pulse pressure, mean arterial pressure, rate pressure product, stroke volume, cardiac output and VO_2 max was 69±4beats/minute, 120±3mmHg, 78±3mmHg, 42.07±4.71mmHg, 91.67±2.94 mmHg, 83.06±5.05beats.min^{-1}.mmHg, 57.38±5.65ml/beat, 3.97±0.28 L/minute and 42.60±2.26 ml.kg^{-1}.min^{-1} respectively. It was concluded from the results of this study that college level football players have less values of haemodynamic and aerobic fitness variables than elite level football players and athletes of other countries. Thus, they may need to focus on improving haemodynamic and aerobic fitness variables and this could be a focus of their training programme.

Key Words: Mean Arterial Pressure, Stroke Volume, Cardiac Output, VO_2max

Introduction

The performance of the football players depend on different kinds of physiological characteristics. Exceptional endurance performance capacity has long been known as important prerequisite for on-field performance of football players *(Ekblom, 1986; Reilly, 1997; Bangsbo et al., 2006).* For instance, a player's aerobic endurance capacity facilitates performance continuity, which is limited by endurance, throughout a 90-120 minute game. In addition, it influences the recuperation capabilities following high-intensity games and training units and the recovery following concise high-intensity exercise spurts throughout the games or training units *(Ekblom, 1986; Reilly, 1997; Reilly et al., 2008).* There is significant agreement that the maximum value for uptake, transport, and use of oxygen is a good sign of the working of the respiratory, cardiovascular and musculoskeletal systems. This is one of the reasons why research has shown great interest in the determination of haemodynamic and aerobic fitness variables, in a direct or indirect way, facilitating the understanding of physiological aspects related to performance of football players during matches and training programme. Therefore, the purpose of this study was to observe selected haemodynamic and aerobic fitness variables of college football players so that players and coaches could know the status of the physiological adaptations of football training programme.

Materials & Methods

Thirty male college football players of state and inter-university level of participation from Mastuana College of Physical Education, Sangrur (Punjab)

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India volunteered to participate in this study and their age ranged between 17 to 28 years. Selected anthropometric measurements on the subjects were recorded by using standardized procedure as described by *Weiner & Lourie (1969).* The aerobic fitness (i.e.VO_2max) was predicted by using resting pulse rate for 20 seconds and enter the number of beats that counted, along with subject's age, into the following equation *(Uth et al., 2004 and Tanaka et al., 2001).*

VO_2max (ml/kg/min) = 15.3 x (MHR/RHR)
where, MHR = Maximum heart rate (beats/minute) = 208 - (0.7 x Age)
RHR = Resting heart rate (beats/minute) = 20 second heart rate x 3

The haemodynamic variables like Pulse Pressure (PP = SBP- DBP), Mean Arterial Pressure (MAP = Diastolic pressure + 1/3 (Systolic - Diastolic pressure)) *(Andy et al., 1985),* Rate pressure product (RPP = HR x SBP /100) *(Nagpal et al., 2007 & Balogun et al., 1990)* was estimated by using various equations.

Statistical Analysis

Statistical analysis was performed with SPSS version 16.0 (free trial, SPSS Inc, Chicago). Results are shown as Mean and Standard Deviation. The alpha level for the data analysis was determined at $p<0.05$.

Results & Discussion

Table 1 shows the number and percent distribution of football players according to their playing positions in the present study. As per their playing positions of the football players 43.3% (N=13) were back, 33.3% (N=10) forward, 16.7% (N=5) center and 6.7% (N=2) goalkeeper.

Table 1: Number of Football Players according to their playing positions

Playing position↓	Number	Percent
1-forward	10	33.3
2-center	5	16.7
3-back	13	43.3
4-goalkeeper	2	6.7
Total	30	100.0

Table 2: Mean ±SD of Haemodynamic & Aerobic Fitness variables of football players

Variables	Mean± Std. Deviation
Age, ***year***	21±3
Height, ***cms***	172.63±8.64
Weight, *Kg*	71.56±10.75
VO_2 max, ***$ml.kg^{-1}.min^{-1}$***	42.60±2.26
Pulse Rate, ***beats/minute***	69±4
Systolic Blood Pressure, ***mmHg***	120±3
Diastolic Blood Pressure, ***mmHg***	78±3
Pulse Pressure, ***mmHg***	42.07±4.71
Mean Arterial Pressure, ***mmHg***	91.67±2.94
Rate Pressure Product, ***$beats.min^{-1}.mmHg$***	83.06±5.05
Stroke Volume, ***ml/beat***	57.38±5.65
Cardiac Output, ***L/minute***	3.97±0.28

The mean age, height and weight of male football players were 21±3 years, 172.63±8.64 cms and 71.56±10.75Kg respectively. The mean Systolic Blood Pressure, Diastolic Blood Pressure, Pulse Pressure, Mean Arterial Pressure, Rate Pressure Product, Stroke Volume and Cardiac Output of football players at rest was 120±3 mmHg, 78±3 mmHg, 42.07±4.71 mmHg, 91.67±2.94 mmHg, 83.06±5.05 $beats.min^{-1}.mmHg$, 57.38±5.65 ml/beat and 3.97±0.28 L/minute respectively. The mean VO_2 max and Pulse Rate of football players at rest was 42.60±2.26 $ml.kg^{-1}.min^{-1}$ and 69±4 beats/minute respectively (Table 2).

Testing of the haemodynamic and aerobic fitness variables can provide an insight to the football player's current physical capability. Also, assessment of

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the football player's current level of aerobic fitness reveals strengths and relative weaknesses that can become the basis for the development of an optimal training program *(Mirzaei et al., 2009).* The results of the measurements in this study were relatively comparable to the values reported in the literature for example *McMillian (2005)* reported that the mean VO_2max of elite soccer players was between 55 and 68 ml/kg/min but in the present it was 42.60±2.26 ml/kg/min . This value was similar to that reported for in other team sport but was much lower than that of elite endurance athletes (90ml/kg/min). However, players from different positions might have different level of cardiorespiratory level. *Reilly et al. (2000)* reported that among the elite Danish players, full-backs and midfield players possessed the highest values for VO_2max, whereas goalkeepers and central defenders had the lowest but in the present study no such trend related to playing position was observed and this may be due to less number of players, their training or level of participation. It is important to note that the results of aerobic fitness components vary depending upon the relationship of the athletes training schedule and competitive schedule *(Roemmich et al. 1997).* Maximum oxygen uptake is considered to be a valid indicator of the function of respiratory, cardiovascular and muscular systems working together *(Impellizzeri & Marcora, 2007).* Studies performed on untrained (UT) males have shown that a good VO_2max is above 40 ml/kg/min; a measure reported above 50 ml/kg/min is considered excellent. In relationship to sport, endurance specific athletes such as cyclists have been shown to have a VO_2max values of the order of 75 ml/kg/min *(Saltin & Astrand, 1967).* Martial art athletes generally exhibit greater cardiorespiratory endurance than untrained individuals, but not as great as athletes who focus on cardiorespiratory endurance as their primary fitness component for success in their sport, such as cyclists. In regard to martial art disciplines, a study of highly trained competitive black belt karate practitioners were found to have a VO_2max of 57.5 ml/kg/min while the lesser skilled competitive white belt karate practitioners were found to have a VO_2max *o*f 57.2 ml/kg/min *(Imamura et al., 1998).* By contrast, VO_2max values of 63.8 ml/kg/min were found in 60 England International boxers *(Smith, 2006).* Wrestlers have been reported to have values for VO_2max of 60.2 ml/kg/min *(Yoon, 2002). Crisafulli et al. (2009)* reported that maximum oxygen uptake for martial art athletes may be as low as 48.5 ml/kg/min and as high as 63.2 ml/kg/min depending upon the specific type of training discipline. Heart rate increases sharply during the first 1–2 minute of exercise, with the magnitude of the increase depending on the intensity of exercise. The increase in heart rate is brought about by parasympathetic withdrawal and activation of the sympathetic nervous system. After approximately 30 min of heavy exercise heart rate begins to drift upward. The increase in heart rate is proportional to the decrease in stroke volume, so cardiac output is maintained during exercise. Stroke volume exhibits a pattern of initial increase, plateaus, and then displays a negative (downward) drift. Stroke volume increases rapidly during the first minutes of exercise and plateaus at a maximal level

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after a workload of approximately 40–50% of VO_2max has been achieved *(Åstrand, et al., 1964).* As for light to moderate exercise, the increase in stroke volume results from an increased venous return, leading to the Frank-Starling mechanism, and increased contractility owing to sympathetic nerve stimulation. Thus, changes in stroke volume occur because left ventricular end–diastolic volume increases and left ventricular end–systolic volume decreases *(Poliner, et al., 1980).* Left ventricular end–diastolic volume increases because of the return of blood to the heart by the active muscle pump, increased venoconstriction (which decreases venous pooling, thereby increasing venous return), and increased cardiac output. Left ventricular end–systolic volume decreases owing to augmented contractility of the heart, which effectively ejects more blood from the ventricle, leaving a smaller residual volume. The downward shift in stroke volume after exercise is most likely due to thermoregulatory stress; plasma loss and a redirection of blood to the cutaneous vessels in an attempt to dissipate heat *(Rowell, 1986).* This effectively reduces venous return and thus causes the reduction in stroke volume. Diastolic blood pressure remains relatively constant because of peripheral vasodilatation, which facilitates blood flow to the working muscles. The rise in systolic blood pressure and the lack of a significant change in diastolic blood pressure cause the mean arterial pressure (MAP) to rise only slightly, following the pattern of systolic blood pressure. The increase in mean arterial pressure is determined by the relative changes in cardiac output and total peripheral resistance. Since cardiac output increases more than resistance decreases, mean arterial pressure increases slightly during dynamic exercise. However, the increase in mean arterial pressure would be much greater if resistance did not decrease.

Conclusion: It was concluded from the results of this study that college level football players of this study have lower values of haemodynamic and aerobic fitness variables than elite level football players and athletes of other countries. Thus, they may need to focus on improving haemodynamic and aerobic fitness variables and this could be a focus of their training programme.

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