DISCUSSION

Osteoarthritis (OA) is a degenerative joint disorder characterized by destruction of articular cartilage and formation of a new bone at the joint surfaces. Its onset is usually in older age group i.e., beyond 40 years of age. Both men and women are affected, but symptoms in women occur earlier and appear to be more severe than in men (Lawrence et al., 1998). Knee joint is the most commonly affected region of the body. Predominant feature is pain, along with decrease in the range of motion. As the disease progresses, movement in the affected joint becomes increasingly limited, initially as a result of pain and muscular spasm, followed by capsular fibrosis, osteophyte formation and remodeling of bone. The exact etiology is unknown. Although usually occurring as a primary disorder, osteoarthritis can occur secondary to other processes. High calcium deposition, trauma to the joint, inflammation, intrarticular fractures, history of immobilization, etc. are the secondary causes of osteoarthritis. Diabetes mellitus, acromegaly and some neuropathic conditions are also associated with osteoarthritis.

Osteoarthritis has negative effect on the quality of life. Patients with osteoarthritis, especially of the weight bearing joints, are less active and tend to be less fit with regard to musculoskeletal
and cardiovascular status than normal controls (Minor et al., 1988; Philbin et al., 1995; Reis et al., 1995). Various medical conditions are found to be associated with secondary osteoarthritis and are potential risk factors for osteoarthritis (Al-Arfaz 2003; Hart et al., 1995; Sun et al., 2000). These medical conditions include diabetes mellitus (Sturmer et al., 2001) and obesity (Bliddal and Christensen, 2006). Therapeutic goals include minimizing symptoms and improving functions.

The present study entitled “Effects of exercise rehabilitation programme on osteoarthritic knee with special reference to biochemical changes” aims to find prevalence of diabetes and obesity in the patients of osteoarthritis knee, to study the effects of quadriceps strength, range of motion, cardiovascular fitness and functional status in osteoarthritis knee patients and to find effects of exercise rehabilitation programme on patients of osteoarthritis knee with special reference to biochemical changes.

To achieve these aims, the subjects were randomly divided into experimental control group (ECG n =100) and experimental patient group (EPG n =100). In order to make the groups more homogeneous, they were further subdivided into males (ECG Males n=30, EG Males n=32) and females (ECG Females n=70, EG Females n=68).
The experimental control group was given conventional physiotherapy programme whereas experimental group was given exercise rehabilitation programme along with conventional physiotherapy programme.

Conventional physiotherapy programme included application of hot packs, isometric exercises, range of motion exercises, stretching exercises, joint mobilization exercises and progressive resisted exercises.

For exercise rehabilitation programme along with conventional physiotherapy programme, mild intensity and long duration aerobic conditioning exercises (at 60% of MHR) were applied to the whole body (including upper limbs). Treatment programme started with the application of hot packs to the knee joints.

Aerobic conditioning exercises: Aerobic warm up was given for 5-10 minutes. It included swinging of arms and legs (upwards, sideways, backwards and laterally). Walking was given for 5-10 minutes and cycling was given for 15-20 minutes (at 60% of MHR), 5 times a week. Aerobic exercises were followed by cool down exercises for 5-10 mins.

A thorough evaluation of the patients physical characteristics (age, weight, height and body mass index); clinical health status (pulse, heart rate, blood pressure-systolic and blood pressure-diastolic); health related fitness (pain, range of motion, strength-
isometric, strength-isotonic, cardiovascular fitness and functional status); physiological parameters (haemoglobin, erythrocyte sedimentation rate) and biochemical parameters (fasting blood glucose, serum cholesterol, serum triglyceride, serum high density lipoprotein-cholesterol and serum uric acid) was done before the start of study programme, after one month of the study programme and after completion of two months of study programme.

The values of physical characteristics, clinical health status, health related fitness, physiological and biochemical parameters were recorded in the data sheets. Standard statistical tests were used with the help of Microsoft Excel and SPSS software.

**PHYSICAL CHARACTERISTICS**

Osteoarthritis usually occurs in older age group i.e., beyond 40 years of age (Brandt and Fife, 1986; Colledge et al., 2010; Downie 1993; Fauci et al., 2008; Hamblen and Simpson, 2009; Joshi and Kotwal, 2000; Lawrence et al., 1966; O’Sullivan and Schmitz, 2001; Rothfuss et al., 1997). Since, it is a degenerative joint disorder, overuse and microtrauma are the causative factors superimposed on degenerated cartilage over a period of time.

Another important change due to age includes biochemical alteration in the articular cartilage that compromises its mechanical properties along with minute structural changes in the bones forming joints. Age related biochemical changes include a small but
significant decrease in water content of articular cartilage. Some differences in the synovial fluid concentration have also been reported. Hyaluronic acid concentration has been reported to rise from the age of skeletal maturity to the age till 60 years (Gardner et al., 1980). Also, chondroitin sulfate/keratan sulfate ratio is decreased along with alteration of collagen and proteoglycan composition.

Table 1 of the present study showed that 46% of osteoarthritis knee patients were of the age group of 51-60 years whereas 15.5% and 38.5% were of the age group 40-50 years and 61-65 years respectively. In general, the present study indicates that the incidence of osteoarthritis knee is more in elderly age group but at the same time young people are also not immune.

Both men and women are affected, but symptoms in women occur earlier and appear to be more severe than in men (Lawrence et al., 1998). This could be due to decreased bone mineral density especially during menopause (Sowers et al., 1996) and also because of effect of hormones on cartilage metabolism. The effect of estrogen on cartilage metabolism has been known to cause osteoarthritis in females (Rosner et al., 1986). About two-third to three-fourth of adults with osteoarthritis knee are women (Jordan et al., 1995).
Also, factors related to lifestyles of females could also be playing a role in it. Since, most of the patients in the present study were housewives, factors related to lifestyles of the females like habitual cross leg sitting position, household activities, cleaning or other floor activities that demand frequent bending of the knees could be the predisposing factor causing early and frequent osteoarthritis of knees especially in females.

Prevalence of osteoarthritis knee in males and females as shown in Table 2 of our study also indicates that osteoarthritis knee is more frequently found in females than in males. 69% of our patients were females and only 31% were males. This finding is also supported by Moskowitz et al., 1992 who reported that osteoarthritis knee occurs more commonly in women during later part of their life.

Obesity is one of the important risk factors of osteoarthritis of knees (Grotle et al., 2008). Several studies have investigated the effect of obesity associated with osteoarthritis knee (Coggon et al., 2001; Davis et al., 1990; Glimet et al., 1990; Niu et al., 2009). Association of obesity with osteoarthritis knee is stronger in women than in men (Felson et al., 1988). Obesity seems to impose a harmful stress over the weight bearing joints, especially the knee joint. Also, obesity is associated with increased bone mass and stiffer bones relating to degradation of articular cartilage (Hamblen and Simpson, 2009).
Table 4 of the present study also shows that 88.4% of females were obese whereas 83.9% of males were obese.

Increased body mass index (BMI) is associated with onset and progression of osteoarthritis of the knee (Reijman et al., 2007). Several studies revealed the effect of weight reduction exercises in reducing pain and disability in patients of osteoarthritis knee (Bliddal and Christensen, 2006; Christensen et al., 2005). Weight reduction programme helps in the management of osteoarthritis knee (Rogind et al., 1998). Weight reduction was found to be a practical adjuvant treatment in the rehabilitation of patients with knee osteoarthritis (Huang et al., 2000).

Tables 5 to 8 of the present study also tallies with the above studies which indicate that weight reduction reduces pain and disability in patients of osteoarthritis knee.

**CLINICAL HEALTH STATUS**

Effect of regular physical exercise for various parameters related to clinical health status like pulse, heart rate, systolic and diastolic blood pressure is now evident (Carter et al., 2003; Cornelissen et al., 2010; Fauci et al., 2008; Iellamo et al., 1997; McArdle et al., 2007; O’Sullivan and Schmitz, 2001; Perini et al., 2002).
Cornelissen et al. (2010) studied the effects of aerobic training intensity on resting, exercise and post-exercise blood pressure, heart rate and heart-rate variability. They aimed to investigate the effects of endurance training intensity on systolic blood pressure (SBP) and heart rate (HR) at rest before exercise, and during and after a maximal exercise test; and on measures of heart rate variability at rest before exercise and during recovery from the exercise test. The results showed that in the three conditions, that is, at rest before exercise, during exercise and during recovery, endurance training at lower and higher intensity reduced systolic blood pressure significantly. The effect of training on heart rate at rest, during exercise and recovery was more pronounced with higher intensity. In conclusion, in participants at higher age, both training programmes exert similar effects on systolic blood pressure at rest, during exercise and during post-exercise recovery, whereas the effects on heart rate are more pronounced after higher intensity training. Tables 9 to 12 of the present study showed similar results on pulse, heart rate, systolic and diastolic blood pressures.

Carter et al. (2003) studied effect of endurance exercise on autonomic control of heart rate. Long-term endurance training significantly influences how the autonomic nervous system controls heart function. Endurance training increases parasympathetic
activity and decreases sympathetic activity in the human heart at rest. Long-term endurance training also decreases submaximal exercise heart rate by reducing sympathetic activity to the heart. Physiological ageing is associated with a reduction in parasympathetic control of the heart; this decline in parasympathetic activity can be reduced by regular endurance exercise. Some research has indicated that females have increased parasympathetic and decreased sympathetic control of heart rate. These gender-specific autonomic differences probably contribute to a decreased cardiovascular risk and increased longevity observed in females.

Perini et al. (2002) studied aerobic training and cardiovascular responses at rest and during exercise in older men and women. The effects of an intense 8-week aerobic training program on cardiovascular responses at rest and during exercise were evaluated. The effects were seen on heart rate, blood pressures, pulse pressure, and oxygen uptake were measured at rest, during, and after exercise. The increase in exercise capacity without changes in cardiovascular parameters suggests that 8 week of aerobic training augmented peripheral gas exchange. The metabolic demand seems to be the main factor for the changes in heart rate that occur during exercise.
Iellamo et al. (1997) studied effects of isokinetic, isotonic and isometric submaximal exercise on heart rate and blood pressure. The purpose of their study was to compare arterial pressure and heart rate responses to submaximal isokinetic, isotonic and isometric exercises employed in physical rehabilitation therapy in terms of both magnitude and time-course. The results of this study indicates that submaximal exercise of a dynamic type induces greater arterial pressure responses than intensity-matched isometric exercise and that even submaximal endurance-type rehabilitation exercise yields an elevated functional stress on the cardiovascular system which could precipitate hazardous events particularly in subjects with unrecognized cardiac diseases.

HEALTH RELATED FITNESS

Regular physical exercise helps in reducing pain, increasing range of motion of joints and improving strength of muscles (American College of Rheumatology, 2000; Bennell et al., 2005; Deyle et al., 2000; Holden et al., 2008; Jan et al., 2009; Lim et al., 2009; Roddy et al., 2005; Steultjens et al., 2001; Thomas et al., 2002). Several studies have revealed the effects of regular physical exercise on various health related fitness parameters in osteoarthritis of knee patients (Fransen et al., 2003; Jan et al., 2009; Jordan et al., 2004; Rajeski et al., 1997; Smidt et al., 2005; Taylor et al., 2007).
Cameron et al. (2006) studied the outcomes on patients with osteoarthritis treated with manual physical therapy and exercise. There was increase in total passive range of motion of joints and decrease in numeric pain rating scores. All patients exhibited reduction in pain and increase in passive range of motion. Table 13 to 16 of the present study shows similar type of effects on pain and range of motion. After 2 months of exercise rehabilitation programme, pain reduced significantly and range of motion improved significantly in both males and females.

Kladny (2005) studied the role of physical therapy on osteoarthritis. Physical therapy is used as a part of guidelines and recommendations in the treatment of osteoarthritis. Different methods were used in the treatment of osteoarthritis. There is evidence that manual physical therapy and exercise improve function and reduce pain in osteoarthritic joints. Table 13 to 16 of the present study showed improvement in functional status of our patients.

Rogind et al. (1998) investigated physical function in patients with severe osteoarthritis of knees. General physical training appears to be beneficial in patients with osteoarthritis of the knee. As shown by the high compliance and low dropout frequency, such a programme is feasible even in patients with severe osteoarthritis of the knee.
The study of Thomas et al. (2002) was to determine whether a home based exercise programme can improve outcomes in patients with knee pain. Primary outcome was self reported score for knee pain on the Western Ontario and McMaster universities index of osteoarthritis at 2 years. Secondary outcomes included knee specific physical function and stiffness (scored on WOMAC index), general physical function (scored on Short Form-36 questionnaire), psychological outlook (scored on hospital anxiety and depression scale) and isometric muscle strength. Regular telephone contact alone did not reduce pain. The reduction in pain was greater the closer patients adhered to the exercise plan. It was concluded that a simple home based exercise programme can significantly reduce knee pain.

Jan et al. (2009) investigated whether weight bearing exercise enhances functional capacity to a greater extent than non weight bearing exercise in patients with osteoarthritis knee. Participants were randomly assigned to weight bearing exercise, non weight bearing exercise or a control group (no exercise). Weight bearing and non weight bearing exercise groups underwent an 8 week knee extension-flexion exercise programme. Western Ontario and McMaster Universities Osteoarthritis Index functional scale, walking speed, muscle torque and knee reposition errors were assessed before and after intervention. Equally significant
improvements were apparent for all outcomes after weight bearing exercise and non weight bearing exercise. There were no improvements in the control group. Simple knee flexion and extension exercises (weight bearing and non weight bearing exercises) performed over a period of 8 weeks resulted in significant improvement in WOMAC function scale and knee strength compared to control group. Tables 13 to 16 of the present study are in accordance with the study of Jan et al. (2009).

Topp et al. (2002) compared 16 weeks of isometric versus dynamic resistance training versus a control on knee pain and functioning among patients with knee osteoarthritis. A total of 102 volunteer subjects with osteoarthritis of the knee randomized to isometric and dynamic resistance training groups or a control were taken. The patients were given strength exercises for the legs, 3 times weekly for 16 weeks. Dynamic group: exercises across a functional range of motion; isometric: exercises at discrete joint angles. Knee pain was assessed immediately after each functional task. The Western Ontario and McMaster Universities Osteoarthritis Index was used to assess perceived pain, stiffness, and functional ability. In the isometric group, time to perform all 4 functional tasks decreased by 16% to 23%. In the dynamic group, time to descend and ascend stairs decreased by 13% to 17%. Both groups decreased knee pain while performing the functional tasks by 28%
to 58%. Other measures of pain and functioning were significantly and favorably affected in the training groups. The improvements in the 2 training groups as a result of their respective therapies were not significantly different. The control group did not change over the duration of the study. Dynamic or isometric resistance training improves functional ability and reduces knee joint pain of patients with knee osteoarthritis. Tables 13 to 16 of the present study are in accordance with the study of Topp et al. (2002). Aerobic exercises were given which caused a decrease in pain, improvement in range of motion and strength in experimental group patients.

Several studies have revealed decreased cardiovascular fitness in the patients of osteoarthritis (Fauci et al., 2008; McArdle et al., 2007; Minor et al., 1988; Philbin et al., 1995; Reis et al., 1995). Cardiovascular fitness is defined as the ability to continue or persist in strenuous task involving large group of muscles for extended period of time (American College of Sports Medicine, 1995; Baroonwaski et al., 1992; Heyward, 2010). This cardiovascular deconditioning results decreased efficiency in delivery of oxygen to the skeletal muscles (Perry, 1985). The inactivity resulted from reduced cardiovascular fitness has further consequences of leading to aggravation of symptoms in the patients of osteoarthritis knee (Philbin et al., 1996).
Minor et al. (1989) studied a group of 120 patients with rheumatoid arthritis and osteoarthritis volunteered to be subjects for this study of aerobic versus non-aerobic exercise. Patients were randomized into an exercise program of aerobic walking, aerobic aquatics or non-aerobic range of motion exercise. Exercise tolerance, disease-related measures and self-reported health status were assessed. The aquatics and walking exercise groups showed significant improvement over the control group in aerobic capacity, 50-foot walking time, depression, anxiety and physical activity after the 12-week exercise program. There were no significant differences in the scores for flexibility, number of clinically active joints, duration of morning stiffness and grip strength. The findings document the feasibility and efficacy of conditioning exercise for people who have rheumatoid arthritis or osteoarthritis.

LaMantia and Marks (1995) studied the efficacy of aerobic exercises for treating patients of osteoarthritis of the knee. Supervised walking programmes and aquarobics combined with stretching and strengthening routines with patient education were given for experimental group. Control group received a non aerobic exercise programme with stretching and strengthening activities with routine patient care. The study revealed decreased pain, increased functional and aerobic capacity in experimental group.
followed by 12 weeks physical conditioning programme when compared with controls receiving a non aerobic exercise programme.

**PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS**

The effect of regular physical exercise on reduction of blood glucose, serum cholesterol, serum triglyceride, serum uric acid levels and elevation of haemoglobin and serum high density lipoprotein levels is evident. Several studies have revealed the effects of regular physical exercise on various physiological and biochemical parameters (Al-Arfaj, 2003; Bhatti and Shaikh, 2007; Black and Karpovich, 1945; Fujitsuka et al., 2005; Giada et al., 1991; Green and Fraser, 1988; Hart et al., 1995; Kjellberg et al., 1949; Kokkinos and Fernhall, 1999; Lampman and Schteingart, 1991; Motoyama et al., 1995; Nagel et al., 1992; Sato et al., 2003; Sohal and Chander, 1997; Sturmer et al., 2001; Sturmer et al., 1998; Sun et al., 2000; Wardyn et al., 2008).

Roitman and Brewer (1973) studied the effects of chronic and acute exercise upon selected blood measures and indices. Red blood cell count, haemoglobin and haematocrit were measured using standard laboratory techniques. The subjects were studied under chronic exercise conditions, that is, throughout the eight week season, and under acute exercise conditions. Samples were taken during the preseason, at two times during training, once after the
season was completed and after two weeks of de-training. The results showed that the haemoglobin level increased significantly from pre-season to post season period (p<0.01). The present study tallies with the study of Roitman and Brewer (1973). The haemoglobin level increased significantly after two months of exercise rehabilitation programme.

The study of Wardyn et al. (2008) also determined the effects of exercise on hematological indices, circulating side population (SP) cells and cytokines. Specifically haemoglobin, haematocrit, white blood cells, platelets, SP cells, plasma vascular endothelial growth factor (VEGF) and interleukin-6 (IL-6) levels were analysed before and following exercise to maximal fatigue. Thirty seven subjects, aged 19 to 35 years, free of cardiopulmonary disease were enrolled and characterized as trained or untrained. Standard hematological indices were measured. Following exercise, significant increases were observed in haemoglobin, haematocrit, platelets, circulating SP cells and interleukin-6 (IL-6) levels in young healthy individuals of both genders and all fitness levels. These changes in haematological, haematopoitic and cytokine parameters suggest that exercise can have a physiological impact by potentially mobilizing stem cells and thereby enhancing tissue repair mechanisms. Tables 17 to 20 of the present study showed significant increase in haemoglobin level after 2 months of exercise programme.
Petersen and Pendersen (2005) studied anti-inflammatory effect of exercise. Regular exercise offers protection against type 2 diabetes mellitus and cardiovascular disease. These disorders have been associated with chronic low grade systemic inflammation reflected by a two to threefold elevated level of several cytokines. Regular exercise also helps production of myokines from contracting skeletal muscle fibres. These myokines are involved in mediating the health beneficial effects of exercise and that in particular are involved in the protection against chronic diseases associated with low grade inflammation such as diabetes and cardiovascular disease.

Neuberger et al. (2007) studied the effects of aerobic exercise on symptoms, function, aerobic fitness and disease outcomes of rheumatoid arthritis patients. 220 patients of age group 40-70 years were studied and measures were obtained at baseline, after 6 weeks of exercise and after 12 weeks of exercise. The disease activity was measured using total blood count, erythrocyte sedimentation rate (ESR) and C-reactive protein levels. Overall symptoms like pain, fatigue and depression were decreased significantly; however there were no significant increase in measures of disease activity. The erythrocyte sedimentation rate (ESR) and C-reactive protein levels decreased consistently at baseline, after 6 weeks of exercise and after 12 weeks of exercise.
but not to a significant level. **Tables 17 to 20** of the present study also showed similar results.

Sato *et al.* (2003) reviewed the evidences based on experimental studies in which physical exercise was described as a beneficial entity on the decreased insulin sensitivity caused by detrimental lifestyle. The major purpose of physical exercise for primary prevention and treatment of lifestyle-related diseases is to improve insulin sensitivity. It was found that continued physical training with moderate or low intensity exercise improves the reduced peripheral tissue sensitivity to insulin in impaired glucose tolerance and diabetes, along with regularization of abnormal lipid metabolism. **Tables 21 to 24** of the present study showed similar results. Fasting blood glucose, serum cholesterol and serum triglyceride shows significant decrease, however serum high density lipoprotein cholesterol shows significant increase in both males and females after 2 months of exercise rehabilitation program.

Regular physical exercise has been known to be beneficial in the treatment of blood glucose parameter in type 2 diabetes mellitus (Martin and Wahren, 1993). Physical exercise promotes utilization of blood glucose and lowers blood glucose levels. Recent data suggested that the improvement of insulin action by physical exercise was attributed to the increase in insulin-sensitive GLUT4 (glucose transporter 4) on the plasma membrane in skeletal muscle
The results showed significant decrease in fasting blood glucose levels at various intervals of time duration. In conclusion, as an adjunct to other forms of therapy, regular physical exercise will play an important role in regulation of blood glucose in type 2 diabetes mellitus. **Tables 21 to 24** of the present study also tallies with the study of Sato (2000).

Sturmer *et al.* (2001) studied 809 patients with knee or hip joint replacement due to osteoarthritis. Non insulin dependent diabetes mellitus (NIDDM) was defined by a history of physician diagnosed diabetes or use of antihyperglycemics. Patients with non insulin dependent diabetes mellitus had more often bilateral osteoarthritis. So, it can be concluded that non insulin dependent diabetes mellitus might be a potentially important systemic risk factor for knee and hip osteoarthritis. There is prevalence of non insulin dependent diabetes mellitus in osteoarthritis knee patients of the present study **(Table 3)**.

Sturmer *et al.* (1998) studied the association between serum cholesterol and osteoarthritis. A total of 809 patients with knee or hip osteoarthritis were studied. Radiographs of the joints as well as blood samples for serum cholesterol were obtained. According to the presence or absence of radiographic features in osteoarthritis, participants were categorized as having bilateral or unilateral osteoarthritis. 85% of participants with radiographs had bilateral
osteoahtritis and 26% had generalized osteoarthritis. Hypercholesterolemia was independently associated with generalized osteoarthritis. This association was almost exclusively due to participants with knee osteoarthritis. The effect of regular physical exercise on the reduction of serum cholesterol levels was also evident. **Tables 21 to 24** of the present study also showed similar results.

Previous studies employing sub maximal exercise showed amelioration of insulin sensitivity, glucose control and improvement of lipid profile. For these reasons, regular aerobic physical activity must be considered as an essential component of the cure of type 2 diabetes mellitus (Santeusanio et al., 2003). **Tables 21 to 24** concludes the similar type of effects on fasting blood glucose, serum cholesterol, serum triglycerides and serum high density lipoprotein cholesterol after 2 months of sub maximal exercise programme.

Exercise has been shown to be beneficial in the prevention of the onset of type 2 diabetes mellitus as well as in the improvement of glucose control as a result of enhanced insulin sensitivity (Helmrich et al., 1994; Martin and Wahren, 1993). Decreased intra-abdominal fat, an increase in insulin sensitive glucose transporters (GLUT-4) in muscle, enhanced blood flow to insulin sensitive tissues and reduced free fatty acid levels appear to be the mechanisms by which exercise restores insulin sensitivity (Erisonn et al., 1997).
Exercise reduces blood glucose through an increase of insulin dependent and insulin independent glucose transport to working muscles (Hamdy et al., 2001). Exercise increases the translocation of glucose transporter 4 (GLUT 4) to the surface of muscle cells (Hayashi et al., 1977).

There is evidence for the presence of two distinct pools of GLUT 4 in skeletal muscle, one responding to exercise and one responding to insulin (Douen et al., 1990; Douen et al., 1989). Muscle contraction increases the AMP/ATP and creatinine/phosphocreatine ratios which rapidly activate adenosine monophosphate protein kinase (AMPK), a key mediator of fatty acid oxidation (Hutber et al., 1997) and glucose transport (Hayashi et al., 1998) in mammalian cells. During muscle contraction, AMPK appears to produce the translocation of GLUT 4 of either the insulin dependent (Merrill et al., 1997) or insulin independent pools. In type 2 diabetic subjects, physical training increases insulin stimulated non oxidative glucose disposal (Bogardus et al., 1984) presumably activating glycogen synthesis. The beneficial effects of regular physical activity on insulin sensitivity appear to be the final result of sum of specific effects of exercise on GLUT 4 content, oxidative capacity and capillary density of skeletal muscle.

Endurance exercise training increases the oxidation of fat during sub maximal exercise (Henriksson, 1977; Jansson and
Kaijser, 1987; Svacinova et al., 2003). Several factors contribute to this adaptive response: increased density of mitochondria in the skeletal muscles, which increases the capacity for fat oxidation (Holloszy, 1967); a proliferation of capillaries within skeletal muscle, which enhances fatty acid delivery to muscle (Saltin and Gollnick, 1983); an increase in carnitine transferase, which facilitates fatty acid transport across the mitochondrial membrane (Mole et al., 1971); and an increase in fatty acid binding proteins, which regulate myocyte fatty acid transport (Turcotte et al., 1999; Turcotte et al, 1991).

Regular physical exercise favorably improves the lipid profile in patients with diabetes mellitus. Serum cholesterol levels are significantly reduced and HDL-c increases significantly (Rimmer and Looney, 1997). Exercise has also been shown to lower serum triglycerides levels in individuals with NIDDM (Ronnemma et al., 1988). The present study also tallies with the study of Ronnemma et al., 1988. He studied the effects of four months physical exercise on serum lipids, lipoproteins and lipid metabolizing enzymes in 25 non insulin dependent diabetic patients into exercise (N = 13) and control (N = 12) groups. Exercise induced a significant decrease in serum cholesterol and an increase in serum HDL-c levels. **Tables 21-24** of the present study showed the effect of exercise rehabilitation programme on serum cholesterol,
serum triglyceride and serum HDL-c levels in patients of osteoarthritis knee. The results are in accordance with the above studies showing gradual decrease in serum cholesterol and serum triglyceride and increase in serum HDL-c levels.

Regular physical activity reduces serum triglycerides concentrations. So, physical exercise programmes should be included in the management of patients with type 2 diabetes mellitus (Uusitupa, 1991). The present study also suggests the role of exercises on reduction of serum triglycerides concentrations.

Regular physical activity modestly increases HDL-c levels (Kodama et al., 2007). The present study also tallies with the study of Kodama et al., 2007. He studied electronic database searches of MEDLINE (1966-2005) for randomized controlled trials that examined the effect of exercise training on HDL-c level. Twenty five articles were included. Mean net change in HDL-c was statistically significant. Tables 21 to 24 of the present study also showed the similar results.

Sun et al. (2000) studied the association between uric acid and patterns of osteoarthritis. Patterns of osteoarthritis were studied in 809 patients with hip or knee osteoarthritis. Patients with osteoarthritis were categorized as having bilateral or generalized osteoarthritis according to the presence of radiographic features. Odds ratios (OR) and 95% confidence intervals (CI) of serum uric
acid and osteoarthritis patterns were estimated with multivariable logistic regression. A positive association between serum uric acid and generalized osteoarthritis was observed. The results suggest a possible role of elevated serum uric acid in the multifactorial etiology of generalized osteoarthritis. Tables 21 to 24 of the present study tallied with the study of Sun et al. (2000).

Several studies demonstrated the effect of exercise on serum uric acid levels (Green and Fraser, 1988; Hashizume and Matsumoto, 2003; Ito, 2000; Lippi et al., 2004; Taniguchi, 2003). The effect depends upon type of exercise performed.

Francis and Hamrick (1984) studied the effect of chronic exercise on hyperuricemia. He concluded that chronic exercise not only helps reducing the risk factor for coronary heart disease but also lowers serum uric acid levels. Tables 21 to 24 of the present study tallied with the study of Francis and Hamrick (1984).

Lippi et al. (2004) compared the levels of serum albumin, creatinine, uric acid and glucose in endurance athletes with healthy controls. The results showed decreased levels of serum albumin, serum creatinine, uric acid and glucose in endurance athletes. Tables 21 to 24 of the present study also showed similar results.