CHAPTER II

REVIEW OF RELATED LITERATURE

The literature related to any problem helps the scholar to discover what is already known, which would enable the investigator to have a deep insight, clear perspective and a better understanding of the chosen problem and various factors connected with the study. So a number of books, journals, and websites were referred. In the following pages, an attempt has been made to present briefly a few of the important researches and studies conducted abroad and in India, as they have significant bearing on the present study.

The reviews of the literature have been classified under the following headings.

1. Studies on Osteoporosis
2. Studies on Strength and Endurance Training
3. Studies on Body Composition
4. Studies on Dietary Supplementation
5. Studies on Biochemical and Hormonal Variable
6. Summary of related literature

2.1 STUDIES ON OSTEOPOROSIS

Alejandro & Constantinescu (2017) documented Osteoporosis in the elderly population is common. It results in more than 1.5 million fractures per year in the United States. The goal of managing osteoporosis is to prevent fractures. In men, osteoporosis is under recognized and undertreated. More men than women die every year as a consequence of hip fractures.

Pande, (2002) analyzed the database of bone mineral density (BMD)in the Indian women and men said that 29.9% women and 24.3% of men between the age of 20 &79 years had low bone mass and about 50% of women and 36% of men over 50 years of age were noted to have low bone mass. The observation of this study suggested the existence of a higher prevalence of low bone mineral density (BMD) in the Indian population compared to the western population.

Multani, et al., (2010) carried out a prospective, cross sectional study in a tertiary health care centre to assess the bone mineral density (BMD) by DEXA method among 214 resident doctors. Osteopenia was noted in 104 (59.7%) females and 27 (67.5%) males. Thirty two (18.39%) females and five (12.5%) males had osteoporosis. Bone mineral density (BMD) had significant positive correlation with weight, height, body mass index, physical activity and dietary calcium phosphorus ratio.

Sahana Shetty, et al, (2011) examined the prevalence of osteoporosis and vitamin D status in healthy South Indian men and to study the influence of various life style factors on bone mineral density. The cross sectional survey study conducted over a duration period of 1 year conducted on men above 50 years of age, out of the total 256 subjects, 63 warranted treatment (50 had osteoporosis plus 13 osteopenics with a more than 3% probable risk of hip fracture). A significantly larger proportion of otherwise normal healthy men in the community had osteoporosis and vitamin D deficiency compared to previously published studies.

Cummings and Melton (2002) reported that bone mass declines and the risk of fractures increases as people age. Hip fractures, the most serious outcome of osteoporosis, are becoming more frequent than before because the world's population is ageing and because the frequency of hip fractures is increasing by 1–3% per year in most areas of the world. Low bone density and previous fractures are risk factors for almost all types of fracture. Prevention of fractures with drugs could potentially be as expensive as medical treatment of fractures. Therefore, epidemiological research should be done and used to identify individuals at high-risk of disabling fractures.

Bonnick, (2006) reviewed the related literature concluded that Osteoporosis is a cause of significant morbidity and mortality in postmenopausal women as well as men. In both men and women, increasing age and low bone mineral density (BMD) are the 2 most important independent risk factors for an initial vertebral or non-vertebral fracture. Although the prevalence of osteoporosis is greater in women, mortality after fracture is higher among men. In both men and women, the incidence of vertebral fracture increases with age, although the increase is more marked in women than in men. The diagnostic criteria for postmenopausal osteoporosis in women are well established; however, there is ongoing debate about the appropriate T-scores and bone mineral density (BMD) thresholds to diagnose osteoporosis in men.

Watts et al., (2012) documented Osteoporosis in men causes' significant morbidity and mortality. They recommend testing higher risk men [aged ≥70 and men aged 50-69 who have risk factors (e.g. low body weight, prior fracture as an adult, smoking, etc.)] using central dual-energy x-ray absorptiometry. Laboratory testing should be done to detect contributing causes. Adequate calcium and vitamin D and weight-bearing exercise should be encouraged; smoking and excessive alcohol should be avoided. Pharmacological treatment is recommended for men aged 50 or older who have had spine or hip fractures, those with T-scores of -2.5 or below, and men at high risk of fracture based on low bone mineral density and/or clinical risk factors. Treatment should be monitored with serial dual-energy x-ray absorptiometry testing.

Aggarwal, Aggarwal, Gupta & Misra (2006) assessed the prevalence of osteopenia in Southeast Asian men with active juvenile idiopathic arthritis (JIA) and to identify predictors of reduced bone mineral density (BMD). Bone mineral density (BMD) of 30 men with active juvenile idiopathic arthritis and 23 healthy men was assessed by dual energy x-ray absorptiometry scans. Clinical variables that influence bone mineral density were analyzed. T scores were calculated based on Caucasian normative data. Absolute bone mineral density (g/cm (2)) was significantly lower in men with active JIA compared to controls at all measured sites, i.e., lumbar spine ($p = 0.018$), hip ($p = 0.018$), and distal third of forearm ($p = 0.044$). More subjects in the JIA group had low bone mineral density (BMD) (T score < or= -1.0) than controls at hip (22/30 vs. 9/23; $p < 0.05$) and distal third of forearm (27/30 vs. 10/23; $p < 0.001$), while at lumbar spine region the difference was not statistically significant (22/30 vs. 13/23). A positive correlation of bone mineral density was found with body mass index. A majority of Southeast Asian men with active juvenile idiopathic arthritis have reduced bone mineral density. More patients in the cohort had low bone mineral density compared to reports from Western countries. This finding may be attributed to use of Caucasian normative data, uncontrolled disease activity, severity of disease, poor nutritional status, or an ethnic variation.

Sahana Shetty (2014) studied the prevalence of osteoporosis and vitamin D deficiency in healthy men and explored the influence of various life style factors on bone mineral density (BMD). Ambulatory south Indian men aged above 50 were recruited by cluster random sampling. The physical activity, risk factors in the FRAX tool, BMD, vitamin D, and PTH were assessed. The number of people needing treatment was calculated, which included subjects with osteoporosis and osteopenia with 10-year probability of major osteoporotic fracture >20 percent and hip fracture >3 percent in FRAX India. A total of 252 men with a mean age of 58 years were studied. The prevalence of osteoporosis and osteopenia at any one site was 20% (50/252) and 58%, respectively. Vitamin D deficiency (<20 ng/dL) was seen in 53%. On multiple logistic regression, BMI (OR 0.3; value = 0.04) and physical activity (OR 0.4; value < 0.001) had protective effect on BMD. Twenty-five percent warranted treatment. A significantly large proportion of south Indian men had osteoporosis and vitamin D deficiency.

Marwaha et al., (2011) examined One thousand six hundred healthy subjects aged more than 50 years, residing in Delhi, were evaluated for bone mineral metabolic parameters. High prevalence of osteoporosis (35.1% subjects) was observed in this population. Bone mineral density (BMD) correlated positively with body mass index (BMI) and negatively with parathyroid hormone (PTH) levels. No correlation was observed with serum 25-hydroxyvitamin D levels.

According to Going & Laudermilk (2009) Osteoporosis is a major public health problem. Mechanical strain, imparted by muscle action and ground reaction forces, regulates bone size, shape, mineral mass, and density and subsequently bone strength. Thus, physical activity is critical for bone development, bone health, and fracture risk reduction. Animal studies, in which strain can be manipulated and measured directly, consistently show bone responds to high-strain magnitudes and rates, and only a few repetitions are needed to elicit a response. Extrapolation to humans suggests resistance exercise may be effective for osteoporosis prevention. Indeed, strength-trained athletes have significantly higher bone mass and density than athletes and non-athletes who do not engage in similar training. Prospective studies also support the benefits of resistance exercise demonstrating slowed bone loss and often an increase of 1% to 3% in regional bone mineral density, especially in women. Although more work is needed to define the optimal dose and the effects of non-mechanical factors (eg, nutritional, endocrine, body composition) on the response, the effects of resistance exercise on muscle mass and strength, balance, and agility, in addition to direct skeletal benefits, underscore its importance for osteoporosis, falls, and fracture prevention.

2.2 STUDIES ON STRENGTH AND ENDURANCE TRAINING

Mohammad hasan khodkaran, Ali hosseini and Ali ghasemi, (2014) investigated the effect of resistance training and intake of calcium and phosphorous on bone density of the nonathletic adolescents. For the purpose, 30 volunteer nonathletic adolescents with mean age of 17.60 ±0.3, weight of 61.31±5.95, height of 162.7±6.21 cm , BMI of 23.37±1.96 kg/m^2 were randomly divided in three groups each including 10 people i.e. resistance exercise, resistance exercise and intake of calcium and phosphor and control group. The resistance exercise programs with intensity of 60 to 80% of a maximum repetition were performed for 8 weeks and 3 days per week. The blood samples of each group of subjects were taken separately before and after completion of the resistance exercise protocol and resistance exercise with intake of supplement for measurement of indices of bone density, Osteocalcin, parathyroid, Alkaline phosphatase, calcium and phosphor in specialized laboratory. Dependent t-test for intra-group changes and one-way ANOVA test was performed to study difference between groups in alpha level of 0.05. The study concluded that the resistance exercise group and resistance exercise group with supplement intake showed significant increase in levels of osteocalcin, parathyroid, alkaline phosphatase, calcium and phosphorus and this increase in the resistance exercise group with calcium and phosphorus supplement intake was higher than that in resistance exercise group. Therefore, based on results of this research, it can be mentioned that intake of calcium and phosphorus supplement along with resistance exercise led to more increase of osteocalcin, parathyroid, alkaline phosphatase, calcium and phosphorus of the body compared with the resistance exercise alone.

Perez-Gomez, et al., (2013) investigated the effect of 10-week of endurance training or resistance training on regional and abdominal fat, and in the lipid profile, examining the associations among the changes in body composition, weight, waist circumference and lipid profile. Body composition, waist circumference and lipid profile were analysed in 26 volunteers healthy young men (age 22.5 ±

1.9 year), randomly assigned to: endurance group (EG), resistance group (RG) or control group (CG). The endurance group significantly decreased after training the body weight, body mass index, total body fat and percentage of fat, fat and percentage of fat at the trunk and at the abdominal region and High-Density Lipoprotein. The resistance group significantly increased total lean mass and decreased total cholesterol, High-Density and Low-Density Lipoprotein. Close relationship were found among changes in weight, total lean mass, regional fat mass, waist circumference and changes in lipid profile ($p < 0.05$). The study was concluded for 10-week of endurance training decreased abdominal and body fat in young men, while 10-week of resistance training increased total lean mass. These types of training had also effects on lipid profile that seem to be to some extent associated to changes in body composition.

Bolam, Vanuffelen& Taaffe, (2013) assessed the effect of weight-bearing and resistance-based exercises interventions on bone mineral density (BMD) measured by dual-energy x-ray absorptiometry, and reported effects in middle-aged and older men were included. Eight trials detailed in nine papers were included. The interventions included walking (n = 2), resistance training (n = 3), walking + resistance training (n = 1), resistance training + impact-loading activities (n = 1) and resistance training + Tai Chi (n = 1). Five of the eight trials achieved a score of less than 50% on the modified Delphi quality rating scale. Further, there was heterogeneity in the type, intensity, frequency and duration of the exercise regimens. Effects of exercise varied greatly among studies, with six interventions having a positive effect on bone mineral density (BMD) and two interventions having no significant effect. It appears that resistance training alone or in combination with impact-loading activities are most osteogenic for this population, whereas the walking trials had limited effect on BMD. Therefore, regular resistance training and impact-loading activities should be considered as a strategy to prevent osteoporosis in middle-aged and older men. High quality randomised controlled trials are needed to establish the optimal exercise prescription

Binder, (2005) studied the effect of progressive resistance exercise training (PRT) to increase muscle strength and fat-free mass (FFM) in elderly persons. Ninety-one community-dwelling sedentary men and women, 78 years and older with physical frailty were enrolled in a 9-month trial of exercise training (ET). Physical frailty was defined as having 2 of the 3 following criteria: modified Physical Performance Test score between 18 and 32, peak aerobic power between 10 and 18 ml/kg/min, or self-report of difficulty or assistance with two instrumental activities of daily living or one basic activity of daily living. Participants were randomly assigned to either a control group that performed a low intensity home exercise program or a supervised exercise training (ET) group that performed 3 months of low intensity exercise and 3 months of progressive resistance exercise training (PRT). After completion of progressive resistance exercise training (PRT), exercise training (ET) participants had greater improvements than the control group participants in maximal voluntary force production for knee extension (mean Δ +5.3 ± 13 ft/lb vs. +1.1 ± 11 ft/lb, p =.05), measured using isokinetic dynamometry. Total body fat-free mass (FFM) (measured using dual energy x-ray absorptiometry) increased in the exercise training (ET) group, but not in the control group (mean Δ +0.84 ± 1.4 kg vs. +0.01 ± 1.5 kg, p =.005). Total, trunk, intra-abdominal, and subcutaneous fat mass did not change in response to progressive resistance exercise training (PRT). Three months of supervised progressive resistance exercise training (PRT) induced improvements in maximal voluntary thigh muscle strength and whole body fat-free mass (FFM) in frail, community-dwelling elderly women and men. This supervised exercise program may not be sufficient to reduce whole-body or intra-abdominal fat area in the population.

Mohamed, (2016) evaluated the role of resistant training on bone density of female students in 100, 200 meters run. Twenty volunteers of female students (age 18-20y) participants, in 100, meters run were assigned to a resistant training group (n = 10), three times weekly for 12 weeks and a control group (n = 10). The resistance training group performed knee extensors by dynamic leg press, and leg extension exercises increasing from low (20RM) to high (8RM) resistance. The control group did not participate to any training. Hip bone density was measured using DEXA, before and after intervention, leg strength was measured by dynamometer, parathyroid hormone by Elisa, calcium by atomic absorption method, data were analysed by means of ANOVA. Resistance training improved leg strength tests, and also increased significantly BMD, calcium and parathyroid hormone increased significantly $P > 0.05$. These findings suggest that resistant training may be effective in retardation osteoporosis and modify risk factors.

Ryan, et al., (2013) determined the effects of 6 months of whole-body resistive training (RT) on total and regional bone mineral density (BMD) and bone mineral content (BMC) by age and gender in young and older men and women. Younger men (n=10) and women (n=7) aged 20-29 years (25+/-1 years) and older men (n=10) and women (n=10) aged 65-74 years (69+/-1 years) participated in 6 months of progressive whole-body RT. Total body fat, lean tissue mass, femoral neck bone mineral density (BMD), Ward's triangle BMD, greater trochanter bone mineral density (BMD), total-body BMD, and L2-L4 spine bone mineral density (BMD)were determined by dual-energy X-ray absorptiometry before and after 6 months of resistive training (RT). Percent body fat decreased only in the young men ($P<0.05$). Lean tissue mass increased after training in young men and women and older men ($P<0.05$) but did not change significantly in older women. Upper- and lower-body 1RM strength increased in all groups ($P<0.01$). Overall, there was a significant increase in bone mineral density (BMD) at the femoral neck, ward's triangle and greater trochanter BMD, as well as total body BMC and leg BMC ($P<0.05$). Total-body BMD and L2-L4 spine BMD did not change with resistive training (RT). There were no gender differences in the training response between men and women for any of the bone mineral density (BMD) regions and no age differences in the training response, except for a trend between young and older subjects for femoral neck ($P<0.08$). A 6-month resistive training (RT) program increases muscle mass and improves bone mineral density (BMD) of the femoral region in young and healthy older men and women as a group, with a trend for this to be greater in young subjects.

Mayer, et al., (2011) studied the intensity and effects of strength training in the elderly and concluded that the elderly needed strength training more and more as they grow older to stay mobile for their everyday activities. The goal of training is to reduce the loss of muscle mass and the resulting loss of motor function. The dose-response relationship of training intensity to training effect has not yet been fully elucidated. Strength training in the elderly (>60 years) increases muscle strength by increasing muscle mass and by improving the recruitment of motor units, and increasing their firing rate. Muscle mass can be increased through training at an intensity corresponding to 60% to 85% of the individual maximum voluntary strength. Improving the rate of force development requires training at a higher intensity (above 85%), in the elderly just as in younger persons. It is now recommended that healthy old people should train 3 or 4 times weekly for the best results; persons with poor performance at the outset can achieve improvement even with less frequent training. Side effects are rare.

Progressive strength training in the elderly is efficient, even with higher intensities, to reduce sarcopenia, and to retain motor function.

Hunter, McCarthy & Bamman, (2004) reviewed the highlights and the benefits of resistance training toward improvements in functional status, health and quality of life among older adults. Sarcopenia (i.e. muscle atrophy) and loss of strength are known to occur with age. While its aetiology is poorly understood, the multifactorial squeal of sarcopenia are well documented and present a major public health concern to the aging population, as both the quality of life and the likelihood of age-associated declines in health status are influenced. These age-related declines in health include decreased energy expenditure at rest and during exercise, and increased body fat and its accompanying increased dyslipidaemia and reduced insulin sensitivity. Quality of life is affected by reduced strength and endurance and increased difficulty in being physically active. Strength and muscle mass are increased following resistance training in older adults through a poorly understood series of events that appears to involve the recruitment of satellite cells to support hypertrophy of mature myofibres. Muscle quality (strength relative to muscle mass) also increases with resistance training in older adults possibly for a number of reasons, including increased ability to neurally activate motor units and increased high-energy phosphate availability. Resistance training in older adults also increases power, reduces the difficulty of performing daily tasks, enhances energy expenditure and body composition, and promotes participation in spontaneous physical activity. Impairment in strength development may result when aerobic training is added to resistance training but can be avoided with training limited to 3 days/week.

Hurley & Roth, (2000) stated that the strength training (ST) is considered a promising intervention for reversing the loss of muscle function and the deterioration of muscle structure that is associated with advanced age. This reversal is thought to result in improvements in functional abilities and health status in the elderly by increasing muscle mass, strength and power and by increasing bone mineral density (BMD). In the past couple of decades, many studies have examined the effects of strength training on risk factors for age-related diseases or disabilities. Collectively, these studies indicate that strength training in the elderly is an effective intervention against sarcopenia because it produces substantial increases in the strength, mass, power and quality of skeletal muscle; strength training can increase endurance performance and normalises blood pressure in those with high normal values and reduces insulin resistance. It also decreases both total and intra-abdominal fat and increases resting metabolic rate in older men, prevents the loss of bone mineral density with age and reduces risk factors for falls and may reduce pain and improve function in those with osteoarthritis in the knee region. However, contrary to popular belief, strength training does not increase maximal oxygen uptake beyond normal variations, improve lipoprotein or lipid profiles, or improve flexibility in the elderly.

Strandberg (2015) evaluated the effects of 24 weeks of resistance training combined with a healthy dietary approach (n-6/n-3 ratio < 2) in a population of healthy and physically active older women (65-70 years). The three-armed randomized controlled trial included a resistance training + healthy diet group (RT-HD), a resistance training group (RT), and controls (CON). All subjects included in the study were physically active and had low levels of serum inflammatory markers. In accordance with the dietary goals, the n-6/n-3 ratio dietary intake significantly decreased only in resistance training + healthy diet group (RT-HD) by 42%. An increase in 1 repetition maximum in leg extension occurred in resistance training group (RT) (+20.4%) and resistance training + healthy diet group (RT-HD) (+20.8%), but not in CON. Interestingly, leg lean mass significantly increased only in resistance training + healthy diet group (RT-HD) (+1.8%). While there were no changes in serum C-reactive protein and IL-6 levels, a significant decrease in serum level of the pro-inflammatory precursor arachidonic acid (−5.3 ± 9.4%) together with an increase in serum n-3 docosahexaenoic acid (+8.3%) occurred only in resistance training + healthy diet group (RT-HD). Altogether, this study demonstrated that the effects of resistance training on muscle mass in healthy older adults can be optimized by the adoption of a healthy diet.

2.3 STUDIES ON BODY COMPOSITION

Kelley, Kelley, & Tran, (2000) examined the effects of exercise on bone mineral density (BMD) in men through the meta-analytic approach. A total of 26 effect sizes (ES) representing 225 subjects from 8 studies met the criteria for inclusion. When bone mineral density (BMD) sites assessed were specific to the sites loaded during exercise, increases of 2.6% (2.1% in the exercisers and −0.5% in the controls) were found. These results were statistically significant (ES = 0.213, 95% bootstrap confidence interval = 0.007–0.452). Statistically significant ES changes were found for older (>31 year) but not younger (<31 year) adults, with differences between groups statistically significant (*P* = 0.04). Statistically significant changes were also observed at the femur, lumbar, and oscalcis sites. The results of this study suggest that site-specific exercise may help improve and maintain bone mineral density (BMD) at the femur, lumbar, and oscalcis sites in older men. However, the biological importance of the small changes observed for most outcomes, quality of studies, and limited data pool prevents from forming any firm conclusion regarding the use of exercise for maintaining and/or improving bone mineral density (BMD) in men. Clearly, a need exists for additional studies.

Kemmler & Engelke, (2004) reviewed the evidence of positive exercise effects on bone mineral density (BMD) in early postmenopausal women (0.5–8 years postmenopausal) by summarising existing studies in this area. Nine studies were identified and included in this review.

All the studies included a non-training control group; half of them were randomised. Exercise effects on bone mineral density at the hip and the spine were qualitatively compared predominantly based on the type of exercise and study duration. A quantitative analysis was not possible due to the in homogeneity of the studies. 5 out of 7 studies (6 out of 9 exercising subgroups) demonstrated significant positive exercise effects defined as bone mineral density (BMD) differences in the exercise versus control group at the lumbar spine, and 3 out of 6 at the proximal femur. Intervention periods of all studies showing no positive results were shorter than nine months. However, only 3 studies showed significant positive bone mineral density (BMD) changes in the exercise group alone. All of these studies used mixed exercise regimes using high impact exercises and resistance training. The results suggest that in particular exercise programmes with high impact and resistance training lasting longer than a year help to maintain or even improve bone mineral density (BMD) at the lumbar spine and hip in early postmenopausal women.

Nindl, et al., (2000) examined the effect of physical training among women to assess changes in whole body and regional (i.e., trunk, legs, arms) fat mass, lean mass, and bone mineral content body composition adaptations in 31 healthy women pre-, mid-, and post-6 mo of periodized physical training. These results were compared with those of a control group of women who had not undergone the training program and were assessed pre- and post-6 months and a group of 18 men that was tested only once. Additionally, magnetic resonance imaging was used to assess changes in muscle morphology of the thigh in a subset of 11 members of the training group. Physical training consisted of a combination of aerobic and resistance exercise in which the subjects engaged for 5 days/week for 24 weeks. Overall, the training group experienced a 2.2% decrease, a 10% decrease, and a 2.2% increase for body mass, fat mass and soft tissue lean mass, respectively. No changes in bone mineral content were detected. The women had less of their soft tissue lean mass distributed in their arms than did the men, both before and after the women were trained. Novel to this study were the striking differences in the responses in the tissue composition of the arms (31% loss in fat mass but no change in lean mass) compared with the legs (5.5% gain in lean mass but no change in fat mass). There was a 12% fat loss in the trunk with no change in soft tissue lean mass. Dual-energy X-ray absorptiometry and magnetic resonance imaging fat mass measurements showed good agreement (r = 0. 72-0.92); their lean mass measurements were similar as well, showing approximately 5.5% increases in leg lean tissue. These findings show the importance of considering regional body composition changes, rather than whole body changes alone when assessing the effects of a periodized physical training program.

Chilibeck, et al., (2002) evaluated the combined the effects of exercise training and bisphosphonate (etidronate) therapy on bone mineral in postmenopausal women was compared. Forty-eight postmenopausal women were randomly assigned (double blind) to groups that took intermittent cyclical etidronate; performed strength training (3 days/week) and received matched placebo; combined strength training with etidronate; or took placebo and served as non-exercising controls. Bone mineral, lean tissue, and fat mass were assessed by dual-energy X-ray absorptiometry before and after 12 months of intervention. After removal of outlier results, changes in bone mineral density (BMD) of the lumbar spine and bone mineral content (BMC) of the whole body were greater in the subjects given etidronate (+2.5 and +1.4%, respectively) compared with placebo (-0.32 and 0%, respectively) ($p < 0.05$), while exercise had no effect. There was no effect of etidronate or exercise on the proximal femur and there was no interaction between exercise and etidronate at any bone site. Exercise training resulted in significantly greater increases in muscular strength and lean tissue mass and greater loss of fat mass compared with controls. They conclude that etidronate significantly increases lumbar spine bone mineral density (BMD) and whole-body BMC and that strength training has no additional effect. Strength training favourably affects body composition and muscular strength, which may be important for prevention of falls.

Ramirez-Campillo, et al., (2013) examined the effects of a localized muscle endurance resistance training program on total body and regional tissue composition. Seven men and 4 women (aged 23 ± 1 year) were trained with their non-dominant leg during 12 weeks, 3 sessions per week. Each session consisted of 1 set of 960-1, 200 repetitions (leg press exercise), at 10-30% 1 repetition maximum. Body mass, bone mass, bone mineral density (BMD), lean mass, fat mass, and fat percentage were determined by dual-emission x-ray absorptiometry. Energy intakes were registered using a food recall questionnaire. At the whole-body level, body mass, bone mass, BMD, lean mass, or body fat percentage was not significantly changed. However, body fat mass significantly decreased by 5.1% (pre-exercise: 13.5 ± 6.3 kg; post-exercise: 12.8 ± 5.4 kg, $p < 0.05$). No significant changes in bone mass, lean mass, fat mass or fat percentage were observed in both the control and trained leg. A significant ($p < 0.05$) decrease in fat mass was observed in the upper extremities and trunk (10.2 and 6.9%, respectively, $p < 0.05$). The reduction of fat mass in the upper extremities and trunk was significantly greater ($p < 0.05$) than the fat mass change observed in the trained leg but not in the control leg. No significant changes were observed in energy intake pre- and post-exercise intervention (2,646 ± 444 kcal·d-1 and 2,677 ± 617 kcal·d-1, respectively). In conclusion, the training program was effective in reducing fat mass, but this reduction was not achieved in the trained body segment.

Nichols, Sanborn & Love, (2001) examined the effects of 15 months of resistance training on bone mineral density (BMD) in female adolescents (aged 14 to 17 years). Participants were randomly assigned to either a training (n= 46) or control group (n = 21). Bone mineral density (BMD) and body composition were measured by using dual-energy x-ray absorptiometry. Strength was assessed by means of one-repetition maximums for the leg press and bench press. The exercise group trained 30 to 45 minutes a day, 3 days per week, using 15 different resistance exercises. Control participants remained sedentary (<2hours of exercise per week). Leg strength increased significantly (40%) in the exercise group, but there were no changes in the control group. Femoral neck bone mineral density (BMD) increased significantly in the training group (1.035 to 1.073 g/cm2, $P < .01$) but not in the control group (1.034 to 1.048 g/cm2). No significant changes were seen in either group in lumbar spine bone mineral density (BMD) (1.113 to 1.142 g/cm2 and1.158 to 1.190 g/cm2, respectively) or total body bone mineral density (BMD) (1.103 to 1.134g/cm2 and 1.111 to 1.129 g/cm2, respectively). No significant changes were seen in lean mass, fat mass, percentage of body fat and body mass index. Resistance training is a potential method for increasing bone density in adolescents, although such a program would be best done as part of the school curriculum.

Stewart et al., (2005) examined the relationships among exercise-induced changes in fitness and fatness with bone mineral density. Randomized controlled trial was conducted between July 1999 and November 2003 for both men and women (n =115) aged 55 to 75 years intervention of six months of exercise training. Fitness measured as peak oxygen uptake and muscle strength, body composition by anthropometry, dual-energy x-ray absorptiometry. A total of 51 men and 53 women completed the trial. Exercise increased aerobic and strength fitness and lean body mass, and reduced general and abdominal obesity. Bone mineral density (BMD) did not change among men in either group. Among women exercisers, there were reductions in total skeleton BMD ($p = 0.02$) and greater trochanter BMD ($p = 0.02$). By bivariate correlation, among women, increased femoral neck BMD was associated with increased aerobic fitness ($p = 0.01$) and with reduced body weight ($p = 0.02$) and BMI ($p = 0.02$). In the final regression model, 13% of the change in femoral neck BMD was explained by the change in aerobic fitness ($p<0.01$). Among the men, increased total hip BMD and femoral shaft BMD were associated with increased lean mass and lower-body strength. In the final regression models, the change in lean mass explained 9% of the variance in total hip BMD ($p = 0.04$). The change in lean mass explained 20% of the change in femoral shaft BMD ($p<0.01$), and the change in lower-body strength explained an additional 6% ($p<0.04$). The study concluded there was no effect on bone mineral density (BMD) among men, and reduced bone mineral density (BMD) among women. When examined by change in fitness and fatness, women who had the greatest increases in aerobic capacity and men who had the greatest increases in strength and lean mass were more likely to increase their BMD. Exercise-induced reductions in fatness did not lead to bone loss.

Nguyen, Center & Eisman, (2000) examined the association between osteoporosis and these two factors in relation to body mass index (BMI) in a cross-sectional, epidemiological study involving 1075 women and 690 men, aged 69 ± 6.7 years (mean ± SD). Dietary calcium intake (median of 580 mg/day) was inversely related to age (p = 0.01), positively related to physical activity index (PAI) (p = 0.01), femoral neck BMD (p = 0.01) in women, and higher lumbar spine (p = 0.003) and femoral neck BMD (p = 0.03) in men. Quadriceps strength was negatively associated with age (p< 0.0001) and positively related to BMI (p< 0.0001) and BMD (p< 0.0001) in both men and women. The PAI was associated with quadriceps strength (p< 0.0001) and femoral neck and lumbar spine BMD in women (p< 0.001) and with femoral neck BMD in men (p = 0.04); however, these associations were not significant after adjusting for age, BMI, quadriceps strength, and dietary calcium. Women in the top tertile of quadriceps strength (≥23 kg) and dietary calcium intake (≥710 mg/day) had 15% higher BMD than those in the lowest tertiles (≤15 kg and ≤465 mg/day); the difference was comparable in men (11%). Among subjects with the lowest tertiles of BMI (≤23 kg/m^2 for women and ≤24 kg/m^2 for men), quadriceps strength (≤15 kg for women and ≤28 kg for men), and dietary calcium intake (≤465 mg/day), 64% and 40% of women and men, respectively, were classified as having osteoporosis (based on a 2.5-SD reduction from the young-normal mean). The prevalence was only 12% in women and 1.5% in men among those in the highest tertiles of the three factors. Adequate dietary calcium intake and maintaining a physically active lifestyle in late decades of life could potentially translate into a reduction in the risk of osteoporosis and hence improve the quality and perhaps quantity of life in the elderly population.

2.4 STUDIES ON DIETARY SUPPLEMENTATION

Kim et al., (2016) examined the associations of dietary calcium intake with metabolic syndrome and bone mineral density (BMD) in Korean men and women, especially postmenopausal women. The study was performed using data from the Korean National Health and Nutrition Examination Survey (2008–2011) and included 14,705 participants (5953 men, 4258 premenopausal women, and 4494 postmenopausal women). Clinical and other objective characteristics, presence of metabolic syndrome, and the bone mineral density (BMD) of the femur neck and lumbar spine were evaluated according to dietary calcium intake. There was a higher tendency for metabolic syndrome in men with a dietary calcium intake of >1200 mg/day than with ≤400 mg of calcium intake; >400 and ≤800 mg of calcium intake was helpful for postmenopausal women to decrease risk for metabolic syndrome. Overall, the group with calcium intake >400 and ≤800 mg daily had significantly increased bone mineral density (BMD) in both femoral neck and lumbar spine from both men and postmenopausal women. From both femoral neck and lumbar spine, the prevalence of osteoporosis in postmenopausal women significantly decreased in the group whose calcium intake was >400 and ≤800 mg daily. Excessive dietary calcium may increase the prevalence of metabolic syndrome in men. For postmenopausal women, calcium intake does not increase the risk of metabolic syndrome, but modest amount decreases the risk. It may increase the bone mineral density (BMD) in men and postmenopausal women, and also reduce the prevalence of both osteoporosis and metabolic syndrome in postmenopausal women.

Nielsen & Lukaski, (2006) documented magnesium is involved in numerous processes that affect muscle function including oxygen uptake, energy production and electrolyte balance. Thus, the relationship between magnesium status and exercise has received significant research attention. This research has shown that exercise induces a redistribution of magnesium in the body to accommodate metabolic needs. There is evidence that marginal magnesium deficiency impairs exercise performance and amplifies the negative consequences of strenuous exercise (e.g., oxidative stress). Strenuous exercise apparently increases urinary and sweat losses that may increase magnesium requirements by 10-20%. Based on dietary surveys and recent human experiments, a magnesium intake less than 260 mg/day for male and 220 mg/day for female athletes may result in a magnesium-deficient status. Recent surveys also indicate that a significant number of individuals routinely have magnesium intakes that may result in a deficient status. Athletes participating in sports requiring weight control (e.g., wrestling, gymnastics) are apparently especially vulnerable to an inadequate magnesium status. Magnesium supplementation or increased dietary intake of magnesium will have beneficial effects on exercise performance in magnesium-deficient individuals. Magnesium supplementation of physically active individuals with adequate magnesium status has not been shown to enhance physical performance. An activity-linked RNI or RDA based on long-term balance data from well-controlled human experiments should be determined so that physically active individuals can ascertain whether they have a magnesium intake that may affect their performance or enhance their risk to adverse health consequences (e.g., immunosuppression, oxidative damage, arrhythmias).

Bohl & Volpe, (2002) reviewed magnesium as an essential element that regulates membrane stability and neuromuscular, cardiovascular, immune, and hormonal functions and is a critical cofactor in many metabolic reactions. The Dietary Reference Intake for magnesium for adults is 310 to 420 mg/day. However, the intake of magnesium in humans is often suboptimal. Magnesium deficiency may lead to changes in gastrointestinal, cardiovascular, and neuromuscular function. Physical exercise may deplete magnesium, which, together with a marginal dietary magnesium intake, may impair energy metabolism efficiency and the capacity for physical work.

Jorde, Szumlas, Haug & Sundsfjord (2002) founded that the patients with primary hyperparathyroidism (PHPT) a low calcium intake might cause increased bone loss and thus aggravate osteoporosis, and a high intake might increase serum calcium level and the risk of nephrolithiasis. Generally, guidelines recommend a normal calcium intake, and accordingly, those with a low intake might benefit from a modest calcium supplementation. This hypothesis was tested in the present study. Thirty-one patients with asymptomatic PHPT were recruited from an epidemiological study (The Tromso study 1994/95). Those with a daily calcium intake below 450 mg were given calcium supplementation (500 mg Ca (2+)), and those with an intake above 450 mg were followed without supplementation. The study was open and lasted 1 year. Serum levels of calcium, PTH, 25-hydroxyvitamin D3 and 1, 25-dihydroxy vitamin D, urinary calcium excretion, blood pressure, and bone mineral density (BMD) were measured. Three subjects dropped out without reason, 1 developed abdominal discomfort from the calcium supplementation, and 3 had an increase in serum calcium of more than 0.2 mmol/L and were therefore excluded. The latter three did not differ from the rest of the group at baseline. Of the remaining 24 that completed the study, 17 were given calcium. In this group there was a non-significant increase in serum calcium and urinary calcium excretion, a significant decrease in parathyroid hormone (PTH) after 4 weeks (13.2 (6.0) vs. 9.4 (3.0) pmol/L, $P < 0.05$), and a significant increase in bone mineral density (BMD) at the femoral neck at the end of the study (0.849 (0.139) vs 0.870 (0.153) g/cm (2), $P < 0.05$). The blood pressure was not significantly affected. Most patients with mild PHPT and a low calcium intake tolerate a moderate calcium supplement. This may have beneficial effects on the bones, but the patients must be followed carefully.

Shea, et al., (2002) examined the effect of calcium on bone density and fractures in postmenopausal women. The randomized postmenopausal women to calcium supplementation or usual calcium intake in the diet and reported bone mineral density of the total body, vertebral spine, hip, or forearm, or recorded the number of fractures, and followed patients for at least 1 yr. They found calcium to be more effective than placebo in reducing rates of bone loss after two or more years of treatment. The pooled difference in percentage change from baseline was 2.05% [95% confidence interval (CI) 0.24–3.86] for total body bone density, 1.66% (95% CI 0.92–2.39) for the lumbar spine, 1.64% (95% CI 0.70–2.57) for the hip, and 1.91% (95% CI 0.33–3.50) for the distal radius. The relative risk (RR) of fractures of the vertebrae was 0.77, with a wide CI (95% CI 0.54–1.09); the RR for nonvertebral fractures was 0.86 (95% CI 0.43–1.72). Calcium supplementation alone has a small positive effect on bone density. The data show a trend toward reduction in vertebral fractures, but do not meaningfully address the possible effect of calcium on reducing the incidence of nonvertebral fractures.

Weaver, (2014) Stated that Calcium is the dominant mineral in bone and is a shortfall nutrient in the diet. For those consuming inadequate dietary calcium, calcium supplements have been a standard strategy for prevention of osteoporosis. Recently, calcium supplementation has been linked to both increased and decreased cardiovascular disease risk creating considerable uncertainty.

Moreover, recent reports have shed uncertainty over the effectiveness of calcium supplements to reduce risk of fracture. The evidence for calcium supplementation effects to both reduce risk of fracture and increase coronary heart disease and mortality are reviewed. Although the importance of good calcium nutrition is well known, determining the advantage of calcium supplementation to either bone or heart health has been hampered by poor subject compliance and study design flaws. At present, the current Recommended Dietary Allowances for calcium still appear to be a good target with potential risks for chronic disease if intakes fall too short or greatly exceed these recommendations.

Reid & Ibbertson, (1986) assessed the value of calcium supplementation in preventing this loss of bone, the metabolic effects of administering 1 g of elemental calcium/day have been studied in 13 steroid-treated patients. After 2 months, the fasting urine hydroxyproline-creatinine ratio decreased from 27.1 +/- 2.5 (SEM) to 21.8 +/- 2.4 (p less than 0.001) and there was an increase in fasting urine-calcium excretion (p less than 0.05). Serum alkaline phosphatase and osteocalcin showed no change. We concluded that calcium supplementation suppresses bone resorption without detectable suppression of indices of bone formation and is, therefore, likely to result in increased bone mass. The safety and low cost of calcium make it a very suitable prophylactic agent in glucocorticoid-treated patients.

Lau, et al., (2001) studied the association between a low calcium intake and risk of hip and vertebral fracture. In this study randomly assigned 200 postmenopausal Chinese women (age range, 55–59 years) to receive 50 g of milk powder containing 800 mg of calcium per day or to a control group. The following are the mean percentage changes (and SEs) in height and bone mineral density (BMD) over 24 months: for height, −0.1 ± 0.2 cm in the milk supplementation group and −0.2 ± 0.1 cm in the control group; for BMD at the total hip, −0.06 ± 0.22% in the milk supplementation group and −0.88 ± 0.26% in the control group; for BMD at the spine (L_1–L_4), −0.56 ± 0.29% in the milk supplementation group and −1.5 ± 0.29% in the control group; for total body BMD, −0.32 ± 0.16% in the milk supplementation group and −1.2 ± 0.19% in the control group ($p< 0.05$ by analysis of covariance [ANCOVA] for repeated measures for height and BMD at all sites). The milk supplementation group had less loss in terms of both height and BMD than the control group ($p< 0.05$ by ANCOVA for repeated measures). Serum parathyroid hormone (PTH) concentration was lower and serum 25-hyroxyvitamin D [25(OH) D] level was higher in the milk supplementation group than the control group at 12 months ($p< 0.05$ by paired *t*-test). We conclude that supplementing the diet of postmenopausal Chinese women with high calcium milk powder retards bone loss.

2.5 STUDIES ON BIOCHEMICAL AND HORMONAL VARIABLE

Tartibian, Maleki, Kanaley & Sadeghi (2011) examined the effects of long-term aerobic exercise and omega-3 (N-3) supplementation on serum inflammatory markers, bone mineral density (BMD), and bone biomarkers in post-menopausal women. Seventy-nine healthy sedentary post-menopausal women aged 58-78 years participated in this study. Subjects were randomized to one of 4 groups: exercise and supplement (n = 21), exercise (n = 20), supplement (n = 20), and control (Con, n = 18) groups. The subjects in the exercise and supplement and exercise groups performed aerobic exercise training (walking and jogging) up to 65% of HR_{max}, three times a week for 24 weeks. Subjects in the exercise and supplement and supplement groups consumed 1000 mg/dl of omega 3 for 24 weeks. The lumbar spine (L_2-L_4) and femoral neck BMD, serum tumor necrosis factor (TNF) α, interleukin (IL) 6, prostaglandin (PG) E_2, estrogen, osteocalcin, 1, 25-dihydroxyvitamin D_3 (1, 25 Vit D), C-telopeptide (CTX), parathyroid hormone (PTH) and calcitonin (CT) were measured at baseline, the end of week 12 and 24. Serum estrogen, osteocalcin, 1, 25 Vitamin D, calcitonin, lumbar spine (L_2-L_4) and femoral neck bone mineral density (BMD)measures increased ($P < 0.05$) and the serum C-telopeptide (CTX), parathyroid hormone, TNF-α, IL-6, and PGE_2 decreased ($P < 0.05$) in exercise and supplement group after the 24 week intervention but not in the exercise or supplement intervention groups. L_2-L_4 and femoral neck BMD, estrogen, osteocalcin, and calcitonin were negatively ($P < 0.05$) correlated with TNF-α and PGE_2. Parathyroid hormone and calcitonin were correlated positively and negatively with IL-6; respectively ($P < 0.05$).The study demonstrated that long-term aerobic exercise training plus N-3 supplementation have a synergistic effect in attenuating inflammation and augmenting bone mineral density (BMD) in post-menopausal osteoporosis.

Soltani, Soltani, Abrishami, Zeiaadini & Ashkanifar, (2015) studied the relationship between physical activity level (low, medium, high) and PTH hormones level and calcitonin in the middle-aged women. This study is considered as the applied research in term of objective, but considered as one of the solidarity schemes in terms of collecting and analyzing data called the research project. So, out of (research population with) 35-45 year-old middle-aged women, 75 subjects were selected by sampling method after doing medical examinations and having no history of disease. They were placed in three groups, 25 patients in group with low levels of physical activity, 25 subjects in group with average level of physical activity and 25 patients in group with high level of physical activity Blood samples were taken by the laboratory technicians in order to determine the PTH and calcitonin hormones level. According that the level of physical activity was a nominal sequential, Spearman correlation test was used in analyzing data. There is significant relationship between the level of physical activity and PTH of subject's serum ($p = 0.0001$). There is no significant relationship between the level of physical activity and calcitonin of subject's serum ($p = 0.634$). Regular physical activity can be an effective treatment to prevent the decreased bone density. Intense exercises and the increased number of exercise sessions per week can increase PTH which is a harmonic factor. Also, the reduced hormone is associated with the increased calcium.

Linda & Hsieh, (2005) compared the effects of strength and endurance exercise on blood pH, total serum calcium, ionized calcium, parathyroid hormone (PTH) and calcitonin (CT) between males with different levels of physical activities. The experimental group consisted of 9 physically active males (runners) and the control group consisted of 10 males who had not exercised regularly for the past year. Subjects were asked to perform both strength (eccentric action) and endurance exercises (VO_2 peak). The blood pH, total serum calcium, ionized calcium, parathyroid hormone and calcitonin were measured before and after exercise. A two-way ANCOVA was used for data analysis. When the control group did anaerobic exercise, the free ionized calcium increased significantly ($p < 0.05$). Mode and intensity of physical activity have no significant effects on the body's calcium regulating hormones. The level of physical activity plays a major role in increasing bone density. High levels of physical activities plus strength exercises can have an additive effect on bone density. In conclusion, regular high intensity exercise will help increase bone density. Strength exercises can maintain bone density not only through mechanical loading, but also through blood pH and biochemical changes in free ionized calcium, which can positively affect bone density. But the effects of exercise on the calcium-regulating hormones and other metabolic variables are not known.

Moghadasi & Siavashpour, (2013) investigated the effect of 12 weeks of resistance training on hormones of bone formation in young sedentary women. Twenty sedentary females (aged 25.3 ± 3.2 years; ±SD) volunteered to participate in this study. The subjects were randomly assigned to a training group (*n* = 10) or control group (*n* = 10). Subjects executed eight resistance exercises selected to stress the major muscle groups in the following order: chest press, leg extension, and shoulder press, leg curls, latissimus pull down, leg press, arm curls, and triceps extension. Resistance training consisted of 50–60 min of circuit weight training per day, 3 days a week, for 12 weeks. This training was circularly performed in eight stations and included two to four sets with 8–12 maximal repetitions at 65–80 % of one-repetition maximum in each station. After 12 weeks, the training group had a significant increase ($P < 0.05$) in the growth hormone, estrogen, parathyroid hormone and testosterone compared to the control group. The results showed that insulin-like growth factor I levels did not change significantly in response to resistance training. In conclusion, the results suggest that resistance training with specific intensity and duration utilized in this study increases the hormones of bone formation in young sedentary women.

O'Neill, et al., (2004) stated that the moderate-duration exercise increases serum catecholamine and serum calcium levels and might as a result be also expected to increase the levels of circulating serum immunoreactive human calcitonin (HCT). To explore this possibility, HCT was studied during and after moderate duration symptom-limited dynamic exercise in 13 healthy males, mean age 28 +/- 6.9 (SD) years. The mean duration of exercise using the Bruce treadmill protocol was 14.1 +/- 2.2 (SD) minutes. The mean heart rate (HR) peaked at 185 +/- 6 (SD) bpm which was 96.1% of the predicted maximal HR for age. Values for HCT, uncorrected for changes in plasma volume, showed a minimal decrease in the recovery phase, whilst HCT corrected for changes in plasma volume did not alter during exercise or recovery. The serum parathyroid hormone (PTH) also did not change. At peak exercise, uncorrected but not corrected values for plasma noradrenaline, adrenaline and dopamine had increased significantly. Corrected plasma total calcium increased during recovery.

Ljunghall et al., (2008) stated that 7-day field exercise maneuver with intense physical activity stimulates secretion of PTH. Serum concentrations of parathyroid hormone (PTH), calcium, magnesium, phosphate and myoglobin were measured regularly during a 5-day recovery period in 17 men who had participated in a 7-day field exercise maneuver with intense physical activity. Immediately after the exercise, there was an increase in serum PTH levels of the same magnitude as the maximal rise during a hypocalcemic test. The rise in

PTH was not related to changes in serum electrolytes, but was significantly correlated to an increase in serum myoglobin, indicating that those who performed the largest amount of work also experienced the greatest stimulus for secretion of PTH. There were no significant changes of the serum total calcium and only a small initial rise of the magnesium concentrations. Serum phosphate levels were greatly reduced and gradually returned during recovery. This study extends previous observations, from short-term investigations, that physical activity stimulates secretion of PTH.

Takada, et al., (2008) examined the effects of amount of exercise on levels of serum parathyroid hormone (PTH) and calcium, and the relationship between PTH response and bone mineral density in adolescent female athletes. Twenty-one female athletes on a top-ranked high school basketball team in Japan participated in a one-month intensive basketball program. Subjects were divided into moderate-exercise and strenuous-exercise groups. The amount of exercise was quantified using estimated metabolic equivalent (METs) and exercise hours. Levels of serum intact-PTH and calcium were examined five times: twice before training to establish a baseline (T-1 and T0), once 3rd week of the training period (T1, once immediately at the end of the program (T2), and again one week later3). Bone mineral density of forearm (distal-BMD) was measured one week after the end of the program. PTH levels at T1, T2 and3 were regressed on PTH at baseline (T0) for both groups and examined for statistical significance. Multiple regression analyses of the changes of PTH and distal-BMD were conducted. Strenuous-exercise subjects showed both increased and decreased PTH levels, while moderate-exercise subjects showed a uniform decrease in PTH throughout the exercise period. Increased PTH was an independent negative predictor of distal-BMD, while high lean body mass, increased serum Ca, and exercise volume were positive predictors. The amount of exercise affects PTH response: moderate exercise suppresses PTH secretion, while strenuous exercise is apt to induce continuous secretion, which has a negative effect on BMD.

2.6 SUMMARY OF RELATED LITERATURE

The investigator has reviewed several journals, research articles and presented the above related studies on the efficacy of aerobic exercise, functional strength training and dietary supplementation on selected body composition, biochemical and hormonal profile in low bone mineral density. From the reviewed studies it was inferred that there was scope for further research in finding out the efficacy of aerobic exercise with functional strength training and dietary supplementation on selected body composition, biochemical and hormonal profile among men with low bone mineral density.