CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter summarises the research studies relating to the problem under investigation. Review of relevant studies are of fundamental importance to provide an insight and better understanding of the problem for researcher to adopt suitable design and to ensure perfection in the study to be made.

Reviews of literature are used as a basis for inductive reasoning, and the researcher may locate and synthesize all the relevant literature on a particular topic (Thomas and Nelson, 1990).

In this chapter the related studies have been reviewed under the following sub sections:

1. Studies on the effect of circuit training exercises on biomotor abilities.

2. Studies on the effect of medicine ball exercises on biomotor abilities

2.1 STUDIES ON THE EFFECT OF CIRCUIT TRAINING EXERCISES ON BIOMOTOR ABILITIES

Greene NP, et.al. (2009) compared changes in physical fitness, body weight, and body composition in physically inactive, overweight, and obese adults after 12 wks of land treadmill (LTM) or UTM training. Fifty-seven physically inactive, overweight, and obese men (n = 25) and women (n = 32)

participated in this investigation. The mean +/- SEM age, weight, body mass index (BMI), and V O2max upon entry were 44 +/- 2 yr, 90.5 +/- 2.4 kg, 30.5 +/- 0.7 kg.m, and 27.1 +/- 0.7 mL O2.kg.min, respectively. Subjects were randomly assigned to exercise three times per week for 12 wk on either LTM (n = 29) or UTM (n = 28) matched for intensity and volume. Session volume was progressively increased from 250 to 500 kcal per session by week 6 and remained at 500 kcal through week 12. Before and after training, V O2max was assessed by the Bruce treadmill protocol with open-circuit calorimetry, and body composition was assessed by dual-energy ray absorptiometry. Data were analyzed by a 2 (training) x 2 (exercise mode) x 2 (gender) ANOVA repeated across training (alpha = 0.05). Training responses were not different between genders. After either UTM or LTM training, V O2max was significantly increased (+3.6 +/- 0.4 mL O2.kg.min), whereas body weight (-1.2 +/- 0.3 kg), BMI (-0.56 +/- 0.11 kg.m), body fat percentage (-1.3% +/- 1.3%), and fat mass (-1.1 +/- 0.3 kg) were significantly reduced (pooled means for UTM and LTM). Regional leg lean body mass (LBM) was significantly increased with both CTM and UTM (0.4 +/- 0.3 and 0.8 +/- 0.2 kg, respectively). An increase in total LBM approached significance with UTM training only (+0.6 +/- 0.3 kg, P = 0.0599). UTM and LTM training are equally capable of improving aerobic fitness and body composition in physically inactive overweight individuals, but UTM training may induce increases in LBM.

Palevo G, et.al. (2009) determined the effect of a structured isotonic strength training (ST) program on left ventricular (LV) function (ejection fraction, stroke volume, and end-diastolic and end-systolic volumes) and physical fitness (6-minute walk test, upper body strength, lower body strength, and body composition) in patients with New York Heart Association class II and III heart failure. METHODS: Sixteen patients were randomized into 2 groups, ST and usual care. The ST group (10 patients) performed 24 ST exercise sessions (3 per week, 8 weeks), while the usual care (6 patients) group followed routine medical care. The structured isotonic ST program involved 12 different exercises on circuit weight machines. LV function (3D echocardiography) and physical fitness were assessed at baseline and 8 weeks. RESULTS: Modest improvements ($P < .05$) in resting ejection fraction (0.32-0.37) and stroke volume (46 to 53 mL/beat), as well as in muscular strength and 6-minute walk distance, were found after training. CONCLUSIONS: A short-term structured isotonic ST program appears to improve selected measures of resting LV function and fitness in patients with mild congestive heart failure. Additional studies utilizing larger numbers of subjects, including women, are needed.

Bolboli L, et.al. (2008) examined the effect of height in the predicted VO2max by the Queens Step test among short and tall young girls. A sample of 38 individuals was selected in two stages from a total of 500 individuals and was assigned to two groups of short ($n = 20$) and tall ($n = 18$). In order to examine the effect of height in the predicted VO2max, the Queens step protocol and the incremental treadmill speed test were used. Respiratory exchange was measured continuously throughout the test by an automated open-circuit gas analysis system. The study results showed that tall girls revealed a higher VO2max on the Queen's step and treadmill tests than short girls (Queen's: 44.09+/-2.66 vs. 38.96+/-1.65; Treadmill: 34.03+/-7.26 vs. 28.15+/-5.09 mL/kg/min). Based on the obtained findings it can be concluded that the higher VO2max seen in tall girls on the both protocols, may be due to their physiological and physical properties; therefore, it seems that designing of the adjustable steps to the height of subjects for optimizing the estimation of VO2max is not necessary and other physiological factors may be involved, which require further investigation.

Wong PC, et.al. (2008) studied the effects of a 12-week twice weekly additional exercise training, which comprised a combination of circuit-based resistance training and aerobic exercises, in additional to typical physical education sessions, on aerobic fitness, body composition and serum C-reactive protein (CRP) and lipids were analysed in 13- to 14-year-old obese boys contrasted with a control group. MATERIALS AND METHODS: Both the exercise group (EG, n = 12) and control group (CG, n = 12) participated in the typical 2 sessions of 40-minute physical education (PE) per week in schools, but only EG participated in additional 2 sessions per week of 45 to 60 minutes per session of exercise training, which comprised a combination of circuit-based resistance training and aerobic exercises maintained at 65% to 85% maximum heart rate (HRmax = 220 - age). Body composition was measured using dual energy X-ray absorptiometry (DEXA). Fasting serum CRP and blood lipids were analysed pre- and postexercise programme. Aerobic fitness was measured by an objective laboratory submaximal exercise test, PWC170 (Predicted Work Capacity at HR 170 bpm). RESULTS: Exercise training significantly improved lean muscle mass, body mass index, fitness, resting HR, systolic blood pressure and triglycerides in EG. Serum CRP concentrations were elevated at baseline in both groups, but training did not result in a change in CRP levels. In the CG, body weight increased significantly at the end of the 12-week period. CONCLUSION: This study supports the value of an additional exercise training programme, beyond the typical twice weekly physical education classes, to produce physiological benefits in the management of obesity in adolescents, including prevention of weight gain.

Monteiro WD, et.al. (2008) investigated the effect of 10 weeks of strength training on the flexibility of sedentary middle-aged women. Twenty women were randomly assigned to either a strength training group (n = 10; age, 37 +/- 1.7 years; body mass, 65.2 +/- 10.7 kg; height, 157.7 +/- 10.8 cm; and body mass index, 25.72 +/- 3.3 kg x m(-2)) or a control group (n = 10; age, 36.9 +/- 1.2 years; body mass, 64.54 +/- 10.18 kg; height, 158.1 +/- 8.9 cm; and body mass index, 26.07 +/- 2.8 kg x m(-2)). The strength training program was a total body session performed in a circuit fashion and consisted of 7 exercises performed for 3 circuits of 8 to 12 repetitions maximum (RM), except for the abdominal exercise which was performed for 15 to 20 RM. Flexibility measurements were taken for 10 articulation movements pre and post training: shoulder flexion and extension, shoulder horizontal adduction and abduction, elbow flexion, hip flexion and extension, knee flexion, and trunk flexion and extension. Pre and post training, 10 RM strength significantly increased ($p < 0.05$). Of the movements examined, only shoulder horizontal adduction, hip flexion and extension, and trunk flexion and extension demonstrated significant increases ($p < 0.05$). Neither elbow nor knee flexion showed a significant change with weight training. The control group showed no significant change in any of the flexibility measures determined. In conclusion, weight training can increase flexibility in previously sedentary middle-aged women in some, but not all joint movements.

Bell LM, et.al. (2007) assessed the effect of a structured 8-wk exercise training program on insulin resistance and changes in body composition in obese children. The study was 8 wk of structured supervised exercise intervention with outcome measures before and after the exercise period. Fourteen obese children (12.70 +/- 2.32 yr; eight male, six female) with high fasting insulin levels were enrolled into the study. Intervention: Intervention consisted of 8 wk of supervised circuit-based exercise training, composed of three fully supervised 1-h sessions per week. Outcome measures were assessed pretraining program and posttraining program and included insulin sensitivity (euglycemic-hyperinsulinemic clamp studies), fasting insulin and glucose levels, body composition using dual energy x-ray absorptiometry scan, lipid profile, and liver function tests. RESULTS: Insulin sensitivity improved significantly after 8 wk of training (M(lbm) 8.20 +/- 3.44 to 10.03 +/- 4.33 mg/kg.min, $P < 0.05$). Submaximal exercise heart rate responses were significantly lower following the training ($P < 0.05$), indicating an improvement in cardiorespiratory fitness. Dual energy x-ray absorptiometry scans revealed no differences in lean body mass or abdominal fat mass. An 8-wk exercise training program increases insulin sensitivity in obese children, and this improvement occurred in the presence of increased cardiorespiratory fitness but is independent of measurable changes in body composition.

Westcott WL, et.al. (2007) made a 12-wk. study was conducted to contrast the effects of a longer and more frequent aerobic exercise protocol with a shorter and less frequent circuit strength-training protocol for improving U.S. Air Force physical fitness test scores of subjects who previously failed to achieve a passing point total. 83 men and women of the U.S. Air Force (M age = 32.7 yr.) participated in either the unsupervised standard conditioning program, which recommended approximately 60 min. of aerobic activity 4 to 5 days per week (n=26), or the supervised circuit strength-training program, which required approximately 25 min. of alternating strength and endurance exercises 3 days per week (n=57). Subjects were assessed on a 2400-m (1.5-mile) run, abdominal circumference, push-ups completed in 1 min., and abdominal crunches completed in 1 min. Dependent t tests with Bonferroni adjustment indicated that significant improvements were attained by the circuit strength-training group only on each of the aforementioned measures. Significantly more participants in the circuit strength-training group (26%) achieved a passing point total than in the standard conditioning group (19%) at Wk. 12 (chi1(2) =3.96, p = .05). Implications for enhancing physical fitness in poorly conditioned adults were discussed.

Muller SM, et.al. (2006) examined the effects of exercise on indices of emotional well-being of 584 college students enrolled in either a lecture-only health course or one of six health-fitness courses, each using a different mode of exercise including cross-training, aerobics, yoga, circuit weight training, swimming, and walk/jog. Each participant completed the Self-perception Profile for College Students developed by Neeman and Harter. Analysis yielded significant differences on five indices of emotional well-being (Global Self-worth, Appearance, Romantic Relationships, Social Acceptance, and Athletic Competence) between pre- and posttest scores of participants enrolled in the health-fitness courses, while no differences were found between pre-and posttest scores of participants enrolled in the lecture-only health course. Of the seven subscales examined, a significant interaction effect was found between sex/time and Romantic Relationships/Athletic Competence, with women reporting greater gains than men.

Nash MS, et.al. (2007) examined the effects of circuit resistance exercise (CRT) training on muscle strength, endurance, anaerobic power, and shoulder pain in middle-aged men with paraplegia. Academic medical center. Seven men (age range, 39-58y) with motor-complete paraplegia from T5 to T12 and confirmed shoulder pain occurring during daily activities. Not applicable. Subjects underwent a 4-month CRT program using alternating resistance maneuvers and high-speed, low-resistance arm exercise. One-repetition maximal force was measured before training and monthly thereafter. Pretraining and posttraining peak oxygen uptake (Vo(2)peak) was measured by graded arm testing. Anaerobic power was measured before and after training using a 30-second Wingate Anaerobic Test. Shoulder pain was self-evaluated by an index validated for people with spinal cord injury (Wheelchair Users Shoulder Pain Index [WUSPI]). Strength increases ranging from 38.6% to 59.7% were observed for all maneuvers (P range, .005-.008). Vo(2)peak increased after training by 10.4% (P=.01), and peak and average anaerobic power increased by 6% (P=.001) and 8.6% (P=.005), respectively. WUSPI scores +/- standard deviation were lowered from 31.9+/-24.8 to 5.7+/-5.9 (P=.008), with 3 of 7 subjects reporting complete resolution of shoulder pain. CRT improves muscle strength, endurance, and anaerobic power of middle-aged men with paraplegia while significantly reducing their shoulder pain.

Dixon CB, et.al. (2006) determined whether acute resistance exercise increases serum malondialdehyde (MDA) levels postexercise, and if so, whether resistance exercise training status influences the magnitude of the exercise-induced lipid peroxidation response. Twelve recreationally resistance-trained (RT) and 12 untrained (UT) men who did not have resistance exercise experience in the past year participated in this study. All subjects completed an 8-exercise circuit resistance exercise protocol consisting of 3 sets of 10 repetitions at 10 repetitions maximum for each exercise. Blood samples were obtained pre-exercise, at 5 minutes postexercise, and at 6, 24, and 48 hours postexercise. At pre-exercise, MDA (nmol.ml(-1)) averaged 3.41 +/- 0.25 (RT) and 3.20 +/- 0.25 (UT) and did not differ ($p > 0.05$) either between groups or over time. Creatine kinase (IU.L(-1)) was significantly ($p < 0.05$) elevated 5 minutes postexercise (170.6 +/- 25.8), 6 hours postexercise (290.3 +/- 34.4), 24 hours postexercise (365.5 +/- 49.9), and 48 hours postexercise (247.5 +/- 38.5) as compared with pre-exercise (126.4 +/- 20.2) for both groups. There was no difference ($p > 0.05$) in CK activity between groups. This study indicated that moderate-intensity whole-body resistance exercise had no effect on serum MDA concentration in RT and UT subjects.

Bhambhani Y, et. al. (2005) examined the time course of the changes in body composition and peak cardiorespiratory fitness resulting from routine brain injury rehabilitation program (BIRP) activities and circuit training in patients with moderate to severe traumatic brain injury (TBI). Time-series design spanning 18 weeks. Trials T1 and T2 were completed in weeks 1 and 2, respectively, to establish reliability of the measurements, followed by trial 3 (T3) 4 weeks later to evaluate changes resulting from the BIRP. A BIRP in a community rehabilitation hospital. PARTICIPANTS: Fourteen inpatients with moderate to severe acquired TBI (Glasgow Coma Scale score, 4.6+/-1.4; time since injury, 17.2+/-17 mo). Twelve-week circuit-training program designed to enhance muscular strength and endurance and aerobic fitness. Subjects were tested midway (T4) through the program and at the end (T5) of 12 weeks. The patients completed an average of 32 supervised sessions, each lasting 1 hour. Changes in body composition and peak cardiorespiratory responses. No significant changes were observed in the body mass or percentage body fat during the study. The peak values of power output, oxygen uptake, and ventilation rate increased significantly as a result of training, with no concomitant increases in peak heart rate or blood lactate (T5>T3, T2, T1; P <.05). No significant changes were evident midway through training. In a heterogeneous sample of patients with moderate to severe TBI, (1) body composition and peak cardiorespiratory responses remained fairly stable during 6 weeks of BIRP activities, (2) improvements in peak cardiorespiratory fitness required more than 6 weeks of circuit training, and (3) a 12-week course of circuit training without controlling caloric intake was not effective in reducing body weight or percentage body fat.

Takeshima N, et.al. (2004) determined the physiological effects of a programmed accommodating circuit exercise (PACE) program consisting of aerobic exercise and hydraulic-resistance exercise (HRE) on fitness in older adults. Thirty-five volunteers were randomly divided into two groups [PACE group (PG) 8 men and 10 women, 68.3 (4.9) years, and non-exercise control group (CG) 7 men and 10 women, 68.0 (3.4) years). The PG participated in a 12-week, 3 days per week supervised program consisting of 10 min warm-up and 30 min of PACE (moderate intensity HRE and aerobic movements at 70% of peak heart rate) followed by 10 min cool-down exercise. PACE increased (P<0.05) oxygen uptake (V(.)O(2)) at lactate threshold [PG, pre 0.79 (0.20) l min(-1), post 1.02 (0.22) l min(-1), 29%; CG, pre 0.87 (0.14) l min(-1), post 0.85 (0.15) l min(-1), -2%] and at peak V(.)O(2) [PG, pre 1.36 (0.24) l min(-1), post 1.56 (0.28) l min(-1), 15%; CG, pre 1.32 (0.29) l min(-1), post 1.37 (0.37) l min(-1), 4%] in PG measured using an incremental cycle ergometer. Muscular strength evaluated by a HRE machine increased at low to high resistance dial settings for knee extension (9-52%), knee flexion (14-76%), back extension (18-92%) and flexion (50-70%), chest pull (6-28%) and press (3-17%), shoulder press (18-31%) and pull (26-85%), and leg press (21%). Body fat (sum of three skinfolds) decreased (16%), and high-density lipoprotein cholesterol (HDLC) increased (10.9 mg dl(-1)) for PG. There were no changes in any variables for CG. These results indicate that PACE training incorporating aerobic exercise and HRE elicits significant improvements in cardiorespiratory fitness, muscular strength, body composition, and HDLC for older adults. Therefore, PACE training is an effective well-rounded exercise program that can be utilized as a means to improve health-related components of fitness in older adults.

Maiorana A, et.al. (2001) investigated the effect of 8 wk of exercise training on functional capacity, muscular strength, body composition, and vascular function in sedentary but healthy subjects by using a randomized, crossover protocol. After familiarization sessions, 19 subjects aged 47 +/- 2 yr (mean +/- SE) undertook a randomized, crossover design study of the effect of 8 wk of supervised circuit training consisting of combined aerobic and resistance exercise. Peak oxygen uptake (.VO(2peak)), sum of 7 maximal voluntary contractions and the sum of 8 skinfolds and 5 segment girths were determined at entry, crossover, and 16 wk. Endothelium-dependent and -independent vascular function were determined by forearm strain-gauge plethysmography and intrabrachial infusions of acetylcholine (ACh) and sodium nitroprusside (SNP) in 16 subjects. RESULTS: Training did not alter ACh or SNP responses. .VO(2peak), (28.6 +/- 1.1 to 32.6 +/- 1.3 mL.kg(-1).min(-1), $P < 0.001$), exercise test duration (17.4 +/- 1.1 to 22.1 +/- 1.2 min, $P < 0.001$), and muscular strength (465 +/- 27 to 535 +/- 27 kg, $P < 0.001$) significantly increased after the exercise program, whereas skinfolds decreased (144 +/- 10 vs 134 +/- 9 mm, $P < 0.001$). These results suggest that moderate intensity circuit training designed to minimize the involvement of the arms improves functional capacity, body composition, and strength in healthy, middle-aged subjects without significantly influencing upper limb vascular function. This finding contrasts with previous studies in subjects with type 2 diabetes and heart failure that employed an identical training program.

Jacobs PL, et.al. (2001) tested the safety and the effects of circuit resistance training (CRT) on peak upper extremity cardiorespiratory endurance and muscle strength in chronic survivors of paraplegia due to spinal cord injury. Ten men with chronic neurologically complete paraplegia at the T5-L1 levels participated in the study. Subjects completed 12 wk of CRT, using a series of alternating isoinertial resistance exercises on a multi-station gym and high-speed, low-resistance arm ergometry. Peak arm ergometry tests, upper extremity isoinertial strength testing, and testing of upper extremity isokinetic strength were all performed before and after training. None of the subjects suffered injury from exercise training. Significant increases were observed in peak oxygen consumption (29.7%, $P < 0.01$), time to fatigue ($P < 0.01$), and peak power output during arm testing ($P < 0.05$). Significant increases in isoinertial strength for the training maneuvers ranged from 11.9% to 30% ($Ps < 0.01$). Significant increases in isokinetic strength were experienced for shoulder joint internal rotation, extension, abduction, adduction, and horizontal adduction ($Ps < 0.05$). Chronic survivors of paraplegia safely improve their upper extremity cardiorespiratory endurance and muscle strength when undergoing a short-term circuit resistance training program. Gains in fitness and strength exceeded those usually reported after either arm endurance exercise conditioning or strength training in this subject population.

Kaikkonen H, et.al. (2000) studied the effects of a 12-week low resistance circuit weight training (CWT) on cardiovascular and muscular fitness were studied in 90 healthy sedentary adults. The subjects were randomized into three equally fit groups: CWT, Endurance (END) and Control (CON) according to their maximal aerobic power (VO2max). Both training groups exercised for 12 weeks, 3 days a week in sessions of 40 min, with a heart rate (HR) level of 70-80% HRmax. The CWT group trained with air resistance machines. Heart rate was controlled by setting the speed of movement. The END group walked, jogged, cross-country skied or cycled. The net differences (between pre- and posttraining changes) between the CWT and CON groups was statistically significant for VO2max (2.45 ml x min(-1) x kg(-1), 95% CI 1.1; 3.8), for abdominal muscles (3.7 reps, CI 0.3; 7.1), for push-ups (1.1 reps, CI 0.2; 2.1), and for kneeling (2.25 reps, CI 0.01; 4.5). The net difference (between pre- and posttraining changes) in the END and CON groups was statistically significant for VO2max (2.75 ml(-1) x min(-1) x kg(-1), 95% CI 0.9; 4.6), and kneeling (3.0 reps, CI 0.7; 5.3). Low resistance CWT with moderately hard HR level has effects comparable to an equal amount of endurance training on the cardiovascular fitness of sedentary adults. The CWT model was benefical also on muscular fitness. Based on the results, this type of exercise can be recommended for beginners because of its multilevel effects.

Jürimäe T, et.al. (2000) compared circulatory responses to circuit weight (CWT) and aerobic walking training sessions of similar energy cost in middle-aged overweight females. Thirty-three middle-aged pre-menopausal females participated in the experiment. They were divided into overweight (n=18, 36.2 +/- 6.3 years, 166.3 +/- 8.0 cm, 83.5 +/- 9.7 kg, BMI 30.2 +/- 3.1 kg m-2) and non-overweight control (n=15, 34.1 +/- 6.3 years, 165.0 +/- 5.6 cm, 61.6 +/- 5.0 kg, BMI 22.7 +/- 1.5 kg m-2) groups. Individual physical working capacity (PWC) was measured using the cycle ergometer test (calculated at the level of predicted HRmax (205 - (1/2) age). A CWT session consisted of leg extension, bench press, sit-ups and leg press exercises. The subjects performed four circuits at the maximal possible speed, using a work-to-rest ratio of 60 s. Blood pressure (BP) was measured during every rest period between the exercises, and the heart rate (HR) was recorded continuously during the whole CWT programme. During the walking training session, the subjects walked as fast as possible on the indoor track. The total energy cost of the walking training session was the same as during the CWT session, approximately 270 kcal, and was controlled by a CALTRAC accelerometer. HR and BP were measured every 5 min during the walking training session. The PWC index was significantly ($P<0.05$) higher in the overweight group in comparison with the control females (215.4 +/- 76.1 and

187.9 +/- 42.4 W, respectively). The resting BP was normal in both groups (<140/90 mmHg). HR was between 120 and 140 beats min-1 during CWT and walking sessions. There were no differences in BP during both training sessions in overweight and control subjects. It was concluded that both CWT and walking training sessions were acceptable forms of physical activity to increase cardiovascular fitness in middle-aged overweight and normal body weight females.

Mosher PE, et.al. (1998) tested the safety and effects of exercise conditioning on cardiorespiratory fitness, body composition, muscle strength, glucose regulation, and lipid/cholesterol levels. Ten male adolescents with insulin-dependent diabetes mellitus (IDDM) and 10 adolescent nondiabetic (ND) subjects. University-based human performance laboratory. Mixed endurance and calisthenic/strength activities performed at a rapid pace three times weekly for 12 weeks. Only one subject with IDDM experienced hypoglycemia after a single exercise session. Both subject groups improved their cardiorespiratory endurance ($p < .05$). Lean body mass of IDDM subjects increased by 3.5% ($p < .05$). Subjects with and without IDDM lowered their percent body fat ($p < .05$ and .001, respectively). Strength improvement of IDDM subjects ranged from 13.7% ($p < .001$) to 44.4% ($p < .01$), depending upon the maneuver. Fasting blood plasma glucose for all subjects was unchanged by training, but glycosylated hemoglobin A1c of IDDM subjects was reduced by .96 percentage point ($p < .05$). Reductions of HbA1c benefitted subjects exhibiting poor preconditioning glycemic control. Low-density lipoprotein cholesterol was decreased in subjects with IDDM ($p < .05$), but not total cholesterol or triglycerides. Adolescents with IDDM undergoing aerobic circuit training improve their cardiorespiratory endurance, muscle strength, lipid profile, and glucose regulation. Aerobic circuit training is safe for properly trained and monitored adolescent diabetics.

Maiorana AJ, et.al. (1997) examined the effects of 10 weeks of CWT on muscular strength, peak oxygen consumption (peak VO2), and myocardial oxygen demand (mVO2) in men after coronary artery bypass surgery. Twenty-six, post-coronary bypass male subjects (mean 19 months after bypass), aged 60 +/- 8.5 years, were randomly allocated to 10 weeks of CWT at 40 to 60% of maximum voluntary contraction ($n = 12$) or to a control group ($n = 14$). Muscular strength was assessed using a modified one repetition maximum technique. Peak VO2 was recorded during symptom-limited treadmill exercise. Rate pressure product, as an indirect measure of mVO2, was measured during isometric, isodynamic, and dynamic exercise. No ischemic symptoms nor electrocardiographic changes were recorded during testing or training. Strength increased by 18% ($P < 0.005$) in five out of seven exercises in the training group, but was unchanged in the control group. Training did not improve peak VO2. Rate pressure product during isometric and isodynamic exercise decreased from pre- to post-testing ($P < 0.05$) but was equivalent to that seen in the control group.

Moderate intensity CWT is safe and can improve strength in selected low-risk patients after coronary artery bypass surgery. However, it does not significantly increase peak VO2 nor reduce mVO2 during isometric, isodynamic, and dynamic exercise.

Verrill DE, and Ribisl PM. (1996) documented that resistive exercise training has become very popular for patients of cardiopulmonary rehabilitation programmes (CRPs). For decades, CRPs focused almost exclusively on improving cardiorespiratory endurance and most programmes ignored muscular fitness development. Moreover, resistance training was thought to be potentially hazardous for the cardiac patient due to the risk of cardiovascular complications from adverse haemodynamic responses. We now know that resistive exercise testing and training is very safe for properly screened patients, even at relatively high workloads. Improvement in muscular strength facilitates return to daily vocational and avocational activities and is important for the CRP participant to regain lost strength and resume work soon after a cardiac event. Circuit weight training (CWT) is helpful in this respect and has been shown to increase muscular strength, cardiovascular endurance, body composition, bone density and mineral content, self-confidence, and self-efficacy in various populations. This article presents an update on current research in cardiac patients and also presents guidelines for implementing a properly supervised cardiac resistive exercise programme.

Butler RM, et.al. (1992) evaluated the feasibility, safety, and efficacy of upper body circuit weight training (CWT) in 25 stable male cardiac patients entering the initial out-of-hospital phase of cardiac rehabilitation. Both groups performed 30 minutes of aerobic exercise only for 6 weeks. The aerobic exercise group (N = 13) continued this regimen for 6 more weeks, during which time the CWT group (N = 12) performed 15 minutes of aerobic exercise followed by CWT (two loops, eight upper body exercises). The only adverse response was in one CWT patient in whom restenosis developed. Peak heart rate during aerobic exercise and CWT was similar, but peak systolic blood pressure during aerobic exercise was significantly greater than during CWT. Peak rate pressure product during aerobic exercise and CWT was similar. Treadmill time increased significantly in both groups. Upper body strength (cumulative pounds lifted) increased significantly only in the CWT group. A coordinated program of CWT and aerobic exercise can be performed safely in stable cardiac patients during phase 2 cardiac rehabilitation, resulting in improved upper body strength and aerobic capacity.

Hortobágyi T, et.al. (1991) examined simultaneous training for strength and endurance during a 13-week, 3-day a week program of hydraulic resistive circuit training and running. Eighteen college males (U.S. Army ROTC) were placed into low resistance (LR; n = 10) or high resistance (HR; n = 8) groups, and 10 college males were controls and did not train. There were 20 exercise stations

(7 upper and lower body, and 6 supplementary). LR and HR performed 2 circuits with a work/rest ratio of 20 to 40 s during the 40 min workout. LR trained at two low resistances (approximately 100 cm.s-1), while HR trained at a higher resistance (approximately 50 cm.s-1). Following the workout, subjects ran 2 miles. Pre and post tests included strength, physical fitness, and anthropometry. Strength was assessed with (1) hydraulic resistance dynamometry for 4 exercises at 2 speeds using a computerized dynamometer (Hydra-Fitness, Belton, TX); (2) isokinetic and isotonic upright squat and supine bench press using the Ariel Exerciser (Trabuco Canyon, CA); (3) concentric and eccentric arm flexion/extension at 60 and 120 degrees.s-1 on the Biodex dynamometer (Shirley, NY), and (4) 1-RM free weight concentric and eccentric arm flexion and extension. The fitness tests included 2-mile run, sit-ups, and push-ups. Anthropometry included 3 fatfolds, 6 girths, and arm and leg volume. There were no significant changes in body composition or interactions between the fitness test measures and the 2 training groups (p greater than 0.05). Improvements averaged 15% (run time), 30% (push-ups), and 19% (sit-ups; p less than 0.05). Significant improvements also occurred in 3 of 8 measures for hydraulic testing (overall change 8.8%), in 3 of 4 1-RM tests (9.4%), and in 2 of 8 Biodex tests (6%), but no significant changes for isokinetic and isotonic squat and bench press (1.9%). The change in overall strength averaged 6.5% compared to 16% in a prior study that used hydraulic resistive training without concomitant running. We conclude

that gains in strength were somewhat compromised by the simultaneous run training, and that improvements in strength and run performance were independent of LR and HR training intensity.

McMurray RG, et.al. (1990) determined the effectiveness of a fitness program designed as an alternative to the standard weight-training and running program and using limited resources and facilities. Forty-three men from the North Carolina Justice Academy, randomly assigned into two groups, completed 12 weeks of physical training. The WT group used a standard weight training and running, whereas the REC group ran and completed a resistive exercise circuit. The REC circuit consisted of nine exercises designed to improve muscular strength and endurance separated by 30 seconds of aerobic exercise. The exercises used chairs, tables, sawhorses, and body weight to provide the resistance. The results indicated that the REC program improved muscular strength and aerobic capacity as well as the WT program. Furthermore, the REC group lost more weight, reduced body fat, and improved their lipid profiles significantly more than the WT group. Thus, the REC program is a viable alternative for the training of public safety officers when only limited resources are available.

Stewart KJ. (1989) reported that resistive training using heavy loads with few repetitions increases strength but does little to improve cardiovascular endurance. Circuit weight training, a form of resistive training using moderate loads with frequent repetitions, is used to improve both cardiovascular and strength fitness. Studies of circuit weight training in healthy adults and athletes have shown increases of 20-45% and cardiovascular improvement from 0 to 15%. An increasing number of exercise programs for cardiac and coronary prone populations have introduced circuit weight training. The few reported studies have shown that high risk patients can attain increases in fitness similar to those seen in healthy populations. Furthermore, the hemodynamic responses to circuit weight training suggest that it is a clinically safe and acceptable form of exercise.

2.2 STUDIES ON MEDICINE BALL EXERCISES ON BIOMOTOR ABILITIES

Marques MC, et.al. (2009) investigated the anthropometric and strength characteristics of elite male volleyball athletes and to determine if differences exist in these characteristics according to playing position. A group of 35 professional male team volleyball players (mean +/- SD age: 26.6 +/- 3.1 years) participated in the study. Players were categorized according to playing position and role: middle blockers (n = 9), opposite hitters (n = 6), outside hitters (n = 10), setters (n = 6), and liberos (n = 4). Height, body mass, muscular strength (4 repetition maximum bench press and 4 repetition maximum parallel squat tests), and muscular power (overhead medicine ball throw, countermovement jump) were assessed. Significant differences ($p < 0.05$) were found among the 5 positional categories. The results indicated that the middle blockers and opposite hitters were the tallest and heaviest players, whereas the libero players were the lightest. Differences were also found in bench press maximal strength, with the middle blockers and opposite players significantly stronger ($p < 0.05$) than the setters and liberos. The setter positional group had significantly poorer ($p < 0.05$) parallel squat performances than the outside hitter and opposite hitter groups. No other significant differences ($p > 0.05$) were found among groups for the strength and power parameters. These results demonstrate that significant anthropometric and strength differences exist among playing positions in elite male volleyball players. In addition, these findings provide normative data for elite male volleyball players competing in specific individual playing positions. From a practical perspective, sport scientists and conditioning professionals should take the strength and anthropometric characteristics of volleyball players into account when designing individualized position-specific training programs.

Skowronski W, et.al. (2009) documented that the Eurofit Special Test is a battery of motor fitness tests resulting from a 10-year project of the Committee of Experts for Sports Research and is comprised of strength, speed, flexibility, and balance. The purpose of this study was to investigate whether the Eurofit Special was able to distinguish variations in functioning among individuals with intellectual disabilities. Significant differences were found in long jump flexibility 25-m dash, medicine ball throw, balance walk, sit ups in 30-s. Analyses demonstrated that the Eurofit Special was able to discriminate performance levels by gender, age, and level of intellectual disability (mild: 177 female, 368 male; moderate: 359 female, 476 male; severe: 92 female, 111 male).

Hoffman JR, et.al. (2009) examined the efficacy of periodization and to compare different periodization models in resistance trained American football players. Fifty-one experienced resistance trained American football players of an NCAA Division III football team (after 10 weeks of active rest) were randomly assigned to 1 of 3 groups that differed only in the manipulation of the intensity and volume of training during a 15-week offseason resistance training program. Group 1 participated in a nonperiodized (NP) training program, group 2 participated in a traditional periodized linear (PL) training program, and group 3 participated in a planned nonlinear periodized (PNL) training program. Strength and power testing occurred before training (PRE), after 7 weeks of training (MID), and at the end of the training program (POST). Significant increases in maximal (1-repetition maximum [1RM]) squat, 1RM bench press, and vertical jump were observed from PRE to MID for all groups; these increases were still significantly greater at POST; however, no MID to POST changes were seen. Significant PRE to POST improvements in the medicine ball throw (MBT) were seen for PL group only. The results do not provide a clear indication as to the most effective training program for strength and power enhancements in already trained football players. Interestingly, recovery of training-related performances was achieved after only 7 weeks of training, yet further gains were not observed.

These data indicate that longer periods of training may be needed after a long-term active recovery period and that active recovery may need to be dramatically shortened to better optimize strength and power in previously trained football players.

Ignasiak Z, et.al. (2007) selected schoolchildren 7-15 years of age (463 males, 436 females) living in the vicinity of copper smelters and refineries were tested for blood lead. In addition to body size and blood lead, physical fitness was measured: right and left grip strength, timed sit-ups, flexed arm hang, plate tapping, shuttle run, standing long jump and medicine ball throw. Simple reaction time was also measured. Results: The effect of blood lead level on physical fitness was indirect and small, and operated through anthropometric dimensions that more directly influenced the measures of fitness. Direct effects of blood lead level on indicators of physical fitness in school age youth are not evident. Blood lead level adversely affects physical fitness indirectly through growth stunting.

Faigenbaum AD, et.al. (2007) evaluated the efficacy of an after-school resistance training program on improving the physical fitness of middle school-age boys. 22 boys (M = 13.9 yr., SD = .4 yr.) participated in a periodized, multiple-set, 9-wk. (2x/week) resistance training program. All subjects were pre- and post-tested on their 10-repetition maximum squat, 10-repetition maximum bench press, vertical jump, medicine ball toss, flexibility, and also percentage of body fat and the progressive aerobic cardiovascular endurance run (PACER).

Statistical analysis indicated that subjects significantly improved performance on the squat (19%), bench press (15%), flexibility (10%), vertical jump (5%), medicine ball toss (12%), and the PACER (36%). Although this design minus a control group limits interpretation, this after-school resistance-training program can improve muscular fitness and cardiovascular fitness in boys and should be replicated with appropriate experimental controls.

Gabbett T, et.al. (2006) investigated the effect of a skill-based training program on measurements of skill and physical fitness in talent-identified volleyball players. Twenty-six talented junior volleyball players (mean +/- SE age, 15.5 +/- 0.2 years) participated in an 8-week skill-based training program that included 3 skill-based court sessions per week. Skills sessions were designed to develop passing, setting, serving, spiking, and blocking technique and accuracy as well as game tactics and positioning skills. Coaches used a combination of technical and instructional coaching, coupled with skill-based games to facilitate learning. Subjects performed measurements of skill (passing, setting, serving, and spiking technique and accuracy), standard anthropometry (height, standing-reach height, body mass, and sum of 7 skinfolds), lower-body muscular power (vertical jump, spike jump), upper-body muscular power (overhead medicine-ball throw), speed (5- and 10-m sprint), agility (T-test), and maximal aerobic power (multistage fitness test) before and after training. Training induced significant ($p < 0.05$) improvements in spiking, setting, and passing accuracy and spiking and passing technique. Compared with pretraining, there were significant ($p < 0.05$) improvements in 5- and 10-m speed and agility. There were no significant differences between pretraining and posttraining for body mass, skinfold thickness, lower-body muscular power, upper-body muscular power, and maximal aerobic power. These findings demonstrate that skill-based volleyball training improves spiking, setting, and passing accuracy and spiking and passing technique, but has little effect on the physiological and anthropometric characteristics of players.

Duncan MJ, et.al. (2005) examined the influence of familiarization with the backward, overhead medicine ball throw test of explosive power. Male rugby players (N = 28) aged 15 to 16 (M +/- SD = 15.1 +/- 0.5) years completed the medicine ball throw six times. Repeated measures ANOVA indicated that the distance thrown differed across trials ($F5,135 = 12.83$, $p < 0.01$). Least significant differences post hoc multiple comparisons revealed significant differences between a number of trials; however, no significant difference was evident between the fifth and sixth trials (Mdiff = .005, $p > 0.05$). Typical error of measurement became less as trials progressed, with the typical error of measurement being 0.10 m between the fifth and sixth trials indicating little within subject variation between medicine ball throws following a familiarization period. The backward, overhead medicine ball throw may be a practical, reliable method to assess total body, explosive power of male teen-aged rugby players;

however, completion of at least 5 to 6 practice trials is suggested for participants to obtain a stable score.

Hoff J. (2005) documented that elite soccer players spend a substantial amount of time trying to improve physical capacities, including aerobic endurance and strength and the strength derivatives of speed and power. The average oxygen uptake for international soccer teams ranges from 55 to 68 ml.kg-1.min-1 and the half-squat maximal strength from 120 to 180 kg. These values are similar to those found in other team sports. Recently, it has been shown that the heart's stroke volume is the element in the oxygen chain that mainly limits aerobic endurance for athletes. These findings have given rise to more intensive training interventions to secure high stroke volumes, which, in turn, have proved positive in changing both maximal oxygen consumption and soccer performance in terms of distance covered, contacts with the ball and number of sprints in a game. The training employed has consisted of 4x4-min "intervals" running uphill at 90-95% of maximal heart rate interspersed with 3 min jogging at 70% of maximal heart rate to facilitate removal of lactate. Research has revealed that a soccer-specific training routine with the ball might be as effective as plain running. Strength training to produce neural adaptations has been effective in changing not only strength in terms of "one-repetition maximum", but also sprinting velocity and jumping height, in elite soccer players without any change in body mass. The same training has also improved running economy and thus aerobic endurance performance. The training regimen used for a European Champions League team was 4x4 repetitions of half-squats with the emphasis on maximal mobilization of force in the concentric action.

Tse MA, et.al. (2005) examined the effectiveness of a core endurance exercise protocol. Forty-five college-age rowers (age 21 +/- 1.0) were assigned to either a core training group [core group] (n = 25), which took part in a core endurance intervention exercise protocol, or to a control training group [control group] (n = 20), which was not given any specialized core training. Training took place 2 days per week for 8 weeks. Trunk endurance was assessed using flexion, extension, and side flexion tests, whereas a variety of functional performance measures were assessed (vertical jump, broad jump, shuttle run, 40-m sprint, overhead medicine ball throw, 2,000-m maximal rowing ergometer test). The results revealed significant improvement in the two side flexion tests for the core group ($p < 0.05$). Interestingly, significant differences were noted in the trunk extension test endurance times for the control group ($p < 0.05$), but not for the core group. No significant differences were found for any of the functional performance tests. In summary, the 8-week core endurance training program improved selected core endurance parameters in healthy young men, but the effectiveness of the core intervention on various functional performance aspects was not supported.

Chamari K, et.al. (2005) determined whether improvement in maximal oxygen uptake was reflected in increased distance covered in the Hoff test. We tested 18 male soccer players (14 years old) both in the laboratory and using the Hoff test before and after 8 weeks of soccer training. The distance covered in the Hoff test correlated significantly with maximum oxygen uptake, and improved by 9.6% during the 8 week training period, while maximum oxygen uptake and running economy improved by 12 and 10%, respectively. Backward multiple regression showed maximum oxygen uptake to be the main explanatory variable for the distance covered in the Hoff test. The present study demonstrated a significant correlation between laboratory testing of VO(2max) and performance in the Hoff test. Furthermore, training induced improvements in VO(2max) were reflected in improved performance in the Hoff test. We suggest that it should be a goal for active U-15 soccer players to cover more than 2100 metres in the Hoff test, as this requires a VO(2max) of above 200 ml/kg(0.75)/min, which should serve as a minimum in modern soccer.

Falk B, et.al. (2004) identified variables of swimming, ball handling and physical ability, as well as game intelligence, which could assist in the selection process of young water-polo players. Twenty-four players aged 14-15 years underwent a battery of tests three times during a 2-year period, before selection to the junior national team. The tests included: freestyle swim for 50, 100, 200 and 400 m, 100-m breast-stroke, 100-m 'butterfly' (with breast-stroke leg motion), 50-

m dribbling, throwing at the goal, throw for distance in the water, vertical 'jump' from the water, and evaluation of game intelligence by two coaches. A comparison of those players eventually selected to the team and those not selected demonstrated that, 2 years before selection, selected players were already superior on most of the swim tasks (with the exception of breast-stroke and 50-m freestyle), as well as dribbling and game intelligence. This superiority was maintained throughout the 2 years. Two-way tabulation revealed that, based on baseline scores, the prediction for 67% of the players was in agreement with the final selection to the junior national team. We recommend that fewer swim events be used in the process of selecting young water-polo players, and that greater emphasis should be placed on evaluation of game intelligence.

Loko J, et.al. (2003) assessed the age differences in growth characteristics and physical abilities of physically active adolescent girls and to compare them to corresponding data for girls nonactive in sport. The cross-sectional study was carried out on 643 Estonian girls, 10-17 years of age, who were regularly training track and field, and 902 nonactive girls. The organized physical activity of the studied girls consisted of lessons in the school curriculum (2 x 45 minutes per week) for both groups and special track and field training for the first group. Height, weight, and the body mass index (BMI) were used to characterize growth status. Physical ability was assessed with the 30-m dash, standing long jump, medicine ball throw (2 kg), standing quintuplet jump, isometric strength of back extensor muscles, and 1-minute ergocycling at the highest possible rate. Girls active in track and field were taller in all the age groups ($P < 0.05-0.001$) and lighter except at 17 years, when they were heavier ($P > 0.05$), but the differences at 12 and 13 years were not significant. BMI was also significantly lower in active girls ($P < 0.05-0.001$) in all age groups, except at 17 ($P > 0.05$). The actively training girls had higher physical abilities at all ages from 10-17. The annual differences in performance scores were significant ($P < 0.05-0.001$) up to 15 years except for the standing long jump. Differences in mean scores of most motor abilities were minimal or reduced significantly at 13-14 years in nonactive girls, but were significant in active girls.

Faigenbaum AD, et.al. (2001) examined the effects of 4 different resistance training protocols on upper-body strength and local muscle endurance development in children. Untrained boys and girls (mean +/- SD age, 8.1 +/- 1.6 years) trained twice per week for 8 weeks using child-sized weight machines and medicine balls weighing 1-2.5 kg. In addition to general conditioning exercises, subjects in each exercise group performed 1 set of the following exercise protocols for upper-body conditioning: 6-8 repetitions with a heavy load on the chest press exercise (HL, n = 15); 13-15 repetitions with a moderate load on the chest press exercise (ML, n = 16); 6-8 repetitions with a heavy load on the chest press exercise immediately followed by 6-8 medicine ball chest passes (CX, n = 12); or 13-15 medicine ball chest passes (MB, n = 11). Twelve children served as nontraining controls (CT). After training, only the ML and CX groups demonstrated significant ($p < 0.05$) improvements in 1RM chest press strength (16.8% and 16.3%, respectively) as compared with the CT group. Local muscle endurance, as determined by the number of repetitions performed posttraining on the chest press exercise with the pretraining 1RM load, significantly increased in the ML group (5.9 +/- 3.2 repetitions) and CX group (5.2 +/- 3.6 repetitions) as compared with the CT group. In terms of enhancing the upper-body strength and local muscle endurance of untrained children, these findings favor the prescription of higher-repetition training protocols during the initial adaptation period.

2.3 SUMMARY OF REVIEW OF RELATED LITERATURE

The investigator has reviewed related literature on effect of circuit training, effects of medicine ball exercises and training on varied frequencies and intensities; effect of circuit training and medicine ball training on biomotor abilities. It was found that there was scope for further research in finding out structured circuit training and progressive intensity medicine ball exercise on biomotor abilities of college men football players. Hence, the investigator undertook this research. Based on the experience gained through the review of related literature, the investigator formed suitable methodology to be adopted for this research which is presented in Chapter III.