

CHAPTER II

REVIEW OF RELATED LITERATURE

A study of relevant literature is an essential step to get a full picture of what has been done with regard to the problem under study. Such a review brings out a deep and clear perspective of the overall field.

The review of literature is instrumental in selection of the topic, transaction of hypothesis and deductive reasoning leading to the problem. It helps to get a clear idea and supports the findings with regard to the problem under study.

The following materials collected from the views expressed by various personalities provide back ground information to the study and help us to understand the effect of various combinations of pilates and plyometric training on motor fitness, physiological and psychological, on college men. The views of the experts and research workers in the field of physical education are given primary importance in the present study.

2.1 STUDIES ON PILATES TRAINING, MOTOR FITNESS, PHYSIOLOGICAL AND PSYCHOLOGICAL VARIABLES.

English and Howe (2007) investigated the effect of pilates exercise on trunk and postural stability and throwing velocity in college baseball pitchers single subject design. Baseball pitchers need trunk strength to maximize performance. The Pilates method of exercise is gaining popularity throughout the country as a fitness and rehabilitation method of exercise. However, very few studies exist that examine the effects of the Pilates method of exercise on trunk strength or performance. Using a single subject, multiple baseline across subjects design, this study examines the effects of the Pilates method of exercise on performance of double leg lowering, star excursion balance test, and throwing velocity in college-aged baseball pitchers. A convenience sample of three college baseball pitchers served as the subjects for this single subject design study. For each subject, double leg lowering, star excursion balance test, and throwing speed were measured prior to the introduction of the

intervention. When baseline test values showed consistent performance, the intervention was introduced to one subject at a time. Intervention was introduced to the other subjects over a period of 4 weeks as they also demonstrated consistent performance on the baseline tests. Intervention was continued with periodic tests for the remainder of the 10 week trial. Each subject improved in performance on double leg lowering (increased 24.43-32.7%) and star excursion balance test (increased 4.63-17.84%) after introduction of the intervention. Throwing speed improved in two of the three subjects (up to 5.61%). It was concluded that the pilates method of exercise may contribute to improved performance in double leg lowering, star excursion balance tests, and throwing speed in college baseball pitchers.

Sureeporn *et al.*, (2011) investigated the comparative effects of Pilates exercise on flexibility and lumbo-pelvic movement control between the Pilates training and control groups. A randomized single-blinded controlled design was utilized in the study. Forty healthy male and female volunteers (mean age 31.65 ± 6.21 years) were randomly divided into Pilates-based training (20 subjects) and the control groups (20 subjects). The Pilates group attended 45-minute training sessions, 2 times per week, for a period of 8 weeks. Flexibility and lumbo-pelvic stability tests were determined as outcome measures using a standard "sit and reach test" and "pressure biofeedback" respectively at 0, 4 and 8 weeks of the study. The results showed that the Pilates training group improved flexibility significantly ($P < 0.001$) during time intervals. This effect was also significantly greater than the control group for both 4 weeks and 8 weeks of the training period ($P < 0.001$). There were 65% and 85% of the subjects from Pilates group passing the lumbo-pelvic stability test at 4 and 8 weeks of training periods respectively. No subjects from the control group passed the test at any stages. Pilates can be used as an adjunctive exercise program to improve flexibility, enhance control-mobility of trunk and pelvic segments.

Ana *et al.*, (2011) analysed the effects of pilates method of exercise in healthy people. To the study evaluate the evidence for the effectiveness of the pilates method of exercise (PME) in healthy people. Two reviewers independently applied the inclusion criteria to selected potential studies. Studies were included if they were

published in a peer-reviewed journal, written in the English language, conducted as a randomized controlled trial (RCT) or quasi-RCT in healthy people, had an inactive and/or exercise control group(s), included key study outcomes, and used the PME as the study intervention in at least 1 study arm. Two reviewers independently extracted data (study, design, subjects, intervention, key outcomes results), applied the Physiotherapy Evidence Database (PEDro) scale to assess the method quality of selected studies, and determined the strength of the evidence using the best evidence synthesis grading system. Sixteen studies met the inclusion criteria. PEDro scale values ranged from 3 to 7 (mean, 4.1), indicating a low level of scientific rigor. The outcomes studied most often were flexibility, muscular endurance, strength, and postural alignment. The PME appears to be effective in improving flexibility (strong evidence), dynamic balance (strong evidence), and muscular endurance (moderate evidence) in healthy people. There was strong evidence to support the use of the PME at least to the end of training to improve flexibility and dynamic balance and moderate evidence to enhance muscular endurance.

Essam and Manal (2011) found the influence of pilates exercises on the serotonin hormone, some physical variables and the depression degree in battered women. The purpose of the study is to identify the Pilates exercises program impact on the serotonin hormone and some physical variables which represented in the (legs and back muscles strength, muscular endurance and flexibility) and the depression degree for battered women. 10 Ladies of the resident in the host and guide institute of the battered women of Minia governorate were subjected to implement the Pilates exercises program for 12 weeks. The researchers used experimental method by pre and post measurement design to one group, using Beck Aaron measure to measure depression degree and statistical data indicated that there are statistically significant differences between pre and post measurements favoring post measurements in the variables under consideration and for the telemetric and the presence of correlation inverse between the serotonin hormone and the depression degree, it was extracted that Pilates exercise have a positive impact on reduction of the depression degree, improvement in muscle strength, muscular endurance and flexibility.

Augusto et al., (2011) conducted a study to find out the influence of Pilates training on muscular strength and flexibility in dancers. The purpose of the present study was to assess the effects of a Pilates training program on muscular strength and flexibility in dance students. Fifteen dance students were divided into 2 groups: experimental (n=7) and control (n=8). Both were assessed in beginning and in the end of the study. Muscular strength was assessed measuring the time supported in the technical skills penché and develop. To assess flexibility, it was measured the angle between limbs in the technical skills arabesque, developpé and cambré. After the first moment of evaluation, the experimental group performed a Mat-Based Pilates Exercise during 11 weeks. The statistic analyses (two-way analysis of variance - ANOVA 2x2) showed significant differences ($p \leq 0,05$) in muscular strength and flexibility measurements between groups after the training program. It was concluded that Pilates training has a positive effect on muscular strength and flexibility in dance students.

Anbalagan and Venugopal (2012) investigated the effects of Pilates Training and Yogic Training with and without Combination on selected physical fitness components among college level obese students. The purpose of the study was to find out the effects of pilates training and yogic training with and without combinations on selected physical fitness components among college level obese student. Eighty male obese students for this study were selected from Bishop Ambrose College, Coimbatore randomly and divided into four groups as three experimental and control groups. Data were collected from each subject before and after the training. The collected data were statistically analysed by using analysis of covariance (ANCOVA). It was found that there was significant improvement on percent body fat and flexibility of experimental groups when compared to the control group.

Amorim et al., (2011) examined the effects of pilates training on muscular strength and balance in ballet dancers. The purpose of this study was to determine the effects of a Pilates training programme on muscular strength and balance in ballet dancers. Fifteen ballet students were divided in experimental and control groups. Besides the daily technical classes, it was applied a Pilates training programme during 11 weeks in the experimental group. Groups were submitted at two moments

of evaluation, before and after the programme. The muscular strength was evaluated through the time obtained in the maintenance of the performance of penché and développé. Balance was evaluated using a Bertec force plate (4060-15). The migration area of the centre of pressure was calculated in the first position and in the attitude derrière skills. Results suggest that the Pilates training have a positive effect on muscular strength.

Stephen (2012) assessed the benefits of pilates for cross fit athletes. Core strength, flexibility, balance, uniform development, and efficient movement patterns – all are benefits of Pilates training and highly relevant to cross fit athletes. Pilates training strengthens the core of the body the deep abdominal, gluteus and deep intrinsic muscles surrounding the spine. Without strengthening these connective muscles, there are lot more prone to injury. Pilates elongates the spine, increasing the elasticity of muscles and the flexibility of joints. It is this balance between strength and flexibility that reduces the potential for injury. Pilates emphasizes moving from the center of the body, the “powerhouse”, and developing core strength in the deep muscles of the center to stabilize the trunk and protect the back. This kind of core training makes Pilates an excellent technique for whole-body fitness, like cross fit.

Keren *et al.*, (2009) investigated the effect of pilates and taiji quan training on self-efficacy, sleep quality, mood, and physical performance of college students. Methods of exercise such as Pilates and taiji quan, which have been shown to have beneficial effects on physical and mental characteristics, have been studied more often in samples of older participants. The purpose of this investigation was to examine the effects of a semester of either Pilates or taiji quan training on perceived self-efficacy, sleep quality and mood, as well as strength and balance in college-age individuals. Self-efficacy was found to be improved in the Pilates and taiji quan groups and there was a trend towards improvement in sleep quality. Mood was found to be improved significantly in the Pilates group while the taiji group showed a trend towards improvement. There were no changes or group differences in the strength or balance measures. Pilates and taiji quan are effective exercise modes to improve mental parameters in college-age individuals.

Russell et al., (2006) conducted the study on effect of 4 weeks of Pilates on the body composition of young girls. There is a need to find ways to increase the physical activity levels and improve the body composition and blood pressure of girls. Thirty 11-year-old girls were recruited from two after school programs in Houston Texas in Spring 2005. Participants from one program (16) were randomly assigned to intervention, the other (14) served as controls. BMI, BMI percentile, waist circumference and blood pressure were assessed before and after the intervention. Pilates classes were provided free of charge for an hour per day at the intervention site, 5 days a week, for 4 weeks. Four participants wore heart rate monitors during every session and completed enjoyment and perceived exertion questionnaires. Repeated measures analysis of variance with time (within) and group (between) as factors was performed. Mean attendance was 75%, mean heart rate 104 bpm, mean perceived exertion 5.9 (1-10 scale) and enjoyment 4.4 (1-5 scale). There was a significant ($P = 0.039$) time by group interaction for BMI percentile. Graphs indicated that this difference was influenced by large reductions in the BMI percentile of healthy girls. Girls enjoyed Pilates, and participation for 4 weeks lowered BMI percentile. Pilates holds promise as a means of reducing obesity.

Culligan et al., (2010) compared the effect of pelvic floor muscle training to a Pilates exercise program for improving pelvic muscle strength. The purpose of this study is to determine whether a Pilates exercise program and a pelvic floor muscle-training (PFMT) program could provide similar improvements in pelvic muscle strength. Sixty-two women with little or no pelvic floor dysfunction were randomized to Pilates or PFMT. Each group had 24 biweekly 1-h sessions with either a physical therapist or Pilates instructor. Strength was measured via perineometry (cmH₂O). Two questionnaires--pelvic floor distress inventory (PFDI-20) and pelvic floor impact questionnaire (PFIQ-7)--were also collected. At baseline, the Pilates and PFMT groups measured 14.9 +/- 12.5 and 12.5 +/- 10.4 cmH₂O, respectively ($p = 0.41$). Both the Pilates and PFMT groups got stronger (6.2 +/- 7.5 cmH₂O, $p = 0.0002$ and 6.6 +/- 7.4 cmH₂O, $p = 0.0002$, respectively), with no difference between groups $p = 0.85$. PFIQ and PFDI scores improved from baseline but not between groups.

Emery et al., (2010) examined the effects of a pilates training program on arm-trunk posture and movement. Shoulder biomechanics and spine alignment have been found to be related to occasional and/or chronic neck-shoulder pain. Pilates is a physical training approach that focuses on posture, flexibility, segmental alignment and core control, through posture and movement exercises. The objectives of this study were to determine the effect of a Pilates training program on arm-trunk posture, strength, flexibility and biomechanical patterns during a functional shoulder flexion task. Nineteen subjects (9 controls, 10 experimental) were assessed twice, 12 weeks apart, during which the experimental group was submitted to a Pilates training program (two 1-h sessions per week). The assessment consisted of trials of seated posture, abdominal strength, shoulder range of motion, and maximal shoulder flexion, during which neck, shoulder and trunk kinematics and the activity of 16 muscles were recorded. After training, subjects showed smaller static thoracic kyphosis during quiet sitting and greater abdominal strength. The experimental group also showed reduced posterior and mediolateral scapular displacements, upper thoracic extension and lumbar lateral flexion, as well as higher activity of the ipsilateral cervical erector spinae, contralateral rhomboid muscles and lower activity of the ipsilateral lumbar erector spinae during the shoulder flexion task. The Pilates training program was effective in improving abdominal strength and upper spine posture as well as in stabilizing core posture as shoulder flexion movements were performed.

Kate et al., (2009) reported the effect of eight-week traditional mat Pilates training-program on adult fitness characteristics. They investigated responses of adult, novice practitioners (n = 9) to an 8-week traditional mat Pilates program (P) that met 1 hr/day three times/week. Classes consisted primarily of beginner and intermediate level exercises. Compared to an active control group (C; n = 13) that showed no improvements, those in P significantly ($p < .05$) improved relative body fat (-1.2% BF), sit-and-reach (+7.5 cm), shoulder reach (+6.9 cm), curl-up (+14 reps), and low back extension (+7 reps) scores, as well as circumferences at the waist (-2.7 cm), chest (-1.7 cm), and arm (-0.5 cm). Baseline differences were noted only for curl-ups and low back extensions, with P being lower than C Body composition,

muscular endurance, and flexibility significantly improved after 8 weeks of traditional mat Pilates.

Kloubec (2010) examined the effectiveness of pilates for improvement of muscle endurance, flexibility, balance, and posture. Many claims have been made about the effectiveness of Pilates exercise on the basic parameters of fitness. The purpose of this study was to determine the effects of Pilates exercise on abdominal endurance, hamstring flexibility, upper-body muscular endurance, posture, and balance. Fifty subjects were recruited to participate in a 12-week Pilates class, which met for 1 hour 2 times per week. Subjects were randomly assigned to either the experimental (n = 25) or control group (n = 25). The Subjects performed the essential (basic) mat routine consisting of approximately 25 separate exercises focusing on muscular endurance and flexibility of the abdomen, low back, and hips each class session. At the end of the 12-week period, a 1-way analysis of covariance showed a significant level of improvement ($p < \text{or} = 0.05$) in all variables except posture and balance. This study demonstrated that in active middle-aged men and women, exposure to Pilates exercise for 12 weeks, for two 60-minute sessions per week, was enough to promote statistically significant increases in abdominal endurance, hamstring flexibility, and upper-body muscular endurance. Participants did not demonstrate improvements in either posture or balance when compared with the control group. Exercise-training programs that address physical inactivity concerns and that are accessible and enjoyable to the general public are a desirable commodity for exercise and fitness trainers. This study suggests that individuals can improve their muscular endurance and flexibility using relatively low-intensity Pilate's exercises that do not require equipment or a high degree of skill and are easy to master and use within a personal fitness routine.

Santana et al., (2010) conducted a study of the effects of the pilates method on the strength, flexibility, agility and balance of professional mountain bike cyclist. There exists quite a bit of information about the history, foundation and exercises of the Pilates Method, however, it is difficult to come across studies that provide scientific data regarding how this method can bring about high level outcomes in sports. The objective of our study is to discover what kind of effects the application

of training based on the Pilates Method have in the areas of strength, flexibility, agility and balance on a professional mountain bike cyclist. The design is within a group, (temporary series of inter subject design) given that the subject, Rúben Ruzafa, is the only professional cyclist in Málaga. Spanish Champion in 2005, 2006, and 2008 and World Champion in 2005 and 2008. 6 measurements have been taken (3 base line measurements and 3 as a posterior evaluation). The greatest effort, (a calculation based on the maximum number of repetitions) in situps, benchpresses, cuadriceps and femorals. The explosive force with the horizontal jump. Resistance force of abdominals until the subject becomes fatigued. Coordination in the slalom test; sit and reach flexibility and balance in the flamenco test. There is marked improvement in strength in all of its forms (maximum, explosive, resistance), agility, flexibility and balance after a 3 day a week, 4 week Pilates Training programme.

Ana et al., (2011) investigated the study of effects of pilates-based exercise on life satisfaction, physical self-concept and health status in adult women. The objective of this study was to determine the effect of Pilates-based mat exercises on life satisfaction, perception of appreciation by other people, perception of physical appearance, perception of functionality, total physical self-concept, and perception of health status in healthy women. A randomized controlled trial was conducted in Évora, Portugal, in 2008, in which 62 healthy adult women were randomized to a Pilates-based mat (experimental group) ($n = 38$, mean age \pm SD, 41.08 ± 6.64 years) or a control group ($n = 24$, mean age \pm SD, 40.25 ± 7.70 years). Experimental group participants performed the Initial Mat of Body Control Pilates twice per week, 60-minutes per session. Repeated measurements were performed at baseline, 3 months and 6 months. No significant differences between the two groups were observed in life satisfaction, perception of appreciation by other people, perception of physical appearance, perception of functionality, total physical self-concept, and perception of health status at three time point measures (baseline, after 3 months, and after 6 months). No significant differences were observed in the control group over time. The experimental group showed significant improvements between baseline and six months in life satisfaction ($p = .04$), perception of appreciation by other people ($p = .002$), perception of physical appearance ($p = .001$), perception of functionality ($p = .01$),

total physical self-concept ($p = .001$), perception of health status ($p = .013$) and between three and six months in life satisfaction ($p = .002$), perception of appreciation by other people ($p = .05$), perception of physical appearance ($p = .001$), perception of functionality ($p = .02$), and total physical self-concept ($p = .001$). Life satisfaction, perception of appreciation by other people, perception of physical appearance, perception of functionality, total physical self-concept and perception of health status may improve after 6 months of Pilates-based mat exercise.

Karen et al., (2010) assessed mindfulness in college students through movement-based courses. Effects on self-regulatory self-efficacy, mood, stress, and sleep quality. This study examined whether mindfulness increased through participation in movement-based courses and whether changes in self-regulatory self-efficacy, mood, and perceived stress mediated the relationship between increased mindfulness and better sleep. 166 college students enrolled in the 2007–2008 academic year in 15 week classes in Pilates, Taiji quan, or Gyrokinesis. At beginning, middle, and end of the semester, participants completed measures of mindfulness, self-regulatory self-efficacy, mood, perceived stress, and sleep quality. Total mindfulness scores and mindfulness subscales increased overall. Greater changes in mindfulness were directly related to better sleep quality at the end of the semester after adjusting for sleep disturbance at the beginning. Tiredness, Negative Arousal, Relaxation, and Perceived Stress mediated the effect of increased mindfulness on improved sleep. Movement-based courses can increase mindfulness. Increased mindfulness accounts for changes in mood and perceived stress, which explain, in part, improved sleep quality.

Sarunas et al., (2012) examined changes in psychosocial adjustment of adolescent girls in the lessons of physical education. The aim of the present study was to establish the changes in psychosocial adjustment of adolescent girls in the modified lessons of physical education. An experimental design was used in the study. The experimental group included 14- to 15-year-old adolescent girls ($n=128$), and the control group comprised adolescent girls of the same school and the same age ($n=137$). The girls of the experimental group participated in modified physical education lessons. Once a month, they had a theory class where they received

knowledge on communication disorders among adolescents and ways of preventing them by means of physical activities. In practical classes, the girls of the experimental group had sports games (basketball, volleyball, and football), enhancing physical abilities, and Pilates exercises. For the estimation of the level of adolescents' psychosocial adjustment and its components (self-esteem and domination), an adapted questionnaire developed by Rogers and Dymond was applied. An adapted questionnaire developed by Huebner was administered to measure students' satisfaction with life. The analysis of the data demonstrated that when comparing the psychosocial adjustment of the adolescent girls in the experimental group before and after the experiment, a significant differences in the score of the psychosocial adjustment scale was established (53.81 ± 8.34 vs. 59.41 ± 7.66 , $P < 0.05$). After the experiment, high life satisfaction was reported by 42.19% of the girls ($P < 0.05$). After the educational experiment, the index of the psychosocial adjustment scale in the experimental group improved statistically significantly.

Eric et al., (2007) examined the effects of Pilates-based exercise on dynamic balance in healthy adults Professionals in theatre, athletics, and rehabilitation settings have integrated Pilates-based exercise into their practice. The Pilates method of exercise claims to have several benefits including improving posture and improving balance; however, there are few studies to support these statements. We studied the effects of Pilates-based exercise on dynamic balance in healthy adults. A certified Pilates instructor conducted all exercise sessions. After completing 10 Pilates-based exercise sessions a significant change ($P = 0.01$) in dynamic balance was found in the functional reach test (FRT) mean scores in the exercise group ($n = 17$). The control group ($n = 17$) demonstrated no significant change ($P = 0.54$). The results suggest that Pilates-based exercise improved dynamic balance as measured by the functional reach test in healthy adults.

Shiv and Abhilash (2012) experimented the effect of yogasanas and pilates exercise on flexibility and cardiovascular endurance of obese boys. The aim of the study was to determine the effects of yogasanas and pilates exercises training on physical status variables including flexibility and Cardiovascular Endurance. Forty five randomly selected male students of K. V. Pattom, Trivandrum, India aged 18 –

24 years, volunteered to participate in the study. Subjects were assigned into three groups: I (experimental A: N-15), II (experimental B: N-15) and III (control: N-15). The subjects from Group I and II were subjected to 12-weeks yoga and pilates training programme. Each yoga session consisted of 25 minutes of asanas, 15 minutes of pranayamas, and 5 minutes of supine relaxation in savasana. The subjects were evaluated pre and post the 12-week training program. Analysis of covariance was used to assess the between-group differences for dependent data to assess the Post-Pre differences. Results indicated including flexibility and Cardiovascular Endurance variables including ($p < 0.05$) significantly improved in group I and II compared with the control group. There was non-significant difference was found between two experimental groups for flexibility and cardiovascular endurance. These findings indicate that regular yoga and pilates practice can elicit improvements in the flexibility and cardiovascular endurance.

Segal et al., (2004) conducted a study on the effects of pilates training on flexibility and body composition. The objective of the study was to assess claims regarding the effects of Pilates training on flexibility, body composition, and health status. A sample of 47 adults (45 women, 2 men) who presented for Pilates training were collected from a community athletic club. There were no interventions. Main Outcomes measured through Fingertip-to-floor distance, truncal lean body mass by bioelectric impedance, health status by questionnaire and visual analog scale were assessed at baseline, 2, 4, and 6 months (1wk). That the result indicated thirty-two of 47 enrolled subjects met the protocol requirements of missing no more than 1 weekly 1-hour session Pilates mat class during each 2-month period. Investigators were blinded to measurements from previous time points. Median (inter quartile range [IQR]) fingertip-to-floor distance improved from baseline by 3.4cm (1.3–5.7cm), 3.3cm (0.3–7.8cm), and 4.3cm (1.5–7.6cm) at 2, 4, and 6 months, respectively (paired nonparametric analysis, all $P_{.01}$). There were no statistically significant changes in truncal lean body mass, height, weight, or other body composition parameters. Self assessment of health also did not change in a statistically significant manner from its baseline median (IQR) value of 77mm (69–85mm). So that it was concluded the Pilates training may result in improved flexibility. However, its effects

on body composition, health status, and posture are more limited and may be difficult to establish. Further study might involve larger sample sizes, comparison with an appropriate control group, and assessment of motor unit recruitment as well as strength of truncal stabilizers.

Wang *et al.*, (2012) examined the effects of eight-week pilates training on limits of stability and abdominal muscle strength in young dancers. This study examined the effects of 8-week Pilates training program on limits of stability (LOS) and abdominal muscle strength in young dancers. Twenty-four female volunteered and randomly assigned as experimental group (EG) or control group (CG). All subjects received the same dance lessons but the EG underwent an extra Pilates mat exercises for 40 minutes, three times a week, for 8 weeks. LOS was evaluated by the Biodex Balance System and the abdominal strength was measured by 30/60 seconds sit-ups test. One factor ANCOVA was used to examine the differences between groups after training. The results showed that the overall LOS scores at levels 2/8 and the 30/60 seconds sit-ups for the EG group pre- and post-training were changed from 22/38 % to 31/51 % and 20/33 times to 24/42 times, respectively. The study demonstrated that 8-week Pilates training can improve the LOS performance and abdominal strength in young dancers.

Samir *et al.*, (2010) has conducted a study to find out the impact of pilates exercises on the muscular ability and components of jumping to volleyball players. This study is regarded a methodological attempt to identify the impact of Pilates exercises on the muscular ability and components of jump on Volleyball Players. Researchers have noticed the low level in skill performance and their endurance to continue the performance in a good way particularly in matches that are approximately similar in level. So, researchers tended to use Pilates exercises to identify their impact on raising muscular ability level and components of jump simultaneously. The experimental approach was applied on a sample of 20 players of eastern company sportive club in Arab Republic of Egypt, their ages ranged between 18 and 20. One of the most important results of this research was the improvement in muscular ability level of legs in the posterior measurement than the prior one by 12.04%. Also, there is an improvement in jump components. The improvement

percentage of the jump height was by 12.58%. As of the flying time, it was 7.86%. As for the power, there was a decrease in level by-11.71%. Contact time decreased in the prior measurement by-5.50% than the posterior one. As for biological capacity variable, there was an improvement estimated by 12.86% in posterior measurement than prior one. There was an improvement in attack performance by 10.06% and it was 20.94% in the block.

2.2 Studies on plyometric training, motor fitness, physiological and psychological variables.

David (2012) compared the effect of aquatic-and land-based plyometric training on power, speed and agility in adolescent rugby union players. The purpose of the study was to compare the effectiveness of an aquatic- and land based plyometric programme upon selected, sport-specific performance variables in adolescent male, rugby union players. A group of 52 rugby players (age: 16.3 ± 0.8 years, height: 176 ± 6.9 cm and body mass: 76.1 ± 11.9 kg) were randomly assigned to one of three groups: aquatic group (n=18), land group (n=17), and a control group (n=17). Prior to and after the seven weeks of training, the power, agility and speed of participants were assessed by means of Fitrodyne repeated countermovement jumps, the Sergeant vertical jump, the Illinois agility test, a standing broad jump, and a 10- and 40- metre sprint. All three groups maintained their summer extra-curricular sport commitments during the intervention period. When the three groups were analysed, no significant differences were found between the groups with regard to all tested performance variables. With regard to within group changes, the aquatic group improved significantly ($p < 0.05$) in the Illinois agility test, performed to the right. The land group showed significant ($p < 0.05$) improvements in peak concentric power during Fitrodyne repeated countermovement jumps. All groups reflected highly significant ($p < 0.01$) improvements in the Sergeant vertical jump. None of the groups displayed any improvements in sprint speed. The control was the only group to improve significantly in the standing broad jump ($p < 0.05$). Land-based plyometric training might be a functionally superior training modality for athletes, although aquatic plyometrics could also offer an effective training modality for performance enhancement in power-based sports such as rugby union football. Aquatic-based

plyometrics should not completely replace land-based plyometrics, as it might not adequately develop the specific neuromuscular patterns or functional needs of explosive sports.

Miller *et al.*, (2006) investigated the effects of a 6-week plyometric training program on agility. The purpose of the study was to determine if six weeks of plyometric training can improve an athlete's agility. Subjects were divided into two groups, a plyometric training and a control group. The plyometric training group performed in a six week plyometric training program and the control group did not perform any plyometric training techniques. All subjects participated in two agility tests: T-test and Illinois Agility Test, and a force plate test for ground reaction times both pre and post testing. Univariate ANCOVAs were conducted to analyze the change scores (post – pre) in the independent variables by group (training or control) with pre scores as covariates. The Univariate ANCOVA revealed a significant group effect $F_{2,26} = 25.42$, $p=0.0000$ for the T-test agility measure. For the Illinois Agility test, a significant group effect $F_{2,26} = 27.24$, $p = 0.000$ was also found. The plyometric training group had quicker post test times compared to the control group for the agility tests. A significant group effect $F_{2, 26} = 7.81$, $p = 0.002$ was found for the Force Plate test. The plyometric training group reduced time on the ground on the post test compared to the control group. The results of this study show that plyometric training can be an effective training technique to improve an athlete's agility.

Compo *et al.*, (2009) investigated the effects of lower-limb plyometric training on body composition, explosive strength, and kicking speed in female soccer players. The aim of the present study was to examine how explosive strength, kicking speed, and body composition are affected by a 12-week plyometric training program in elite female soccer players. The hypothesis was that this program would increase the jumping ability and kicking speed and that these gains could be maintained by means of regular soccer training only. Twenty adult female players were divided into 2 groups: control group (CG, $n = 10$, age 23.0 ± 3.2 yr) and plyometric group (PG, $n = 10$; age 22.8 ± 2.1 yr). The intervention was carried out during the second part of the competitive season. Both groups performed technical and tactical training

exercises and matches together. However, the CG followed the regular soccer physical conditioning program, which was replaced by a plyometric program for PG. Neither CG nor PG performed weight training. Plyometric training took place 3 days a week for 12 weeks including jumps over hurdles, drop jumps (DJ) in stands, or horizontal jumps. Body mass, body composition, countermovement jump height, DJ height, and kicking speed were measured on 4 separate occasions. The PG demonstrated significant increases ($p < 0.05$) in jumping ability after 6 weeks of training and in kicking speed after 12 weeks. There were no significant time \times group interaction effects for body composition. It could be concluded that a 12-week plyometric program can improve explosive strength in female soccer players and that these improvements can be transferred to soccer kick performance in terms of ball speed. However, players need time to transfer these improvements in strength to the specific task. Regular soccer training can maintain the improvements from a plyometric training program for several weeks.

Rimmer and Sleivert (2000) examined the effects of a plyometrics intervention program on sprint performance. To determine the effects of a sprint-specific plyometrics program on sprint performance, an 8-week training study consisting of 15 training sessions was conducted. Twenty-six male subjects completed the training. A plyometrics group ($N = 10$) performed sprint-specific plyometric exercises, while a sprint group ($N = 7$) performed sprints. A control group ($N = 9$) was included. Subjects performed sprints over 10-and 40-m distances before (Pre) and after (Post) training. For the plyometrics group, significant decreases in times occurred over the 0-10-m (Pre 1.96 \pm 0.10 seconds, Post 1.91 \pm 0.08 seconds, $p = 0.001$) and 0-40-m (Pre = 5.63 \pm 0.18 seconds, Post = 5.53 \pm 0.20 seconds, $p = 0.001$) distances, but the improvements in the sprint group were not significant over either the 0-10-m (Pre 1.95 \pm 0.06 seconds, Post 1.93 \pm 0.05 seconds) or 0-40-m distance (Pre 5.62 \pm 0.14 seconds, Post 5.55 \pm 0.10 seconds). The magnitude of the improvements in the plyometrics group was, however, not significantly different from the sprint group. The control group showed no changes in sprint times. There were no significant changes in stride length or frequency, but ground contact time decreased at 37 m by 4.4% in the plyometrics group only. It is

concluded that a sprint-specific plyometrics program can improve 40-m sprint performance to the same extent as standard sprint training, possibly by shortening ground contact time.

Spurrs *et al.*, (2003) experimented the effect of plyometric training on distance running performance. Previous research has reported that plyometric training improves running economy (RE) and ultimately distance-running performance, although the exact mechanism by which this occurs remains unclear. This study examined whether changes in running performance resulting from plyometric training were related to alterations in lower leg musculotendinous stiffness (MTS). Seventeen male runners were pre- and post-tested for lower leg MTS, maximum isometric force, rate of force development, 5-bound distance test (5BT), counter movement jump (CMJ) height, RE, Vo_2max , lactate threshold (Th_{la}), and 3-km time. Subjects were randomly split into an experimental (E) group which completed 6 weeks of plyometric training in conjunction with their normal running training, and a control (C) group which trained as normal. Following the training period, the E group significantly improved 3-km performance (2.7%) and RE at each of the tested velocities, while no changes in Vo_2max or Th_{la} were recorded. CMJ height, 5BT, and MTS also increased significantly. No significant changes were observed in any measures for the C group. The results clearly demonstrated that a 6-week plyometric programme led to improvements in 3-km running performance. It is postulated that the increase in MTS resulted in improved RE. We speculate that the improved RE led to changes in 3-km running performance, as there were no corresponding alterations in Vo_2max or Th_{la} .

Brown *et al.*, (2010) examined oxygen consumption, heart rate, and blood lactate responses to an acute bout of plyometric depth jumps in college-aged men and women. Although plyometric are widely used in athletic conditioning, the acute physiologic responses to plyometric have not been described. The purpose of this study was to investigate the oxygen consumption, heart rate, and blood lactate responses to a single session of plyometric depth jumps. Twenty recreationally trained college-aged subjects (10 men, 10 women) participated in a single session of 8 sets of 10 box depth jumps from a height of 0.8 m with 3 minutes of passive

recovery between each set. Plyometric depth jumping elicited $82.5 \pm 3.1\%$ and $77.8 \pm 3.1\%$ of the measured maximal oxygen consumption ($O_2\text{max}$) for women and men, respectively, with no difference in oxygen consumption in ml/kg/min or percent $O_2\text{max}$ between sexes or sets. Heart rate significantly increased ($p < 0.05$) from 68.1 ± 2.9 beats·min⁻¹ at rest to 169.6 ± 1.2 beats·min⁻¹ during depth jumping. Sets 5 to 8 elicited a higher ($p < 0.05$) heart rate (173.3 ± 1.3 beats·min⁻¹) than sets 1 to 4 (164.6 ± 1.8 beats·min⁻¹). Women exhibited a higher heart rate ($p < 0.05$) during sets 1 and 2 (169.9 ± 2.8 beats·min⁻¹) than men (150.7 ± 4.4 beats·min⁻¹). The blood lactate concentrations were significantly ($p < 0.05$) increased above resting throughout all sets (1.0 ± 0.2 mmol·L⁻¹ compared with 2.9 ± 0.1 mmol·L⁻¹), with no differences between sexes or sets. Plyometric depth jumping significantly increased oxygen consumption, heart rate, and blood lactate in both men and women, but no significant difference was found between the sexes. Plyometric depth jumping from a height of 0.8 m has similar energy system requirements to what Wilmore and Costill termed “Aerobic Power” training, which should enhance $O_2\text{max}$, lactate tolerance, oxidative enzymes, and lactate threshold.

Grieco *et al.*, (2012) investigated the effects of a combined resistance-plyometric training program on muscular strength, running economy, and Vo_2 peak in division I female soccer players. Resistance and plyometric training programs have demonstrated consistent improvements in running economy (RE) in trained and untrained adults in the absence of improvements in maximal oxygen consumption. The purpose of this study was to investigate the effect of a 10-week combined resistance-plyometric training program on the RE and $V O_2\text{max}$ [Combining Dot Above] in female soccer players. Fifteen Division 1A female soccer players (age 19.0 ± 0.7 years; height 1.67 ± 0.1 m; weight 61.7 ± 8.1 kg) performed a treadmill test for V [Combining Dot Above] $O_2\text{max}$ and RE at the end of a competitive season (PRE) and after a 10-week training program (POST). Isometric strength was measured in knee flexion and extension. Resistance training was conducted 2 d·wk⁻¹ on non-consecutive days; plyometric training was conducted separately on different non-consecutive days. Eleven subjects were included in the PRE-POST analysis (age 19.0 ± 0.8 years; height 1.67 ± 0.5 m; weight 59.9 ± 6.7 kg). Descriptive statistics were

compared using analysis of variance with repeated measures with a Bonferroni adjustment, and significance was set at $p < 0.05$. A significant increase occurred after training in the $\dot{V}O_2$ peak (10.5%; $p = 0.008$), time to fatigue (6.9%; $p = 0.017$), and interpolated maximal speed (3.6%; $p = 0.016$), despite there being a decrease in the maximal respiratory exchange ratio (2.9%; $p = 0.001$). There was no significant change in the RE at $9 \text{ km}\cdot\text{h}^{-1}$; however, there was a significant decrease in the percentage of the $\dot{V}O_2$ peak at $9 \text{ km}\cdot\text{h}^{-1}$ (-5.6%; $p = 0.02$). Maximal isometric strength of knee flexors and extensors did not change. The results suggest a plyometric-agility training program may increase the $\dot{V}O_2$ peak in female soccer players; however, the effect on RE was equivocal.

Vino and Kumaresan (2012) examined influence of plyometric training on breath holding time of volleyball players. The purpose of this study was to find out the influence of plyometric training on breath holding time of volleyball players. Only thirty men volleyball players were selected as subjects at random from the Scott Christian College, Nagercoil, Tamilnadu, India. The selected subjects were divided into two groups of fifteen each. Group I underwent plyometric training, Group II acted as control group who did not participate in any other training other than their regular routine. The age of the subjects ranged from 17 to 22 years. During the training period the experimental groups underwent their respective training programme in addition to their regular programme of the course of study. The duration of training session in the twelve weeks was between 45 to 75 minutes approximately, including warming up and cool down. The data collected from the two groups before and after the experimental period were analyzed by using the analysis of covariance (ANCOVA) and it revealed that the statistically significant differences were found among experimental and control groups. Plyometric training group significantly improved the physiological variable breath holding time of volleyball players.

Vallimurugan et al., (2012) assessed the effect of complex training on selected physiological variables of women sports participants. The purpose of the study was to find out the effect of complex training (combination of plyometrics and

weight training) on selected physiological variables of women sports participants. To achieve the purpose of the present study, thirty women sports participants from Idhaya Engineering College for Women, Tamilnadu, India were selected as subjects and their ages were from 18 to 24 years. The subjects were divided into two equal groups. The groups were assigned as complex training and control group in an equivalent manner. The experimental group was participated the training for a period of twelve weeks to find out the outcome of the training package. Analysis of covariance (ANCOVA) was applied to find out the means difference between two groups. The result reveals that the complex training group showed significant improvement on all selected variables (Systolic Blood Pressure, Diastolic Blood Pressure, Resting Heart rate, Breath Holding Time, Vital Capacity) among women sports participants. It was also found that the experimental group shown significant improvement on all the selected variables than the control group.

Luebbers *et al.*, (2003) examined the effects of 2 plyometric training programs, equalized for training volume, followed by a 4-week recovery period of no plyometric training on anaerobic power and vertical jump performance. Physically active, college-aged men were randomly assigned to either a 4-week ($n = 19$, weight = 73.4 ± 7.5 kg) or a 7-week ($n = 19$, weight = 80.1 ± 12.5 kg) program. Vertical jump height, vertical jump power, and anaerobic power via the Margaria staircase test were measured pretraining (PRE), immediately posttraining (POST), and 4 weeks posttraining (POST-4). Vertical jump height decreased in the 4-week group PRE (67.8 ± 7.9 cm) to POST (65.4 ± 7.8 cm). Vertical jump height increased from PRE to POST-4 in 4-week (67.8 ± 7.9 to 69.7 ± 7.6 cm) and 7-week (64.6 ± 6.2 to 67.2 ± 7.6 cm) training programs. Vertical jump power decreased in the 4-week group from PRE ($8,660.0 \pm 546.5$ W) to POST ($8,541.6 \pm 557.4$ W) with no change in the 7-week group. Vertical jump power increased PRE to POST-4 in 4-week ($8,660.0 \pm 546.5$ W to $8,793.6 \pm 541.4$ W) and 7-week ($8,702.8 \pm 527.4$ W to $8,931.5 \pm 537.6$ W) training programs. Anaerobic power improved in the 7-week group from PRE ($1,121.9 \pm 174.7$ W) to POST ($1,192.2 \pm 189.1$ W) but not the 4-week group. Anaerobic power significantly improved PRE to POST-4 in both groups. There were no significant differences between the 2 training groups. Four-week and 7-week plyometric programs are equally effective for improving vertical jump height,

vertical jump power, and anaerobic power when followed by a 4-week recovery period. However, a 4-week program may not be as effective as a 7-week program if the recovery period is not employed.

Gomez *et al.*, (2008) investigated the effects of a training program consisting of weight lifting combined with plyometric exercises on kicking performance, myosin heavy-chain composition (vastus lateralis), physical fitness, and body composition (using dual-energy X-ray absorptiometry (DXA)) was examined in 37 male physical education students divided randomly into a training group (TG: 16 subjects) and a control group (CG: 21 subjects). The TG followed 6 weeks of combined weight lifting and plyometric exercises. In all subjects, tests were performed to measure their maximal angular speed of the knee during in-step kicks on a stationary ball. Additional tests for muscle power (vertical jump), running speed (30 m running test), anaerobic capacity (Wingate and 300 m running tests), and aerobic power (20 m shuttle run tests) were also performed. Training resulted in muscle hypertrophy (+4.3%), increased peak angular velocity of the knee during kicking (+13.6%), increased percentage of myosin heavy-chain (MHC) type IIa (+8.4%), increased 1 repetition maximum (1 RM) of inclined leg press (ILP) (+61.4%), leg extension (LE) (+20.2%), leg curl (+15.9%), and half squat (HQ) (+45.1%), and enhanced performance in vertical jump (all $p < \text{or} = 0.05$). In contrast, MHC type I was reduced (-5.2%, $p < \text{or} = 0.05$) after training. In the control group, these variables remained unchanged. In conclusion, 6 weeks of strength training combining weight lifting and plyometric exercises results in significant improvement of kicking performance, as well as other physical capacities related to success in football (soccer).

Siegler *et al.*, (2003) evaluated changes in soccer-specific power endurance of 34 female high school soccer players throughout a season either with or without an intermittent, high-intensity exercise protocol. Thirty-four female high school soccer players were tested prior to the 2000 fall season and again 10 weeks later. The tests included an abridged 45-minute shuttle test (LIST), hydrostatic weighing, vertical jump, 20-m running-start sprint, and 30-second Wingate test. The experimental group (EG; $n = 17$, age 16.5 \pm 0.9 years) completed a 10-week in-season plyometric,

resistive training, and high-intensity anaerobic program. The control group (n = 17, age 16.3 +/- 1.4 years) completed only traditional aerobic soccer conditioning. Statistical significance was set at alpha < 0.05. The experimental group showed significant improvements in the LIST (EG = delta 394 seconds +/- 124 seconds), 20-m sprint (EG = Delta-0.10 seconds +/- 0.10 seconds), increase in fat-free mass (EG = delta 1.14 kg +/- 1.22 kg), and decreases in fat mass (EG = Delta-1.40 kg +/- 1.47 kg) comparing pre- to postseason. This study indicates that a strength and plyometric program improved power endurance and speed over aerobic training only. Soccer-specific power endurance training may improve match performance and decrease fatigue in young female soccer players.

Wagner et al., (1997) attempted to determine multivariate approach to assess anaerobic power in 20 athletes and 20 nonathletes undergoing 6 weeks of plyometric training, and 20 controls. A 3 x 2 mixed model MANOVA was done to analyze the pre- and posttest scores of vertical jump, 50-m dash, and Margaria-Kalamen stairclimbing test. The Group x Test interaction was significant (p < 0.001). Both groups that underwent plyometric training improved significantly (p < 0.01) on all tests of anaerobic power. Of the dependent measures, the Margaria-Kalamen test was the most influential in the development of a multivariate composite of anaerobic power. It appears that plyometrics is effective for increasing lower body anaerobic power for both athletes and nonathletes, and the Margaria-Kalamen stairclimbing test is a better tool for assessing this power than either the vertical jump or the 50-m dash.

Durham et al., (2001) compared the effects of plyometric (P) and weighted-plyometric (WP) training on lower body anaerobic power using the modified 30 second Bosco jump test. 14 strength trained females (> 1yr training experience; 1RM squat 1.3 ± 0.3% BW) participated. After 4 wks of supervised high intensity strength training, subjects were randomly assigned into P (7 females age 26 ± 5yrs, ht 163 ± 6cm wt 64 ± 9 kg) and WP (7 female age 23 ± 3yrs, ht 166 ± 7 cm, wt 62 ± 9 kg) training groups. Subjects performed 4 wks of P or WP training. P training consisted of depth jumps, split squats and double leg hops with BW. WP performed the same exercises using weights ranging from 20% (wk1) to 40% (wk4) of baseline squat 1RM. Both P and WP significantly (p < 0.05) increased in number of jumps, average

jump ht and peak jump ht. There was no significant difference ($p > 0.05$) for P and WP in fatigue index, average W/kg or peak W/kg. There was no significant difference between P and WP in any variables pre or post. It was concluded that there is no significant difference in effects of P and WP training on power output. Both P and WP training will increase jump height and number of jumps but will not effects power output or fatigue index.

Rahimi and Behpur (2005) compared the effects of 3 different training protocols -plyometric training, weight training, and their combination on the vertical jump performance, anaerobic power and muscular strength. Based on their training, forty-eight male college students were divided into 4 groups: a plyometric training group (n=13), a weight training group (n=11), a plyometric plus weight training group (n=14), and a control group (n=10). The vertical jump, the fifty-yard run and maximal leg strength were measured before and after a six-week training period. Subjects in each of the training groups trained 2 days per week, whereas control subjects did not participate in any training activity. The data was analyzed by a 1-way analysis of variance (repeated-measures design). The results showed that all the training treatments elicited significant ($P < 0.05$) improvement in all of the tested variables. However, the combination training group showed signs of improvement in the vertical jump performance, the 50 yard dash, and leg strength that was significantly greater than the improvement in the other 2 training groups (plyometric training and weight training). This study provides support for the use of a combination of traditional weight training and plyometric drills to improve the vertical jumping ability, explosive performance in general and leg strength.

Sankarmani et al., (2012) experimented the effectiveness of plyometrics and weight training in anaerobic power and muscle strength in female athletes. They said Success in many sports depends heavily upon the athlete's explosive leg power and muscular strength, in jumping, throwing, track field events and other activities. The distinct method of training for power or explosiveness has been termed Plyometrics. The purpose of this study was to compare the effects of weight training with and without plyometrics. Subjects were 40intercollegiate athletes assigned to two training groups randomly: plyometric weight training and weight training. Each group

completed a 6-week training program. There was more significant improvement in anaerobic power and muscle strength for the athletes trained with Plyometric weight training methods than weight training alone. There was significant improvement of vertical jump height, 50 yard dash and 1RM squat performance in plyometrics and weight training group than the weight training group alone. Plyometric with weight training is more effective in improving vertical jump, 50 yard dash and 1 RM squat performance in athletes than the weight training alone.

Blakeyl (1987) investigated the combined effects of weight training and plyometrics on dynamic leg strength and leg power. The purpose of this study was to determine the effects of plyometric exercise (depth drops), combined with weight training, on dynamic leg strength and leg power. Plyometrics are exercises that force a rapid lengthening of muscle prior to contraction, to result in increased force output during contraction. Thirty-one volunteer university students were randomly assigned to three groups according to height of drop (1.1 m=high, 0.4 m=low and no height). Subjects in each group were classified in two conditions according to leg strength-body weight ratio (low=less than 2, and high=greater than 2). All groups were administered a dynamic leg strength test and Magaria anaerobic power test prior to and following an eight-week plyometric and weight training program. A two-way ANOVA (groups (3) x conditions (2)) revealed no significant differences between groups, conditions, and no significant interactions for leg strength and Magaria power scores. Independent T-tests for mean differences between pre- and post-test scores demonstrated significant gains in both strength and power for each group. It was concluded that participating in a combined 8-week program of plyometrics and weight training will improve leg strength and power.

Soundararajan and Pushparajan (2010) assessed effects of plyometric training on the development of vertical jump in volleyball players. The study investigated the effect of plyometric training on development of the vertical jump of volleyball players. The study consisted of 30 male volleyball players from PSG College of Arts & Science, Coimbatore, their age ranged from 18 to 25 years. Participants participants were randomly assigned Group I underwent plyometric training group and Group II control group. The plyometric training group carried out

a set of plyometric exercises also designed by the researcher twice a week for six weeks. The control group was allowed to play their game, but they were not given any treatments. For the purpose of this research, two tests for the evaluation of the volleyball vertical jump were validated: the block jump and spike jump. The data was analysed using Paired t-tests which were used to test the effect of treatment groups individually between pre and post -tests, of all the groups, on variables used in the present study. The analysis of covariance was used to analyze the collected data. The result of the study reveals that there was significant difference in 0.05 levels. Based on the findings of the research and the discussion, one could conclude that the exercise model for the development of the vertical jump that had been used, as the fundamental factor of the experimental group, has contributed to the statistically significant difference in the increase of the vertical jump in comparison to the control group, which had used technically tactical contents to develop the vertical jump.

Michal et al., (2009) investigated the changes in speed and strength in female volleyball players during and after a plyometric training program. The goal of this article was the validation of a plyometric training program and the evaluation of the changes in monitored speed and explosive power predispositions during and after the end of the training program. The program was applied to a group of female youth volleyball players ($n = 11$) twice a week during an eight week period. Their actual level of explosive power and locomotor speed was evaluated before, during and after the intervention was completed. The levels were determined with the following tests: the standing vertical jump, the vertical jump with an approach and the shuttle run for 6×6 m. There were positive changes in the average values of test scores during the period of testing, but the dynamics of the changes in the explosive power and the speed were different. Other increases in all the characteristics were noticeable when the final measurements were made six weeks after the completion of the training program. Examination of the differences in the test scores by the follow up group, before the beginning and six weeks after finishing the intervention, was centred on objectively and statistically important changes in the volleyball players' motor predispositions ($p < .05$). The results of the program support the opinion that plyometric exercises are effective tools in the development of explosive power and speed in young athletes.

Esfangreh (2011) examined the effect of six week plyometric exercise on dynamic postural control of male athletic students. The purpose of this study was to consider the effect of plyometric exercises on dynamic postural control of male athlete students. 30 male athletic students with average and standard deviation age of 22.17 ± 6.2 yr, weight 74.21 ± 2.92 kg and length 171.62 ± 3.83 cm without any precedence of lower extremity, head and vestibular injuries, voluntarily participated in this study. They divided into two groups as follow: group 1: plyometric exercise and group 2: control group. One day before from executing of exercises, dynamic postural control assessed with using The SEBT1 test. Within 6 week that plyometric exercise groups executing exercise programs, Control group asked to continue their daily activities. One day after from completing of exercises, dynamic postural control of subjects assessed with using The SEBT1 test. Descriptive statistics-Dependent and Independent T-test used for analysis of data. Significant increase shown in reaching distance in all directions for two groups. Due to results, using plyometric exercises in training programs are recommended to decrease likelihood of injury and improve the athletes' dynamic postural control.

Shaffer (2007) conducted a study on the effects of a six-week land-based and aquatic-based plyometric training program on power, peak torque, agility, and muscle soreness. Plyometric exercise has been shown to increase strength and explosiveness in athletes participating in football, tennis, golf, soccer, volleyball, running, and basketball. Aquatic exercises have been noted to have beneficial effects, however there has been little research conducted comparing plyometrics in a land-based and an aquatic-based setting. The purpose of this study is to compare the effects of a plyometric-training program in a land-based and an aquatic-based setting on power, peak torque, agility, and muscle soreness. There were four $2 \times 3 \times 3$ factorial designs for the KinCom tests, two 2×3 factorial designs for vertical jump and the LEFT tests, and one 3×7 factorial design for the VAS test with two experimental groups and a control group. This study included 18 healthy, volunteer, college-aged subjects who met the inclusion criteria set at the beginning of the study. The six-week protocol for the experimental groups was conducted following a specific program twice a week for an average of 30-minutes. Both groups experienced a training program that included plyometric exercises that advanced from week to week. The focus of the exercises

was placed on hops and jumps forwards, backwards, or laterally. All subjects performed the KinCom test, Vertical Jump test, and the Lower Extremity Functional test for pretest and post-test measurements. Also, all subjects recorded measurements with the Visual Analogue test for a baseline test, as well as after the last session of each week for the six weeks. Outcomes measured through the KinCom machine was used for the quadriceps and hamstrings concentric and eccentric contractions to measure peak torque values. Also, the vertical jump was used to measure power, the LEFT was used to measure agility, and the VAS along with a body chart, were used subjectively to measure muscle soreness. For VAS, there was a significant main effect for test ($F_{1,17} = 17.696$, $P=.000$, $ES= .541$, $\beta= 1.000$) and for group ($F_{1,17} = 10.702$, $P=.001$, $ES= .588$, $\beta= .969$) for the land by aquatic and land by control groups at the $P=0.006$ and $P=0.002$ level, respectively. A significant main effect was found with vertical jump for test ($F_{1,17} = 10.834$, $P=.005$, $ES= .419$, $\beta= .868$). There were no other significant results found within or between groups. For the KinCom test for flexion and concentric contraction at all three speeds, a significant interaction was found for test by group ($F_{1,17} = 7.855$, $P=.005$, $ES = .512$, $\beta = .902$). For extension and concentric contraction at all three speeds, a main effect was found within subjects for speed ($F_{1,17} = 11.127$, $P=.000$, $ES = .426$, $\beta = .985$). No differences were recorded for the measures of flexion and eccentric contraction or extension and eccentric contraction at all three speeds or for the LEFT test. In conclusion, aquatic therapy may help to decrease muscular soreness while performing exercises. However, more research needs to be conducted to determine the affects of plyometric training in the aquatic setting.

2.3 SUMMARY REVIEW OF RELATED LITERATURE

The reviews are presented under the two sections namely studies on pilates training and motor fitness, physiological and psychological variables ($n=24$) and studies that are presented in this section prove that pilates training and plyometric training significantly improved the selected motor fitness, physiological and psychological variables.

Research studies using pilates training revealed compatible results (Sureeporn et al. 2011, Ana et al. 2011, Augusto et al. 2011, keran et al. 2009, Santana et al. 2010,

and Wang et al. 2012). There was a clean evidence that the use of pilates training was one of the effective training methods to improve the selected criterion variables among college men.

The literature reviewed by the investigation suggested that there was significant contribution of plyometric training in the improvement of selected variables (Miller et al. 2006, Brown et al. 2010, Vallimurugan et al. 2012, Luebber et al. 2003 and Michal et al. 2009).

The relevant literatures collected from different sources throw ample light with regard to Pilates training and plyometric training on motor fitness, physiological and psychological variables of college men. The present study may serve as a foundation and main ingredient for future research and investigate the proper training methods for changing the motor fitness, physiological and psychological variables of college men.