Chapter II

REVIEW OF RELATED LITERATURE

A study of relevant and related literature is an essential step to get a full picture of what has been done and suggested with regard to the problem under study. Such a review brings about deeper insight and clear perspective of the overall field. The researcher has presented a brief review of the research articles published in relation to the present study.

The researcher finds out some of the review of literature which could be very supportive and strengthen this study. The reviews of the literature have been classified under the following headings:

1. Studies Pertaining to Swissball Training
2. Studies Pertaining to Flexibility Training
3. Studies Pertaining to Combined Training
4. Summary of the Literature.

2.1: Studies Pertaining to Swiss Ball Training

Zemkova and Hamar (2013) compared the power outputs in concentric phase of chest presses and squats performed without and with countermovement on stable and unstable support surface. A group of 16 physical education students performed randomly in four different days 3 repetitions of: 1) barbell chest presses on the bench and Swiss ball, respectively, and 2) barbell squats on stable support base and Bosu ball, respectively. Exercises were performed without and with countermovement (CM) using maximal effort in concentric phase of lifting. Initial weight of 20 kg increased by 10 kg or 5 kg (at higher loads) up to at least 85% of previously established 1RM under stable conditions. A PC based system FiTRO Dyne Premium was used to monitor force and velocity and to calculate power. As a parameter of the capability to use elastic energy was considered the difference in mean power in concentric phase of weight exercises (ΔP) performed with and without CM. The ability to utilize elastic energy during CM chest presses is more profoundly compromised under unstable than stable conditions, namely at higher weights lifted. On the other hand, there is similar enhancement of power in concentric phase of CM squats on stable and unstable support surface regardless of weights lifted. Besides the type of exercise, this may be ascribed to different degree of instability of devices used (Swiss ball vs. Bosu ball).

Saeterbakken and Fimland (2013) compared 6-repetition maximum (6RM) loads and muscle activity in bench press on 3 surfaces, namely, stable bench, balance cushion, and Swiss ball. Sixteen healthy, resistance-trained men (age 22.5 ± 2.0 years, stature 1.82 ± 6.6 m, and body mass 82.0 ± 7.8 kg) volunteered for 3 habituation/strength testing sessions and 1 experimental session. In randomized order on the 3 surfaces, 6RM strength and electromyographic activity of pectoralis major, deltoid anterior, biceps brachii, triceps brachii, rectus abdominis, oblique external and erector spinae were assessed. In conclusion, stable bench press had greater 6RM strength and triceps and pectoralis EMG activity compared with the unstable surfaces. These findings have implications for athletic training and rehabilitation, because they demonstrate an inferior effect of unstable surfaces on muscle activation of prime movers and strength in bench press.

Gappmaier, Tavazoie and Jacketta (2013) aim to determine if individuals of varying fitness levels would reach aerobic training levels by evidence-based standards as described in American College of Sports Medicine (ACSM) publications. Fourteen volunteers performed a maximal exercise test and on subsequent days, two submaximal exercise tests on the LTR (LTR-A and -B). LTR-A consisted of four 5-minute stages of exercise at progressive intensity levels. LTR-B included 20 minutes of continuous exercise. Oxygen consumption (VO_2) and heart rate (HR) during exercise on the LTR were compared with ACSM recommended standards. The average (range) peak intensity achieved during LTR-A was 66.8% (51.7-82.7%) of maximal VO_2 reserve (VO_2R) and 82.9% (70.7%-91.2%) of maximal heart rate (HRmax). During LTR-B, HR and VO_2 of all participants was maintained at moderate exercise intensity and averaged 56% of VO_2R and 78% of HRmax during the 20 minute exercise period. These findings suggest that individuals with a wide range of aerobic fitness are able to reach and maintain aerobic training levels with appropriate exercise on a large therapeutic roll or ball.

Delmore, Laudner and Torry (2013) purpose was to identify the varying activation levels of the adductor longus during common hip adductor exercises.

Participants were 24 physically active, college-aged students. Main measurement outcomes was Peak and average electromyographic (EMG) activity of the adductor longus muscle during the following six hip adductor rehabilitation exercises: side-lying hip adduction, ball squeezes, rotational squats, sumo squats, standing hip adduction on a swiss ball, and side lunges. The side-lying hip adduction exercise produced more peak and average activation than any other exercise ($p<.001$). Ball squeezes produced more peak and average activation than rotational squats, sumo squats, and standing adduction on a swiss ball ($p<.001$). Ball squeezes had more average activation than side lunges ($p=.001$). All other variables for peak activation during the exercises were not statistically significant ($p>.08$). These results allowed us to provide an overall ranking system (highest to lowest muscle activation): side-lying hip adduction, ball squeezes, side lunges, standing adduction on a swiss ball, rotational squats, and sumo squats. This study provides a ranking system on the activation levels of the adductor longus muscle for six common hip adductor rehabilitation exercises, with the side-lying hip adduction and ball squeeze exercises displaying the highest overall activation, respectively.

Barton and others (2013) aimed to establish the effect of varying forms of squatting exercises on gluteal muscle activation. Nineteen (11 male) healthy participants (28.4 +/- 2.7 years old) were compared using one-way repeated measures analysis of variance. Main outcome measures was surface electromyography (EMG) measures of gluteus medius (GMed) and gluteus maximus (GMax) during the isometric phase of single-legged and double-legged squatting, with and without a Swiss ball. A greater percentage of maximal voluntary contraction (%MVC) during single-legged squatting was found compared to double-legged squatting for GMed (42 versus 9%MVC, $p < 0.001$) and GMax (35 versus 14%MVC, $p < 0.001$). Additionally, the Swiss ball increased GMax activity (42 versus 35%MVC, $p = 0.026$) and demonstrated a trend toward increased GMed activity (46 versus 42%MVC, $p = 0.075$) during the single-legged squat. These results indicate single-legged squatting may be more appropriate than double-legged squatting to facilitate strength gains of GMed and GMax. Additionally, the Swiss ball may be a useful adjunct to target gluteal muscle strengthening during single-legged squatting.

Romero-Franco and others (2013) determined the short-term stabilometric effects of proprioceptive training in athletes by using a BOSU ball and a Swiss ball as unstable platforms. Thirty-seven athletes from a variety of disciplines were divided into a control group (n = 17) and an experimental group (n = 20). Both performed a warm-up, and in addition, the experimental group carried out a proprioceptive exercise session after the warm-up. Proprioceptive exercise session consisted of six 25-minute exercise sessions with the BOSU ball and the Swiss ball as unstable platforms. Bipedal stabilometry was assessed before the training session (M0), immediately after training (M1), 30 minutes later (M2), 1 hour after training (M3), 6 hours after training (M4), and 24 hours after training (M5). Analysis of variance ($\alpha = 0.05$) revealed significant differences immediately after training (M1) in speed ($p = 0.022$) and length covered by the center of pressure ($p = 0.021$) in the experimental group. These differences were even more acute 6 hours later (M4; $p = 0.021$). In fact, the same group exhibited significant differences in mediolateral position after 30 minutes (M2; $p = 0.001$) compared with the baseline measure and the control group. Apart from these, no other significant differences were found. A proprioceptive exercise session using a BOSU ball and a Swiss ball as unstable platforms induced short-term negative effects on the stabilometry of athletes. Likewise, an immediate trend to improvement was apparent in the stabilometry of control group after the warm-up.

Bhaskar and others (2013) determined the effect of neuromuscular training program (NMTP) focused on core stability and lower extremity strength on performance of star excursion balance test (SEBT) in basketball players. Pre to post test experimental study design randomized thirty Basketball players each 15 into NMTP and control group. Players trained together as a team in which NMTP group participated 4 weeks of NMTP twice a week and Control group followed their regular protocol as guided by their coach. When means of post intervention compared using Independent ‘t’ between NMTP and Control group there is no statistically significant difference ($p<0.05$) in anterior, posterior-medial and posterior-Lateral direction reach distance of star Excursion test but there is a statistically significant difference in means of anterior, posterior medial and posterior-Lateral direction reach distance when analyzed within in groups using Paired't' test and Wilcoxon signed rank test. Neuromuscular Training program found to be effective for Basketball Players on Performance of Star Excursion Balance Test and this improvement can significantly predict the prevention of injury.

Sundstrup and others (2012) compared muscle activation as measured by electromyography (EMG) of global core and thigh muscles during abdominal crunches performed on Swiss ball with elastic resistance or on an isotonic training machine when normalized for training intensity. Forty two untrained individuals (18 men & 24 women) aged 28-67 years participated in the study. EMG activity was measured in 13 muscles during 3 repetitions with a 10 RM load during both abdominal crunches on training ball with elastic resistance and in the same movement utilizing a training machine (seated crunch, Technogym, Cesena, Italy). The order of performance of the exercises was randomized, and EMG amplitude was normalized to maximum voluntary isometric contraction (MVIC) EMG. Crunches on a Swiss ball with added elastic resistance induces high rectus abdominis activity accompanied by low hip flexor activity which could be beneficial for individuals with low back pain. In opposition, the lower rectus abdominis activity and higher rectus femoris activity observed in machine warrant caution for individuals with lumbar pain. Importantly, both men and women, younger and elderly, and individuals with and without pain benefitted equally from the exercises.

Sekendiz, Cug and Korkusuz (2010) investigated the effects of Swiss-ball core strength training on trunk extensor (abdominal)/flexor (lower back) and lower limb extensor (quadriceps)/flexor (hamstring) muscular strength, abdominal, lower back and leg endurance, flexibility and dynamic balance in sedentary women (n = 21; age = 34 ± 8.09; height = 1.63 ± 6.91 cm; weight = 64 ± 8.69 kg) trained for 45 minutes, 3 d·wk-1 for 12 weeks. Results of multivariate analysis revealed significant difference ($p \leq 0.05$) between pre and postmeasures of 60 and 90° s trunk flexion/extension, 60 and 240° s-1 lower limb flexion/extension (Biodex Isokinetic Dynamometer), abdominal endurance (curl-up test), lower back muscular endurance (modified Sorensen test), lower limb endurance (repetitive squat test), lower back flexibility (sit and reach test), and dynamic balance (functional reach test). The results support the fact that Swiss-ball core strength training exercises can be used to provide improvement in the aforementioned measures in sedentary women. In conclusion, this study provides practical implications for sedentary individuals, physiotherapists, strength and conditioning specialists who can benefit from core strength training with Swiss balls.

Marshall and Desai (2010) determined whether or not muscle activity measured during advanced Swiss ball exercises was at an approximate intensity recommended for strength or endurance training in advanced, or novice individuals. After a familiarization session, 14 recreationally active subjects performed 6 different "advanced" Swiss ball exercises in a randomized order. The primary dependent variables in this study were the activity levels collected from anterior deltoid, pectoralis major, rectus abdominis (RA), external obliques, lumbar erector spinae, vastus lateralis (VL), and biceps femoris using surface electromyography. All signals were normalized to maximal voluntary isometric contractions performed before testing for each muscle. Rectus abdominis activity was greatest during the bridge exercise (61.3+/-28.5%, p<or=0.01). This was the only exercise to elicit RA muscle activity commensurate with a strength training effect. The remainder of the exercises elicited abdominal activity that would require a higher number of repetitions to be performed for an endurance training adaptation. Although this study has provided evidence for one advanced Swiss ball exercise providing a significant whole-body stimulus, the practical difficulty and risks of performing these more complicated Swiss ball exercises may outweigh potential benefits.

Anderson and Behm (2004) objective was to measure differences in force output and electromyographic (EMG) activity of the pectoralis major, anterior deltoid, triceps, latissimus dorsi, and rectus abdominus for isometric and dynamic contractions under stable and unstable conditions. Ten healthy male subjects performed a chest press while supported on a Swiss Ball. They concluded that unstable isometric maximum force output was 59.6% less than under stable conditions. However, there were no significant differences in overall EMG activity between the stable and unstable protocols. Greater EMG activity was detected with concentric vs. eccentric or isometric contractions. The decreased balance associated with resistance training on an unstable surface may force limb musculature to play a greater role in joint stability. The diminished force output suggests that the overload stresses required for strength training necessitate the inclusion of resistance training on stable surfaces.

Bair and others (2009) investigated the shoulder muscle EMG activity in women during push up on varying surfaces. Eighteen female college students were recruited to perform a push up on a BOSU® ball and on an exercise bench while EMG muscle activity was measured in 7 muscles (biceps, triceps, rectus abdominus, external oblique, pectoralis major, latissimus dorsi, and posterior deltoid). They observeded that overall, muscles used during a push up performed on the bench showed the greatest EMG muscle activity. The greatest EMG muscle activity occurred in the rectus abdominus and the triceps muscles on the bench push up compared to the standard push up and the unstable push up. This study showed a significant increase in EMG muscle activity during the bench push up compared to the BOSU pushup, contradicting the finding of previous research."

Behm, Anderson and Curnew (2002) determined differences in isometric force output, muscle activation (interpolated twitch technique), and EMG activity of the quadriceps, plantar flexors (PF), and their antagonists under stable and unstable conditions. Instability in subjects was introduced by making them perform contractions while seated on a "Swiss ball". Eight male subjects performed unilateral leg extensor (LE) and PF contractions while seated on a bench (LE), chair (PF), or a ball. They suggested that Swiss balls may permit a strength training adaptation of the limbs, if instability is moderate, allowing the production of overload forces. Unstable LE and PF forces were 70.5 and 20.2% less than their stable counterparts. Unstable quadriceps and PF activation averaged 44.3 and 2.9% less than activation under stable conditions. Unstable antagonist/agonist ratios were 40.2 and 30.7% greater than stable ratios in the LE and PF protocols.

Behm and others (2005) examined the trunk muscle electromyographic activity with unstable and unilateral exercises. Eleven subjects (6 men and 5 women) between 20 and 45 years of age were used to evaluate the effect of unstable and unilateral resistance exercises on trunk muscle activation. Six trunk exercises, as well as unilateral and bilateral shoulder and chest presses against resistance, were performed on stable (bench) and unstable (Swiss ball) bases. EMG activity of the upper lumbar, lumbosacral erector spinae, and lower-abdominal muscles was monitored. Instability generated greater activation of the lower-abdominal stabilizer musculature (27.9%) with the trunk exercises and all trunk stabilizers (37.7-54.3%) with the chest press. There was no effect of instability on the shoulder press. Unilateral shoulder press produced greater activation of the back stabilizers. Unilateral chest press resulted in higher activation of all trunk stabilizers, when compared with bilateral presses. Regardless of stability, the superman exercise was the most effective trunk-stabilizer exercise for back-stabilizer activation. The side bridge was the optimal exercise for lower-abdominal muscle activation (again regardless of the stability).

Clark, Holt and Sinyard (2003) compared electromyographic activity of the upper and lower rectus abdominis during abdominal exercises. Eight healthy adults were used to assess the effects of 6 different abdominal exercises (curl up, Sissel ball curl up, Ab Trainer curl up, leg lowering, Sissel ball roll out, and reverse curl up) on the electrical activity of the upper rectus abdominis (URA) and lower rectus abdominis (LRA). Both the URA and the LRA recorded significantly higher mean amplitudes during the Sissel ball curl up than during all other exercises. The curl up, Sissel ball curl up, and Ab Trainer curl up had significantly higher normalized EMG activity in both muscle sites than the reverse curl up, the leg lowering exercise, and the Sissel ball roll out. The curl up and the Ab Trainer curl up exercises were not significantly different in terms of their normalized EMG activities for both the URA and the LRA.

Cowley, Swensen and Sforzo (2007) examined the efficacy of instability resistance training. Fourteen women performed a 1 repetition maximum (1RM) barbell chest-press and the YMCA bench press test (YBT) on a stability ball and flat bench, as well as two field tests measuring abdominal power (front abdominal power test and side abdominal power test). The purpose of the study was to evaluate the influence of platform (unstable vs. stable / stability ball vs. flat bench) on strength and work capacity during barbell chest-press as well as to determine the effects of a barbell chest-press training program performed on a stability ball or flat bench on strength, work capacity, and abdominal power. Platform (stability ball vs. flat bench) had no influence on strength, but work capacity was initially 12 % lower on the stability ball. The increase in work capacity was 32% and 13% on the stability ball and flat bench for the stability ball group, and 27% and 26% for the flat bench group, respectively", (3) Performance on the front abdominal power test improved by 5% for the stability Ball group, and 22% for the flat bench group. Performance on the side abdominal power test did not change for either group.

Drinkwater, Pritchett and Behm (2007) analyzed the effect of instability and resistance on unintentional squat-lifting kinetics. Fourteen active men performed sets of 3 repetitions of squats with under conditions of increasing instability. Each session consisted of standing on a stable floor, foam pads, or BOSU balls. Resistance training in an unstable environment at an intensity sufficient to elicit strength gains of the prime movers results in deleterious effects in concentric squat kinetics and squat technique.

Duncan (2009) investigated the muscle activity of the upper and lower rectus abdominis during exercises performed on and off a Swiss ball. Fourteen healthy adults (7 male, 7 female) were tested to examine differences in upper rectus abdominis and lower rectus abdominis muscle activity during four abdominal exercises (the curl-up, Swiss ball curl-up, Swiss ball jackknife and Swiss ball rollout) using a Swiss Ball and EMG readings. He concluded that muscle activity was greater when exercises were performed on a Swiss ball in comparison to a stable surface.

Goodman and others (2008) compared 1RM strength, and upper body and trunk muscle EMG activity during the barbell chest press exercise on a stable (flat bench) and unstable surface (exercise ball). The results show that there was no difference in 1RM strength or muscle EMG activity for the stable and unstable surfaces. There was no difference in elbow range-of-motion between the two surfaces. These results do not support the notion that resistance exercises performed on an exercise ball are more efficacious than traditional stable exercises.

Kohler, Flanagan and Whiting (2009) examined muscle activation patterns while lifting stable and unstable loads on stable and unstable surfaces. Thirty resistance-trained subjects performed the shoulder press exercise for 3 sets of 3 repetitions under 2 load (barbell, dumbbell) and 2 surface (exercise bench, Swiss ball) conditions at a 10RM relative intensity. Surface electromyography (EMG) measured muscle activity for 8 muscles (anterior deltoid, middle deltoid, trapezius, triceps brachii, rectus abdominis, external obliques, and upper and lower erector spinae). The findings provide little support for training with a lighter load using either unstable loads and/or unstable surfaces. Based on the muscle activation patterns, their results do not support the use of training with dumbbells or Swiss Balls over training with the heavier loads associated with a barbell on an exercise bench for developing core musculature during the overhead lift".

Lehman, Hoda and Oliver (2005) compared myoelectric activity in 4 trunk muscles in both prone and supine bridging exercises on and off a Swiss Ball. They fund that the addition of an exercise ball didn't affect the Internal Oblique or Erector Spinae in either bridging exercise. The addition of an exercise ball didn't affect the Rectus Abdominus or External Oblique during a supine bridge, but did during a prone bridge.

Marshall and Murphy (2005) analyzed the core stability exercises on and off a Swiss ball. Eight healthy volunteers were used to assess lumbopelvic muscle activity during 4 different core stability exercises (inclined press-up, upper body roll-out, single-leg hold, and quadruped exercise) on and off a Swiss ball with

EMG measurements. They suggested that the swiss ball provides a training stimulus for the rectus abdominus, the relevance of this change to core stability training requires further research because the focus of stabilization training is on minimizing rectus abdominus activity."

Petrofsky (2007) analyzed core muscle activity during exercise on a mini stability ball compared with abdominal crunches on the floor and on a Swiss ball. Ten subjects were examined to determine muscle use that occurred during core body exercise using a 7-inch diameter mini stability ball compared with abdominal crunches on the floor and on a Swiss Ball. Muscle use was evaluated through the surface EMG recorded above the abdominal and lower back muscles. Crunches on the Swiss ball used approximately 50% more muscle work per second of exercise as did work with floor crunches. The lightest exercise (sitting crunches with the mini stability ball behind the back) was about equal to half of the work per second as floor crunches. The most intense exercises with the mini ball were as much as 4 times the work as abdominal crunches per second of exercise. The greatest difference in the mini stability ball exercise was seen when the degree of flexion/extension was increased from 50 to 90 degrees.

Stanton, Reaburn and Humphries (2004) examined the effect of short-term Swiss ball training on core stability and running economy. Eighteen young male athletes were tested for six weeks to determine the effects of using a Swiss Ball on core stability and running economy, with assessments conducted both before and after for stature, body mass, core stability, EMG activity of the abdominal and back muscles, treadmill VO_2max, running economy, and running posture. While data analysis revealed a significant effect of Swiss ball training on core stability in the experimental group, no significant differences were observed for myoelectric activity of the abdominal and back muscles, treadmill VO_2max, running economy, or running posture. It appears Swiss ball training may positively affect core stability without concomitant improvements in physical performance in young athletes.

Cosio-Lima (2003) compared the effects of 5 weeks of physioball core stability and balance exercises with conventional floor exercises in women. The experimental group ($n = 15$) performed curl-ups and back extensions on the physioball while the control group ($n = 15$) performed the same exercises on the floor. Baseline and post-training tests included electromyography (EMG) recordings of the rectus abdominus and erector spinae muscles; abdominal, back, and knee strength measurements with the Cybex Norm System; and 2 unilateral stance balance tests. The physioball group was found to have significantly greater mean change in EMG flexion and extension activity ($p = 0.04$ and $p = 0.01$, respectively) and greater balance scores ($p < 0.01$) than the floor exercise group. No significant changes ($p > 0.05$) were observed for heart rate or Cybex strength measurements. Early adaptations in a short-term core exercise program using the physioball resulted in greater gains in torso balance and EMG neuronal activity in previously untrained women when compared to performing exercises on the floor.

Wahl and Behm (2008) measured the EMG activity of the soleus, bicep femoris, rectus femoris, lower abdominal, and lumbosacral erector spinae muscles with a variety of instability devices, stable and unstable exercises, and a fatiguing exercise in 16 highly conditioned individuals. Devices used included Dyna Disc, BOSU ball, wobble board, and a Swiss ball. The experiment found increased activity for all muscles when standing on a Swiss ball and all muscles other than the rectus femoris when standing on a wobble board. Only lower abdominals and soleus EMG activity increased while squatting on a Swiss ball and wobble board. Devices such as the Dyna Disc and BOSU ball did not exhibit significant differences in muscle activation under any conditions, except the lumbosacral erector spinae in the standing Dyna Disc conditions. During the exercise protocol, there were no significant changes in muscle activity between stable and unstable conditions. With the fatigue protocol, soleus EMG activity was 51% greater with a stable base. These results indicate that the use of moderately unstable training devices did not provide sufficient challenges to the neuromuscular system in highly resistance-trained individuals.

2.2: Studies Pertaining to Flexibility Training

Stathokostas and others (2012) systematically reviewed the effects of flexibility-specific training interventions on measures of functional outcomes in healthy older adults over the age of 65 years. Five electronic databases were searched for intervention studies involving concepts related to aging, flexibility, functional outcomes, and training interventions. After evaluating the articles for relevance, 22 studies were considered. The results suggested that while flexibility-specific interventions may have effects on range of motion (ROM) outcomes, there is conflicting information regarding both the relationship between flexibility interventions and functional outcomes or daily functioning. Due to the wide range of intervention protocols, body parts studied, and functional measurements, conclusive recommendations regarding flexibility training for older adults or the validity of flexibility training interventions as supplements to other forms of exercise, or as significant positive influences on functional ability, require further investigation.

Chen and others (2011) investigated whether flexibility training would attenuate muscle damage induced by maximal eccentric exercise. Thirty untrained young men were allocated to static stretching (SS), proprioceptive neuromuscular facilitation (PNF), or control group (n = 10 per group). The SS consisted of 30 sets of a 30-s standard SS with a 30-s rest between sets, and the PNF included 5 sets of the 30-s standard SS followed by 3 sets of three "contract-relax-agonist-contract" procedures. These were performed three times a week for 8 wk, and all subjects performed six sets of 10 maximal isokinetic (30°·s) lengthening contractions of the knee flexors after the 8-wk training or 8 wk after the baseline measures (control). Changes in indirect markers of muscle damage before and for 5 d after the eccentric exercise were compared among the groups. The range of motion (ROM) of the hip joint increased by 25°, and the optimum angle of the knee flexors shifted ($P < 0.05$) to a longer muscle length by 10° after training, without significant differences between SS and PNF. No significant changes in these variables were evident for the control group. Compared with the control group, the SS and PNF groups showed significantly ($P < 0.05$) smaller decreases and faster recovery of knee flexor muscle strength and smaller changes in optimum angle, ROM, muscle soreness, and plasma creatine kinase activity and myoglobin concentration without significant differences between the groups. The preeccentric exercise ROM or optimum angle was significantly ($P < 0.05$) correlated with the changes in the muscle damage markers.These results suggest that both SS and PNF training are effective in attenuating eccentric exercise-induced muscle damage and that flexible muscles are less susceptible to the damage.

Corey and others (2012) observed that stretching of the back improves gait, mechanical sensitivity and connective tissue inflammation in a rodent model. The role played by non-specialized connective tissues in chronic non-specific low back pain is not well understood. In a recent ultrasound study, human subjects with chronic low back pain had altered connective tissue structure compared to human subjects without low back pain, suggesting the presence of inflammation and/or fibrosis in the low back pain subjects. Mechanical input in the form of static tissue stretch has been shown in vitro and in vivo to have anti-inflammatory and anti-fibrotic effects. To better understand the pathophysiology of lumbar non-specialized connective tissue as well as potential mechanisms underlying therapeutic effects of tissue stretch, they developed a carrageenan-induced inflammation model in the low back of a rodent. Induction of inflammation in the lumbar connective tissues resulted in altered gait, increased mechanical sensitivity of the tissues of the low back, and local macrophage infiltration. Mechanical input was then applied to this model as in vivo tissue stretch for 10 minutes twice a day for 12 days. In vivo tissue stretch mitigated the inflammation-induced changes leading to restored stride length and intrastep distance, decreased mechanical sensitivity of the back and reduced macrophage expression in the non-specialized connective tissues of the low back.

Hall and others (2005) describes two power mobility training protocols used with seniors and compares post training driving performance. Twelve users of power mobility were consecutively recruited from two residential facilities in Toronto, Canada. The aim of training at both sites was to make clients comfortable with and safe at driving power mobility devices. The content of training was similar, but training protocols differed significantly in terms of the number of sessions (means of 3.43 vs. 9.80; *p* # .05) and the time frame over which the sessions were offered (means of 1.57 vs. 5.10 weeks; *p* # .01). Participants at the two sites differed significantly in terms of overall driving performance (*p* # .05), gender (*p* # .01), and type of device used (*p* # .05). Overall, driving performance was significantly associated with facility, gender, type of device used, and training duration (*p* # .05). When these variables were entered into an exploratory hierarchical regression, facility accounted for 64% of the variance in driving performance. When facility was controlled for, the correlations between device and duration of training with driving performance were no longer significant. The determinants of driving performance are difficult to clearly specify as the variable facility encompasses gender as well as all other differences between the two training protocols.

Kloubec (2010) 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). 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 < 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 Pilates exercises that do not require equipment or a high degree of skill and are easy to master and use within a personal fitness routine.

Monteiro and others (2008) investigate 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.

Santos and others (2010) examined whether moderately intense resistance training improves flexibility in an exclusively young, sedentary women population. Twenty-four, young, sedentary women were divided into 3 groups as follows: agonist/antagonist (AA) training group, alternated strength training (AST) group, or a control group (CG). Training occurred every other day for 8 weeks for a total of 24 sessions. Training groups performed 3 sets of 10 to 12 repetitions per set except for abdominal training where 3 sets of 15 to 20 reps were performed. Strength (1 repetition maximum bench press) and flexibility were assessed before and after the training period. Flexibility was assessed on 6 articular movements: shoulder flexion and extension, horizontal shoulder adduction and abduction, and trunk flexion and extension. Both groups increased strength and flexibility significantly from baseline and significantly when compared with the CG ($p \leq 0.05$). The AST group increased strength and flexibility significantly more than the AA group ($p \leq 0.05$) in all but one measurement. This study shows that resistance training can improve flexibility in young sedentary women in 8 weeks.

Calasky (2001) determined the duration of range of motion restriction by athletic tap brands and athletic braces, subjected to standardized moments. Ankle range motion was measured during prewrab or sock (CN) initial application (I), and 5- min intervals for 25 min (T5,T10, T15,T20,T25) during simulated exercise. Tap brands tested included Ace. Bike Mueller, Tru-Fit, and Johason and Johason"s coach and were applied by the same certified athletic trainer is a standard noninjury Prodocol, Athletic braces tested were Swede –O Ankle – Lok,Don Joy Rocket Sco – Neo Don Joy Rocket Lace,and Done Joy Stabilizing Ankle, the subject for this study was an artificial ankle built to simulate the moments of a fully function ankle. Ankle range motion was measured using an inclinometer, while a standard force was applied using a spring gauge.Four 2 – way repeated measures analysis of variance were used to test for statistical differences between brands of tap and braces and length of exercise. The Tukey test was used for post hoc analysis. The critical value for value for statistical significance for all tests was P <.05.All tested athletic tapes and braces significantly reduced ankle range motion from cn to I and also from I trough the first 5 min (T5) activity. Athletic taps initially produced a greater reduction in ankle range motion over braces; however, the braces did not cede as much range motion as the taps at T25. post hoc Tukey tests indicated that the swede – o brace performed better than all other braces and taps in restricting planter flexion range motion. Tests also indicated that the Dan Joy braces performed better than all tapes tested except the Bike brand in plantar flexion restriction. Post hoc tests for inversion range motion showed Don Joy Rocket Lace and Rocket soc-neo restricted better than Swede-o, Don Joy stabilizing performed better than Swede-o and Don Joy Rocket Soc-Neo, Ace and Tru-fit more effective than Swede-o or Joy Rocket Soc-Neo, and Bike, coach, and Muller tapes performed better than Swede-o. The results suggest that the lace up brace was the most effective range of motion control prophylaxis with implications for preventing ankle sprains. The Don Joy Rocket Lace performed more efficiently than the Swede-o. All braces performed better over time. There was no statistical difference between tape brands in reducing ankle range of motions.

Adams and others (2001) investigated effects of an 8-wk, low-frequency and low-volume, supervised, progressive strength training program emphasizing free weight, multijoint movements on the muscular power, strength, endurance, and flexibility of African American women 44 to 68 yr of age. Nineteen sedentary African American women were randomly assigned to a strength training (ST) only group (N = 12; mean age, 51 yr) or a nonexercise control (C) group (N = 7; mean age, 52 yr). Maximal power, strength, absolute endurance, and flexibility were assessed before and after training. Subjects trained 2 d x wk(-1) using free weight (barbells and dumbbells) and machine (plate loaded) exercises for two to three sets of 8 to 10 repetitions on both primary and assistance exercises. This study demonstrates that 8 wk of low-frequency, supervised, progressive strength training emphasizing free weight, multijoint movements can safely cause significant gains in muscle strength, absolute endurance, and flexibility in older African American women.

Burke (2000) compared 2 methods of delivering the same proprioceptive neuromuscular facilitation (PNF) flexibility exercise protocol: one manual and the other machine. Thirty-six college students (18 male and 18 female), between 18 and 25 years of age, were randomly assigned to 1 of 3 groups: manual, machine, or control. The manual group used techniques described in Scientific Stretching for Sport *(3S),* while the machine group used 2 pieces of exercise equipment designed to simulate PNF training principles. Subjects in the training groups exercised their low back and hamstring musculature 5 days per week for 3 consecutive weeks. Pretest and posttest measurements consisted of 4 different flexibility tasks and were taken on days 1 and 15, respectively. The results were analyzed for comparisons of group and gender differences in performance scores. Both training groups had significant ($p < 0.05$) improvements in all measures. The machine group had significantly greater increases than the manual group on trunk flexion and right hip flexion. Females had significantly greater improvements than males for trunk flexion. Despite many similarities between the 2 training methods, there were numerous beneficial aspects associated with the use of the flexibility exercise equipment.

McMillian (2006) compared the effect of a dynamic warm up (DWU) with a static-stretching warm up (SWU) on selected measures of power and agility. Thirty cadets at the United States Military Academy completed the study (14 women and 16 men, ages 18–24 years). On 3 consecutive days, subjects performed 1 of the 2 warm up routines (DWU or SWU) or performed no warm up (NWU). The 3 warm up protocols lasted 10 minutes each and were counterbalanced to avoid carryover effects. After 1–2 minutes of recovery, subjects performed 3 tests of power or agility. The order of the performance tests (T-shuttle run, underhand medicine ball throw for distance, and 5-step jump) also was counterbalanced. Repeated measures analysis of variance revealed better performance scores after the DWU for all 3 performance tests (p _ 0.01), relative to the SWU and NWU. There were no significant differences between the SWU and NWU for the medicine ball throw and the T-shuttle run, but the SWU was associated with better scores on the 5-step jump (p _ 0.01). Because the results of this study indicate a relative performance enhancement with the DWU, the utility of warm up routines that use static stretching as a stand-alone activity

Segal and others (2004) assessed the 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. 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). 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 (interquartile 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). 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.

2.3: Studies Pertaining to Combined Training

Rafaella and others (2012) evaluated the effects of stretching and/or resistive exercise, followed by detraining, on the functional status of older people. Forty-five subjects were divided into four groups: control (CG; n=13; 66±6 years), stretching (SG; n=10; 69±6 years), resistive exercise (RG; n=13; 69±5 years), and resistive exercise and stretching (RSG; n=9; 66±5 years). The CG did not perform any exercise. The SG, RG, and RSG had warm-up sessions prior to performing lower-body exercises twice a week. The SG performed 4 repetitions of stretching. Resistive exercise was performed at a load of 65% of 10 repetitions maximum (RM) for five weeks, 70% for the next four weeks, and 75% for the last three weeks of the program. The RSG performed both exercises. Cardiorespiratory capacity was evaluated using the 6-minute walk test (6MWT) at baseline, at the six- and 12-week follow-ups, and after a six-week period of detraining. Lower limb muscle strength was assessed using the stand up from a chair and sit down test (SUCSD), and blood pressure was measured using a sphygmomanometer and a stethoscope. The results were analyzed using ANOVA ($p \leq 0.05$). Six weeks of training increased walking distance (6MWT) in the RG and decreased SUCSD time in the SG. However, detraining increased systolic blood pressure (SBP) in the RG compared to the SG. Diastolic blood pressure (DBP) decreased after six weeks in the RSG and 12 weeks in the SG. Six weeks of stretching or resistive training can improve the functional status of older people. Nevertheless, DBP decreased after six weeks with the combination of resistive exercise and stretching. Detraining increased SBP when resistive exercise alone was used.

Simao and others (2011) examined the strength and flexibility gains after isolated or simultaneous strength and flexibility training after 16 weeks. Eighty sedentary women were randomly assigned to 1 of 4 groups: strength training (ST; n = 20), flexibility training (FLEX) (n = 20), combination of both (ST + FLEX; n = 20) and control group (CG; n = 20). All the groups performed pre and post training sit and reach test to verify the flexibility level and 10RM test for leg press and bench press exercises. The training protocol for all groups, except for the CG, included 3 weekly sessions, in alternated days, totaling 48 sessions. Strength training was composed of 8 exercises for upper and lower body, executed in 3 sets of periodized training. The flexibility training was composed of static stretching exercises that involved upper and lower body. Results showed that ST (30 ± 2.0 to 36 ± 3.0 cm), ST + FLEX (31 ± 1.0 to 42 ± 4.0 cm), and FLEX (32 ± 3.0 to 43 ± 2.0 cm) significantly increased in flexibility in relation to baseline and to CG (30 ± 2.0 to 30 ± 2.0 cm); however, no significant differences were observed between the treatment conditions. Strength tests demonstrated that ST and ST + FLEX significantly increased 10RM when compared to baseline, FLEX, and the CG. In conclusion, short-term strength training increases flexibility and strength in sedentary adult women. Strength training may contribute to the development and maintenance of flexibility even without the inclusion of additional stretching, but strength and flexibility can be prescribed together to get optimal improvements in flexibility.

Mathew and Vasanthi (2013) find out "the effect of suryanamaskar and Swiss ball training on selected physical variables on sedentary girls". Forty five healthy, untrained girls were selected from Yenepoya Medical College, Mangalore, Karnataka, for this research. The subjects were divided randomly into three equal groups namely one control and two experimental groups consisting of fifteen girls in each group. The subject's age ranged between 18 to 23 years. Experimental groups were given 12 weeks suryanamaskar and Swiss ball training and the control groups were not allowed to participate in any of the training programmes. The training programme was given three days in a week for 45 minutes. Each group was tested before and after the training on abdominal strength. The data were computed statistically by using (ANOCOVA) to find out the significant changes. The result reveals that the suryanamaskar practice group and Swiss ball training group has significant effect on abdominal strength of sedentary girls when compared to control group.

Chaouachi, and others (2013) compared the effectiveness of plyometric only (plyo) with balance and plyometric (combined) training on balance and power measures in children. Before and following an 8-week training period, testing assessed lower body strength (1 repetition maximum leg press), power (horizontal and vertical jumps, triple hop for distance, reactive strength, leg stiffness), running speed (10m and 30m sprint), static and dynamic balance (Standing Stork Test and Star Excursion Balance Test), and agility (shuttle run). Subjects were randomly divided into two training groups (plyo, n=14 and combined, n=14) and a control group (n=12). Results based on magnitude-based inferences and precision of estimation indicated that the combined training group was considered likely to be superior to the plyo group in leg stiffness (d=0.69, 91% likely), 10-meter sprint (d=0.57, 84% likely) and shuttle run (d=0.52, 80% likely). The difference between the groups was unclear in eight of the 11 dependent variables. Combined training enhanced to a greater degree, activities such as 10m sprints and shuttle runs. Combined training could be an important consideration for reducing the high velocity impacts of plyometric training. This reduction in SSC stress on neuromuscular system with the replacement of balance and landing exercises might help to alleviate the overtraining effects of excessive repetitive high load activities.

Kibele and Behm (2009) compared the effect of a 7-week unstable and stable resistance training program on measures of strength, balance, and functional performance. Forty participants were divided into unstable or stable resistance training groups. Training was conducted twice a week for 7 weeks. Pre- and post-testing measures included leg extension strength, static and dynamic balance, sit-ups, long jump, hopping test for time, shuttle run, and sprint. Results showed that there was no overall difference between unstable and stable resistance training and the training effects were independent of gender. All measures except sprint time improved with training. Interaction effects demonstrated that unstable resistance training did provide an advantage for number of sit-ups performed ($p = 0.03$; 8.9%) and the right leg hopping test (6.2%; $p = 0.0001$). This study has demonstrated that instability resistance training may be considered as effective as traditional stable resistance training for inexperienced resistance trainers. Based on the present study and the literature, instability resistance training should be incorporated in conjunction with traditional stable training to provide a greater variety of training experiences without sacrificing training benefits.

Misic and others (2009) examine the effectiveness of cardiovascular endurance training (CVE) compared with balance and flexibility training (FLEX) and to explore the relationship of muscle strength to LEPF. Fifty-five adults (69.1 +/- 5.6 years, 35 female) were randomly assigned to 10 months of CVE or FLEX. Knee extension and flexion at 60 and 120 degrees s(-1) were measured using an isokinetic dynamometer. LEPF was measured using a battery of tasks. The CVE group exercised using treadmills, cycles, and elliptical trainers. The FLEX group participated in a group exercise class that incorporated flexibility and balance activities. The CVE training group significantly improved peak oxygen consumption by 6% (p = 0.03), while the FLEX training group showed no change (p = 0.47). Participants significantly improved peak torque at both speeds and muscle actions by 21-65% (p <or= 0.05), with no group effect (p > 0.05). Both groups also significantly improved performance on all LEPF tasks included in this study (4-7%, p <or= 0.05). Significant correlations (all p = 0.00) were found between improvements in strength and improvements in LEPF including timed walk and peak torque extension and flexion at 60 degrees s(-1) (r = 0.40 and 0.27,

respectively), obstacle walk and peak torque extension and flexion at 60 and 120 degrees s(-1) (r range 0.27-0.40), and stair ascent and peak torque extension at 120 degrees (-1) (r=0.37). Sedentary older adults achieve similar improvements in strength and LEPF with either CVE or FLEX training with the latter being related to improvements in leg strength.

Christou and others (2006) examined the effects of a progressive resistance training program in addition to soccer training on the physical capacities of male adolescents. Eighteen soccer players (age: 12-15 years) were separated in a soccer (SOC; $n = 9$) and a strength-soccer (STR; $n = 9$) training group and 8 subjects of similar age constituted a control group. All players followed a soccer training program 5 times a week for the development of technical and tactical skills. In addition, the STR group followed a strength training program twice a week for 16 weeks. The program included 10 exercises, and at each exercise, 2-3 sets of 8-15 repetitions with a load 55-80% of 1 repetition maximum (1RM). Maximum strength ([1RM] leg press, bench-press), jumping ability (squat jump [SJ], countermovement jump [CMJ], repeated jumps for 30 seconds) running speed (30 m, 10 x 5-m shuttle run), flexibility (seat and reach), and soccer technique were measured at the beginning, after 8 weeks, and at the end of the training period. After 16 weeks of training, 1RM leg press, 10 x 5-m shuttle run speed, and performance in soccer technique were higher ($p < 0.05$) for the STR and the SOC groups than for the control group. One repetition maximum bench press and leg press, SJ and CMJ height, and 30-m speed were higher ($p < 0.05$) for the STR group compared with SOC and control groups. The above data show that soccer training alone improves more than normal growth maximum strength of the lower limps and agility. The addition of resistance training, however, improves more maximal strength of the upper and the lower body, vertical jump height, and 30-m speed. Thus, the combination of soccer and resistance training could be used for an overall development of the physical capacities of young boys.

Kotzamanidis and others (2005) investigated the effect of a combined heavy-resistance and running-speed training program performed in the same training session on strength, running velocity (RV), and vertical-jump performance (VJ) of soccer players. Thirty-five individuals were divided into 3 groups. The first group (n = 12, COM group) performed a combined resistance and speed-training program at the same training session, and the second one (n = 11, STR group) performed the same resistance training without speed training. The third group was the control group (n = 12, CON group). It was concluded that the combined resistance and running-speed program provides better results than the conventional resistance training, regarding the power performance of soccer players.

Tricoli and others (2005) compared the short-term effect of heavy resistance training combined with either the vertical jump (VJ) or weight Lift (WL) program. Thirty-two young men were assigned to 3 groups: WL = 12, VJ =

12, and control = 8. These 32 men participated in an 8-week training study which consisted of squat jump (SJ) and countermovement jump (CMJ) tests, 10- and 30-m sprint speeds, an agility test, a half-squat 1RM, and a clean-and-jerk 1RM (only for WL). The WL program significantly increased the 10-m sprint speed ($p < 0.05$). In conclusion, Olympic WL exercises seemed to produce broader performance improvements than VJ exercises in physically active subjects.

Fatouros and others (2002) investigated the effects of aerobic training, strength training and their combination on joint range of motion of inactive older individuals. Thirty-two inactive older men (65–78 yr) were assigned to one of four groups (n = 8 per group): control (C), strength training (ST), cardiovascular training (CT), and combination of strength and aerobic training (SA). Subjects in the S, A, and SA trained three times a week for 16 weeks. ST included 10 resistance exercises for the major muscle groups at an intensity of 55–80% of 1-RM and CT included walking/ jogging at 50–80% of maximal heart rate. Body weight and height, physical activity level and maximal oxygen uptake ($V\dot{O}_2$-max) were measured before the training period. Isokinetic (60 and 180 deg K sec–1) and concentric strength (1-RM in bench and leg press) were assessed prior to and at the end of the training period. Hip flexion, extension, abduction, and adduction, shoulder extension, flexion, and adduction, knee flexion, elbow flexion and sit-and-reach score were determined before and at 8 and 16 weeks of training. There were no differences between groups in $\dot{V}O_2max$, body weight, and height

($p < 0.05$). ST and SA but not CT and C increased isokinetic and concentric strength at the end of the training period ($p < 0.05$). ST and SA increased significantly ($p < 0.05$) sit-and-reach performance, elbow flexion, knee flexion, shoulder flexion and extension and hip flexion and extension both at mid- and post-training. CT increased ($p < 0.05$) only hip flexion and extension at post training. Results indicate that resistance training may be able to increase range of motion of a number of joints of inactive older individuals possibly due to an improvement in muscle strength.

2.4: Summary of the Literature

All the research studies were presented in this section prove that Swiss ball and flexibility training produced better results on physical fitness components and skill performances. The review of literature helped the researcher from the methodological point of view too. It was learnt that most of the research studies cited in this chapter are appropriate methods for developing fitness and sports performance. The present study may serve as a foundation and main ingredient for future research and investigation in different training methods for enhancing the physical fitness, biochemical and skill performance variables.

Most of the studies in the literature are conducted only physical and physiological measures of athletes and soccer players. Therefore, the mechanism(s) behind the increases in game performance among volleyball players due to twelve weeks of isolated and combined Swiss ball and flexibility training have really been the subject of conjecture. There are only few studies in the literature that have actually measured the skill performances of volleyball players.

Numerous Swiss ball abdominal exercises are employed for core muscle strengthening during training and rehabilitation, but there are minimal data to substantiate the ability of these exercises to improve volleyball game performance. It is also unknown how physical, biochemical and skill performance improvement in isolated Swiss ball and flexibility exercises compares to combination of swiss ball and flexibility training.

Flexibility training, or stretching, is used in varying forms by practically every coach, athlete and physiotherapist on a regular basis. That is to say, a form of stretching is likely to take place at some point in every training or therapy session. In terms of its scientific basis, flexibility training is probably the least understood of the fitness components. The research suggests that, to improve sports performance, active stiffness should be reduced and active ROM should be improved. This will be more specific than static stretches which reduce passive tension, since sports involve both movement and muscular contractions. Studies looking at training methods to reduce active stiffness are limited, but one can assume that they will be similar to the methods used to improve active range of movement.

Modern coaching techniques advocate the use of flexibility exercises as essential components in the belief that this kind of exercise will be more beneficial to sports performance and less likely to cause injury. Unfortunately there is little research to support this. The importance of maintaining fitness among volleyball players is well documented and various training modalities have been recommended; however, the effectiveness of Swiss ball and flexibility training has not been completely characterized. Additionally, isolated and combined effect of swiss ball and flexibility training on physical, biochemical and skill performance among volleyball players warrants further investigation.

In this chapter, the researcher had given research abstracts, which has been conducted recently and published through magazines, journals and periodicals pertaining to the topic considered in this study. These reviews of related literature helped the researcher for the better understanding of the problem and to interpret the result.