CHAPTER II

REVIEW OF RELATED LITERATURE
CHAPTER - II

REVIEW OF RELATED LITERATURE

A summary of findings in the concerned discipline and of previous research provides evidence that the investigator is familiar with what is already known and what is still unknown. Since effective research is based upon past knowledge, this review helps to frame relevant hypothesis and helpful suggestions for significant investigations. Moreover, the review makes the investigator to be aware of the status by providing a background for the research investigations. Keeping these important features in mind, only the study that are relevant are completely executed, segmented and clearly reported under appropriate headings in this chapter.

2.1 STUDIES ON RESISTANCE TRAINING

Adams, et.al (2002) studied the linear effects of four weeks of strength training followed by four weeks of power training on agility and power in strength trained women (N = 14). After strength training, there were no significant improvements in power (vertical and standing long jumps) or agility. After the power training cycle, significant improvements in both power and agility were observed. Strength (1 RM leg squat) improved at the end of both training stages; by 25% after strength training and by a further 11% after power training. Traditional strength training does not improve power or agility. Only when performance characteristics in training (power and agility) match the intended capacity measurement do test results improve. To improve power and agility, those characteristics have to be trained.

Berger (1962) examined nine different weight training programmes and which was more effective improving strength. The experiment was conducted with the bench press lift for a period of 12 weeks with approximately 20
subjects in each weight training program. Subjects were tested for 1RM on the bench press lift at the beginning of the training and at three week intervals. Training took place three times weekly with the variations in programs involving one, two and three sets and two, six and ten repetitions per set. Respectively the result showed that three sets and six repetitions per set were best for improving strength.

Hoff et al., (2000) conducted a study on resistance training loads that light loads (30% 1 RM) and heavy loads (85% 1 RM) are the appropriate loads to improve dynamic athletic performance, usually the vertical jump. This investigation used male soccer players performing half-squats under different treatments. A control group (N = 10), a body-weight alone group doing simulated training without external loads (N = 11), a group using an external load of 30% of 1 RM squats (N = 10), and a group using an external load of 85% of 1 RM squats (N = 10). Vertical jump improved only in the highest training load group but only, when the vertical jump was performed with a 50-kg weight. Vertical jump measures did not improve in outweighed or light-loaded jumping protocols. The highest power production occurred when jumping without any external load. Sprinting tests of 10 m and 40 m improved only in the highest-load training group. It was concluded that improving vertical jumping height involved more than just the training load in resistance training. The specificity of the training effects of resistance exercises is again demonstrated in this investigation.

Kraemer et al (2001) conducted a study on effect of resistance training on women's strength/power and occupational performances. Specific training programs resulted in significant increases in body mass (TP), 1-RM squat (TP, TH, FLD), bench press (all except AER), high pull (TP), squat jump (TP, TH, FLD), bench throw (all except AER), squat endurance (all except AER), 1-RM box lift (all except aerobic), repetitive box lift (all), push-ups (all except AER),
sit-ups (all except AER), and 2-mile run (all). Strength training had improved the physical performances of women over 6 months and adaptations in strength, power, and endurance were specific to the subtle differences (e.g., exercise choice and speeds of exercise movement) in the resistance training programs (strength/power vs strength/hypertrophy). Upper- and total-body resistance training resulted in similar improvements in occupational task performances, especially in tasks that involved upper-body musculature. Finally, gender differences in physical performance measures were reduced after resistance training in women, which underscores the importance of such training for physically demanding occupations.

Marcinik et al. (1991) showed that strength training had positive effects of endurance in cycling capacity. Eighteen males performed 12 weeks of strength training three times a week. The strength training consisted of 8-12 repetitions of upper body exercise (bench press, push-ups, lat pull-downs, arm curls) and 15-20 repetitions on lower body exercises (knee extensions, hip flexion's, parallel squats) with a 30-second rest between exercises. The strength training program had no effect on the subjects VO2max. However, 1 RM for knee extension and hip flexion improved by 30% and 52% respectively. More important is that the cycle time to exhaustion at 75% of VO2max proved a massive 33% from 26.3 minutes before strength training to 35.1 minutes after training. He concluded that the strength training improves cycle endurance performance independently of changes in VO2max and that this improvement appears to be related to increase in leg strength.

Sailors and Berg (1987) compared the effects of an eight week training programmes on strength / Muscular endurance and Somato – type in pubescent boys (N=11, mean age S.D. =12.6+.69 years) and male college students (N=9; mean age S.D.=240+5.12 years). Control groups were used to account for the effects of maturity in these measures. Strength Muscular endurance was
assessed by determining the 5 RM (Repetition Maximum) in the arm curl, Squat and bench press. Both the training groups significantly increased the 5 RM in each lift (P<05) while no significant changes were observed in either control groups. The differences in the 5 RM gains between the pubescent and Men’s training groups were not significantly different. Somato type analysis indicated no significant changes in groups except for decrease in mesomorphy among boys in training group (P<-05). These boys also showed an increase in height (P<05) and a decrease in skin folds (P<-05). It appears that young males at this age are as trainable as mature men with regards to performance of 5 RM.

Silva (2007) investigated the effects on cardiovascular response acute cardiovascular responses to different high-velocity resistance exercise protocols were compared in untrained older women. Twelve apparently healthy volunteers (62.6 ± 2.9 y) performed three different protocols in the bench press (BP). All protocols involved three sets of 10 repetitions performed with a 10RM load and 2 minutes of rest between sets. The continuous protocol (CP) involved ten repetitions without a pause between repetitions. The discontinuous protocols were performed with a pause of five (DP5) or 15 (DP15) seconds between the fifth and sixth repetitions. Heart rate (HR), systolic blood pressure (SBP), rate pressure product (RPP), Rating of Perceived Exertion (RPE), and blood lactate (BLa) were assessed at baseline and at the end of all exercise sets. Factorial ANOVA was used to compare the cardiovascular response among different protocols. Compared to baseline, HR and RPP were significantly (p < 0.05) higher after the third set in all protocols. HR and RPP were significantly (p < 0.05) lower in DP5 and DP15 compared with CP for the BP exercise. Compared to baseline, RPE increased significantly (p < 0.05) with each subsequent set in all protocols. Blood lactate concentration during DP5 and DP15 was significantly lower than CP. It appears that discontinuous high-
velocity resistance exercise has a lower cardiovascular demand than continuous resistance exercise in older women.

Toumi et al (2004) studied the effects of jump training as a complement to weight training on jump performance and muscle strategy during the squat and countermovement jump. Twenty-two male handball players, between the ages of 17 and 24, and in good health, were randomly divided into three groups. Two were trained groups, weight training (WTG) and jump training combined with weight training (CTG), and one was a control group (CG). Maximal isometric force and maximal concentric power were assessed by a supine leg press, squat jump (SJ), counter movement jump (CMJ), and surface EMG was used to determine changes in muscle adaptation before and after the training period. After 6-wk training programs, the two training groups increased maximal isometric force, maximal concentric power, and squat jump performance. However, only combined training presented a significant increase in height jump performance during the countermovement jump (P < 0.05). EMG analysis (as interpreted through the root mean square values) showed that the SJ was performed similarly before and after the training period for the two training groups. However, during the CMJ, only the CTG group adopted a new technique manifested by a short transition phase together with an increase in knee joint stiffness and knee extensor muscle activation and rectus femoris ratio. It was suggested that the central activities in knee joint during the transition phase, in conjunction with intrinsic muscle contractile properties, play a major role in the regulation of performance during a CMJ.

Wenzel and Perfetto (1992) tested the effect of speed training versus strength training in power development. Sixty-five football players participated in an off-season weight training program. All players lifted three times per week and used the same program with hips led program, while the remaining forty athletes performed squat and vertical jump measures which were
recorded. No difference was found between two groups on any of the measures. Modeling was used to test the effect of training on power development while controlling for initial differences, but no group difference in training effectively was found. It was concluded that speed training was not found to be superior to strength training; it could be used as an equivalent substitute.

2.2 STUDIES ON PLYOMETRIC TRAINING

Brown et al (1986) has shown that plyometric training can improve the vertical jump of high school male basketball players. The vertical jumping ability of 26 freshman and sophomore high school male players (average age = 15 years) was tested after 3 weeks (18 sessions) of practice. Two jump types were measured: a vertical jump in which the arms (VJA) were free to be used in a double-arm swing and one in which the arms were clasped behind the back (VJNA). The group was divided into 2 sub-groups: the "plyometric" group performed 3 sets of 10 repetitions (with 1 minute rest between sets) of depth jumping from a 45 cm bench. A total of 34 training sessions were undertaken over a 12-week period. The "control" group performed normal basketball training only. From the results, it was observed that there was no difference between the 2 groups at the pre-training stage. After training, there was again no difference between the groups for the 'no arms' condition, and both groups had improved their vertical jumping ability. Both groups made significant improvements in their vertical jump when using the arms (21.3% and 17.7% for the plyometric and control groups respectively), but the improvement made by the plyometric group was significantly greater than that made by the control group. The findings support the use of plyometric-style training, in which the muscles are shortened immediately after being loaded eccentrically (i.e. lengthened). The results of this study suggest that 57% of the increase in jump ability is due to improvements in technique, while the remaining 43% is due to
the plyometric training. Thus, while basketball practice alone is sufficient to improve vertical jump performance in high school boys, greater improvements may be generated by employing plyometric training techniques.

Diallo et al (2000) examined the effectiveness of plyometric training and maintenance training on physical performances in prepubescent soccer players. Twenty boys aged 12-13 years were divided in two groups (10 in each): jump group (JG) and control group (CG). JG trained 3 days/week during 10 weeks, and performed various plyometric exercises including jumping, hurdling and skipping. The subsequent reduced training period lasted 8 weeks. However, all subjects continued their soccer training. Maximal cycling power (Pmax) was calculated using a force-velocity cycling test. Jumping power was assessed by using the following tests: countermovement jump (CMJ), squat jump (SJ), drop jump (DJ), multiple 5 bounds (MB5) and repeated rebound jump for 15 seconds (RRJ15). Running velocities included: 20, 30 and 40 m (V20, V30, V40 m). Body fat percentage (BF percent) and lean leg volume were estimated by anthropometry. As results, before training, except for BF percent, all baseline anthropometric characteristics were similar between JG and CG. After the training programme, Pmax (p<0.01), CMJ (p<0.01), SJ (p<0.05), MB5 (p<0.01), RRJ15 (p<0.01) and V20 m (p<0.05), performances increased in the JG. During this period no significant performance increase was obtained in the CG. After the 8-week of reduced training, except Pmax (p<0.05) for CG, any increase was observed in both groups. These results demonstrate that short-term plyometric training programmes increase athletic performances in prepubescent boys. These improvements were maintained after a period of reduced training.

Kotzamanidis, C. et.al (2006) conducted a study on effect of plyometric training on running performance and vertical jumping in pre pubertal boys. The purpose of this study was to investigate the effect of plyometric training on
running velocity (RV) and squat jump (SJ) in prepubescent boys. Fifteen boys (11.1 ± 0.5 years) followed a 10-week plyometric program (JUMP group). Another group of 15 boys (10.9 ± 0.7 years) followed only the physical education program in primary school and was used as the control group (CONT group). Running distances (0-10 m, 10-20 m, 20-30 m, and 0-30 m), were selected as testing variables to evaluate the training program. The total number of jumps was initially 60 per session, which was gradually increased over a period of 10 weeks to 100 per session. Results revealed significant differences between COUNT and JUMP groups in RV and SJ. In JUMP group the velocity for the running distances 0-30, 10-20, and 20-30 m increased (p < 0.05), but not for the distance 0-10 m (p > 0.05). Additionally, the SJ performance of the JUMP group increased significantly, as well (p < 0.05). There was no change in either RV or SJ for the CONT group. These results indicate that plyometric exercises can improve SJ and RV in pre pubertal boys. More specifically, this program selectively influenced the maximum velocity phase, but not the acceleration phase.

Kraemer et al. (1994) conducted a study on the factors of training for development of vertical jump. The explosive strength is a characteristic of performance that is common in many sporting endeavors. However, training very frequently includes reduced velocity "strength" training which develops capacities which are only appropriate for a very few activities (e.g., power lifting). Strength training is often required because it is believed to improve explosive strength. Training with heavy loads (70-120% of 1 RM) improves maximal isometric strength but not the maximal rate of force development. In some cases it might even reduce the ability of the muscles to develop force rapidly. On the other hand, light load training with an accent on speed of movement increases an athlete's ability to rapidly develop force. A typical total-body explosive movement (e.g., vertical jump) requires force to be developed in
a time period between 200 and 350 ms. Most of the heavy-strength training-induced increases in force-producing potential cannot be realized over such a short time. Heavy strength training is of little benefit to already strong individuals who wish to perform explosive movements.

Kubachka et al (1966) studied the effects of plyometric training and strength training on the muscular capacities of the trunk. The effects of plyometric, strength training, and body weight exercises on the power, strength, and endurance capacities of the trunk muscles were examined. Training sessions occurred twice per week for five weeks (a total of 10 training sessions). Plyometrics use two physiological properties of muscle, the stretch reflex and storage of elastic energy. When a rapid lengthening of a muscle occurs just prior to rapid shortening, a more powerful contraction results. Plyometrics significantly increased power (8.6%) and strength (45.9%). Strength training increased power (7.3%) and strength (82.5%). Body weight increased strength only (21.9%). Both plyometrics and strength training were as effective as each other. This study showed the rapid and substantial gains that can be made when plyometric or strength training is confined to a restricted set of muscles.

Luebbers et al (2003) conducted a study on the effects of plyometric training and recovery on vertical jump performance and anaerobic power. They examined the effects of two 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 pre training (pre), immediately post training (post), and 4 weeks post training (POST-4). Vertical jump height
decreased in the 4-week group pre to post. Vertical jump height increased from pre to post in 4-week and 7-week training programs. Vertical jump power decreased in the 4-week group from pre to post) with no change in the 7-week group. Vertical jump power increased pre to post-4 week and 7-week training programs. Anaerobic power improved in the 7-week group from pre 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.

Martel et al (2005) studied on effect of aquatic plyometric training on vertical jump of female volleyball players. Nineteen female volleyball players (aged 15 +/- 1 yr) were randomly assigned to perform 6 wk of APT or flexibility exercises (con) twice weekly, both in addition to traditional preseason volleyball training. Testing of leg strength was performed at baseline and after 6 wk, and VJ was measured at baseline and after 2, 4, and 6 wk. Similar increases in VJ were observed in both groups after 4 wk (APT = 3.1%, con = 4.9%; both P < 0.05); however, the APT group improved by an additional 8% (P < 0.05) from week 4 to week 6, whereas there was no further improvement in the con group (-0.9%; P = NS). After 6 wk, both groups displayed significant improvements in concentric peak torque during knee extension and flexion at 60 and 180 degrees x s(-1) (all P < 0.05). The combination of APT and volleyball training resulted in larger improvements in VJ than in the con group.

Matavulj et al (2001) conducted a study on the effects of plyometric training on jumping performance in junior basketball players. This study attempted to assess the effects of plyometric training when it is added to the
training of adolescent males (N = 33; 15-16 years) who already can jump very well. Three groups of elite junior basketball players were established: a) a control group that only performed regular basketball training, b) a group that performed plyometrics (drop-jumps) from 50 cm, and c) a group that performed plyometrics from 100 cm. The added training was performed three times per week for six weeks. Both experimental groups improved significantly in the maximal vertical jump (4.8 cm for the 50-cm group and 5.6 cm for the 100-cm group) and rate of force development in the knee extensors. There were no significant differences between the experimental groups in any measure. Drop-jump plyometric training could improve jumping height in adolescent basketball players.

Miller et.al (2006) studied the effects of a 6-week plyometric training program on agility was to determine if six weeks of plyometric training can improve the athlete’s agility. Subjects were divided into two groups, plyometric training and a control group. 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 posttest 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 posttest 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.

Wilson et al (1993) compared the effects of 10 wk of training with traditional back squats or one of two forms of plyometric training loaded jump squats or drop jumps--on vertical jump performance. Two types of vertical jump tests were performed: 1) counter-movement jump in which the subjects started from a standing position, performed a rapid crouch, and then jumped for
maximal height, and 2) a jump from a static crouching position, i.e., with no counter movement. All training groups except the drop-jump group produced significant increases in vertical jump performance. For the counter-movement jump, the group that trained with loaded jump squats produced the greatest improvement (18%), which was significantly greater than that for the drop-jump group (10%) or for the weight-trained group (5%). For the static crouch jump, the group trained with loaded jump squats increased jump height by 15%, which was significantly greater than the increase for the drop-jump group (7.2%) and for the weight training group (6.8%). These results were similar to those obtained by Berger (1963), who also found that training with jump squats loaded at 30% of maximum resulted in greater increases in vertical jump than did training programs consisting of traditional weight training, drop-jump training, or isometric training.

2.3 STUDIES ON COMPLEX TRAINING

Baker et al (2005) conducted a study to determine if a complex training consisting of contrasting agonist and antagonist muscle exercises would result in an acute increase in power output in the agonist power exercise. Twenty-four college-aged rugby league players who were experienced in combined strength and power training served as subjects for this study. They were equally assigned to an experimental (Antag) or control (Con) group and were no different in age, height; body mass, strength, or maximal power. Power output was assessed during bench press throws with a 40-kg resistance (BT P40) with the Plyometric Power System training device. After warming up, the Control group performed the BT P40 tests 3 minutes apart to determine if any acute augmentation to power output could occur without intervention. The Antag group also performed the BT P40 tests; however, an intervention strategy of a set of bench pulls, which is an antagonistic action to the bench throw, was performed between tests to determine if this would acutely affect power output.
during the second BT P40 test. Although the power output for the Control group remained unaltered between test occasions, the significant 4.7% increase for the Antag group indicates that a strategy of alternating agonist and antagonist muscle exercises may acutely increase power output during complex power training. This result may affect power training and specific warm-up strategies used in ballistic sports activities, with increased emphasis placed upon the antagonist muscle groups.

Comyns et al. (2007) examined the effect of various resistive loads on the biomechanics of performance of a fast stretch-shortening cycle activity to determine if an optimal resistive load exists for complex training. Twelve elite rugby players performed three drop jumps before and after three back squat resistive loads of 65%, 80%, and 93% of a single repetition maximum (1-RM) load. All drop jumps were performed on a specially constructed sledge and force platform apparatus. Flight time, ground contact time, peak ground reaction force, reactive strength index, and leg stiffness were the dependent variables. Repeated-measures analysis of variance found that all resistive loads reduced (P < 0.01) flight time, and that lifting at the 93% load resulted in an improvement (P < 0.05) in ground contact time and leg stiffness. From a training perspective, the results indicate that the heavy lifting will encourage the fast stretch-shortening cycle activity to be performed with a stiffer leg spring action, which in turn may benefit performance. However, it is unknown if these acute changes will produce any long-term adaptations to muscle function.

Ebben (2002) has gained popularity as a training strategy combining weight training and plyometric training. Recently, several studies have examined complex training. Despite the fact that questions remain about the potential effectiveness and implementation of this type of training, results of recent studies are useful in guiding practitioners in the development and implementation of complex training programs. In some cases, research suggests
that complex training has an acute ergogenic effect on upper body power and the results of acute and chronic complex training include improved jumping performance. Improved performance may require three to four minutes rest between the weight training and plyometrics sets and the use of heavy weight training loads.

Evans et al (2000) examined the complex training by studying the effect of combined bench press and medicine ball throws demonstrating improve plyometric performance in the complex condition. More specifically, one study sought to determine whether or not upper body power could be enhanced by performing a heavy bench press set prior to an explosive medicine ball put. Subjects included 10 college age males with experience performing the bench press. Subjects performed a seated medicine ball put before and four minutes after performing the bench press with a 5RM load. Results indicate a significant increase medicine ball put distance of 31.4 cm (no standard deviation available) following the 5RM bench press compared to the medicine ball put before the bench press. Researchers also report a strong correlation between improvement in medicine ball put distance and 5RM bench press strength.

Ford HT Jr, et. al (1983) conducted a study on effects of three combinations of plyometric and weight training programs on selected physical fitness test items. To determine the effects of prescribed training programs on 5 physical fitness test items, each of 50 high school boys participated for 10 wk. in one of three programs (wrestling, softball, and plyometrics; weight training; and weight training and plyometrics). (a) On the sit-ups, 40-yd. dash, vertical jump, and pull-ups, each group improved significantly from pre- to posttest. (b) On the shuttle run, none of the groups improved significantly from pre- to posttest. (c) On the vertical jump, groups had a significant effect, but the interaction was no-significant. No effects were significant.
Jensen et al (1999) used complex training as a method of combining weight and plyometric exercises during the same training session is growing in popularity, despite limited scientific support for its efficacy. The purpose of this study was to examine the effect of a set of high-load bench press exercises (BP) on a subsequent set of medicine ball power drop exercises (MBPD) via mean ground reaction force, maximum ground reaction force, and mean electromyography (EMG$_{int}$). Ten male (19 ± 1.4 years) NCAA Division 1 basketball players with experience in weight and plyometric training performed plyometric exercises under 2 randomly determined conditions. One condition included a BP followed immediately by a MBPD. The other condition included only the MBPD. Mean ground reaction force, maximum ground reaction force, and EMG$_{int}$ were recorded during the MBPD for both conditions. Results indicated that no significant differences exist for mean ground reaction force, maximum ground reaction force, and EMG$_{int}$ for the pectoralis major and triceps muscles between the MBPD and the BP plus MBPD conditions. These results indicate there is no heightened excitability of the central nervous system. However, there also appears to be no disadvantage of performing high-load weight training and plyometric exercises in complex pairs. Therefore, complex training may be a useful training strategy because of the organizational advantages of performing weight and plyometric exercises in the same training session.

Moore (2005) compared the performance effect of TRT (30 minutes) combined with either OSL or non-depth jump PE (15 minutes) on entry level competitive collegiate athletes. Ten female and 5 male competitive soccer players, divided into 2 groups, completed 12 weeks of tri-weekly training during their off-season. Countermovement vertical jump, 4 repetition maximum squat, 25-m sprint, and figure-8 drill on a 5-dot mat were conducted pre-, mid-, and postintervention. Significant improvements were made by both groups in
each performance parameter over the 12-week period (p < 0.05), with no significant differences found between the training groups. Although these training modalities may achieve their results through slightly different mechanisms, the performance-related improvements may not be significantly different for entry-level collegiate athletes with little resistance training experience.

Rahman Rahimi et al (2005) conducted a study on the effect of plyometric, weight and plyometric-weight training on anaerobic power and muscular strength. The effect of three different training protocols—plyometric training, weight training, and their combination on the vertical jump performance, anaerobic power and muscular strength. Based on their training, 48 male college students were divided into 4 groups namely plyometric training group (n=13), weight training group (n=11), plyometric plus weight training group (n=14) and a control group (n=10). The data were analyzed by a one-way analysis of variance (repeated measure design). The results showed that all the training treatments elicited significant (p<0.5) improvement in all of the tested variable. However the combination training group showed sings of improvement in the vertical jump performance, the 50 yard run, and leg strength that was significantly greater than the improvement in the other 2 training groups (plyometric, weight training groups) this study provides support for the use of combination of traditional weight training and plyometric drills to improve the vertical jump ability, explosive performance in general and leg strength.

Sale et al (1990). Studied the responses to concurrent strength and endurance training were assessed. Subjects (M = 4; F = 4) trained one leg for strength and the other leg for strength and endurance. A second group (M = 4; F = 4) trained one leg for endurance and the other for endurance and strength. Endurance training used a cycle ergometer with five 3-min bouts of activity at
an intensity of 90-100% VO2max. Strength training consisted of six sets of 15-20 repetitions with the heaviest weight possible on a leg press machine. Training was performed three times per week for 22 weeks. Concurrent strength and endurance training did not interfere with strength or endurance development, the two improving independently.

Stemm and Jacobson (2007) conducted a study to compare vertical jump performance after land- and aquatic-based plyometric training. A convenience sample of 21 active, college-age (24 +/- 2.5 years) men were randomly assigned to 1 of 3 groups: group I, aquatic; group II, land; and group III, control. Training for the AQ and LN groups consisted of a 10-minute warm-up followed by 3 sets of 15 squat jumps, side hops, and knee-tuck jumps separated by 1-minute rests. The aquatic group performed the exercises in knee-level water adjusted to parallel the axis of the knee joint (+1 in.). The land group performed identical plyometric exercises on land. The control group engaged in no training. Participants trained twice a week for 6 weeks, and all training sessions were monitored. Pre- and post-test data were collected on maximum vertical jump height. A 2x3 analysis of variance with repeated measures was used to compare vertical jump height among the 3 groups. Results suggested that the aquatic- and land-based groups significantly (p < 0.05) outperformed the control group in the vertical jump. No significant difference was found in vertical jump performance between the aquatic- and land-based groups. It was concluded that aquatic training resulted in similar training effects as land-based training, with a possible reduction in stress due to the reduction of impact afforded by the buoyancy and resistance of the water upon landing.

Toji et al. (2004) studied on the effect of training with a combination of different loads (multiple-load training) on the force-velocity and force-power relationships was examined with training programs that included maximal isometric contraction (Fmax) and concentric contraction of the elbow
flexor muscles. Twenty-one male college students were placed into 3 equal training groups (G (30 + 60), G (30 + 100), and G (30 + 60 + 100)) and performed multiple-load training 3 days per week for 8 weeks. The training load was a set fraction of the maximal isometric strength (% Fmax). The G (30 + 60) group performed 6 repetitions of elbow flexion at 30 and 60% Fmax. The G (30 + 100) group performed 6 repetitions at 30% Fmax and six 5-second Fmax loads. The G (30 + 60 + 100) group performed 4 repetitions at 30 and 60% Fmax and four 5-second Fmax loads. After training, Fmax and maximal velocity significantly increased (p < 0.05) in all 3 training groups. The increases in maximal power were significantly (p < 0.05) different between the G (30 + 60 + 100) group (52.9%) and the G (30 + 100) group (24.2%). These results suggest that multiple-load training programs with 4-6 repetitions are effective for improving muscle power and velocity of the elbow flexors.

Young et al (1998) in his study demonstrated a potential acute complex training effect. He evaluated the counter movement jumps (CMJ) could be enhanced if proceeded by a set of five repetition maximum (5 RM) half squats. Subjects performed two sets of five CMJ, one set of 5 RM half squats, and one set of five CMJ with four minutes rest between all sets. The jump height for the CMJ after the squat was 40.0 cm ± 3.5cm compared to a pre-squat jump height of 39.0 ± 3.3 cm, resulting in a 2.8% improvement in jump performance. The authors indicate that there was a significant correlation between the 5 RM load and jump performances. Results suggest that for complex training, a high load weight training exercise performed four minutes before a power exercise increased the performance of the power exercise, especially for stronger individuals.

Zepeda et al. (2000) examined the effectiveness of a complex training group compared to a group who performed all of the weight training exercises after the plyometric exercises. Each group performed the same 7 week routine
except the complex training group performed the plyometric exercises in a superset with biomechanically similar resistance training exercises, whereas the other group performed the plyometric exercises separately, following the resistance training exercises. Subjects included seventy-eight division I college football players. Subjects were pre and post-tested with a variety of tests including percentage of body fat, bench press, squat, power clean, medicine ball throw, broad jump, and vertical jump. Both groups demonstrated improvement in all eight of the tests. However, the complex training group demonstrated significant between group vertical jumps improvements (2.8 cm) compared to the non-complex training group (0.1 cm).

2.4 STUDIES ON STRETCHING EXERCISES

Bandy and Irion (1994) they conducted a study on the effect of time on static stretch on the flexibility of the hamstring muscles. With the purpose of examined the length of time the hamstring muscles should be placed in a sustained stretched position to maximally increase ROM. Fifty-seven subjects (40 men, 17 women), ranging in age from 21 to 37 years and with limited hamstring muscle flexibility (ie, 30 degrees loss of knee extension measured with femur held at 90 degrees of hip flexion), were randomly assigned to one of four groups. Three groups stretched 5 days per week for 15, 30, and 60 seconds, respectively. The fourth group, which served as a control group, did not stretch. Before and after 6 weeks of stretching, flexibility of the hamstring muscles was determined by measuring knee extension ROM with the femur maintained in 90 degrees of hip flexion. Data were analyzed with a 4 x 2 analysis of variance (group x test) for repeated measures on one variable. The data analysis revealed a significant group x test interaction, indicating that the change in flexibility was dependent on the duration of stretching. Further post hoc analysis revealed that 30 and 60 seconds of stretching were more effective at increasing flexibility of the hamstring muscles (as determined by increased ROM of knee
extension) than stretching for 15 seconds or no stretching. In addition, no significant difference existed between stretching for 30 seconds and for 1 minute, indicating that 30 seconds of stretching the hamstring muscles was as effective as the longer duration of 1 minute. The results of this study suggested that duration of 30 seconds is an effective time of stretching for enhancing the flexibility of the hamstring muscles.

Davis et.al (2005) studied the effectiveness of 3 stretching techniques on hamstring flexibility using consistent stretching parameters. This study compares the effects of 3 common stretching techniques on the length of the hamstring muscle group during a 4-week training program. Subjects were 19 young adults between the ages of 21 and 35. The criterion for subject inclusion was tight hamstrings as defined by a knee extension angle greater than 20 degrees while supine with the hip flexed 90 degrees. The participants were randomly assigned to 1 of 4 groups. Group 1 (n = 5) was self-stretching, group 2 (n = 5) was static stretching, group 3 (n = 5) was proprioceptive neuromuscular facilitation incorporating the theory of reciprocal inhibition (PNF-R), and group 4 (n = 4) was control. Each group received the same stretching dose of a single 30-second stretch 3 days per week for 4 weeks. Knee extension angle was measured before the start of the stretching program, at 2 weeks, and at 4 weeks. Statistical analysis (p < or = 0.05) revealed a significant interaction of stretching technique and duration of stretch. Post hoc analysis showed that all 3 stretching techniques increase hamstring length from the baseline value during a 4-week training program; however, only group 2 (static stretching) was found to be significantly greater than the control at 4 weeks. These data indicated that static stretching 1 repetition for 30 seconds 3 days per week increased hamstring length in young healthy subjects. These data also suggested that active self-stretching and PNF-R stretching 1 repetition for 30
seconds 3 days per week is not sufficient to significantly increase hamstring length in this population.

Laur, et.al (2003) studied the effects of an acute stretching regime on hamstring muscle fatigue and rating of perceived exertion during a dynamic, sub-maximal bout of resistance exercise. Sixteen healthy males and sixteen healthy females volunteered to participate in two experimental sessions. After establishing their one-repetition maximum for the hamstring curl, the participants were assigned at random to one of two groups. Group 1 performed three bouts of 20 hamstring stretches with the assistance of one of the investigators, while Group 2 did not perform the stretches; instead, they sat resting for 3 minutes. Then, after stretching or resting, the participants performed as many hamstring curls as they could at 60% of their one-repetition maximum established earlier. All participants were assessed for their perceived exertion using a modified Borg category ratio (CR-10) scale. The participants returned within 1 week to complete the experiment. This time group 1 did not perform hamstring stretches, whereas Group 2 did. As on the first occasion, all participants performed hamstring curls after stretching or resting. The participants in Group 1 were able to perform more curls on the second day of testing than their counterparts in Group 2. There were no significant differences between males and females or between the stretch and non-stretch conditions. There was a significantly higher first repetition rating of perceived exertion for the stretch condition (2.88 +/- 1.01) than for the non-stretch condition (2.50 +/- 0.95); there was no significant difference in the median ratings of perceived exertion between the stretch and non-stretch conditions. Significantly higher power function exponents were exhibited in the non-stretch (0.57 +/- 0.16) than in the stretch condition (0.51 +/- 0.12). In addition, females exhibited significantly higher power function exponents than males, irrespective of stretch condition and day (females: 0.59 +/- 0.12; males: 0.49 +/- 0.11). In
conclusion, they found a small but statistically significant effect of an acute bout of stretching on ratings of perceived exertion during fatiguing hamstring muscle resistance exercise.

Reid and McNair (2004) studied the passive force, angle, and stiffness changes after stretching of hamstring muscles. Periodic or long-term stretching programs have demonstrated changes in joint range of motion. The suggested mechanisms for these increases in range of motion are changes in the tissue properties of the muscle and more recently stretch tolerance. However, few studies have examined changes in passive resistive forces and related these changes to increases in range of motion. The purpose of this study was to investigate the influence of a 6-wk hamstring-stretching program on knee extension range of motion, passive resistive forces, and muscle stiffness. A randomized control trial with repeated measures was undertaken with 43 school-age subjects. Hamstring extensibility was assessed by a passive knee extension test using a Kincom isokinetic dynamometer. The intervention group participated in a 6-wk hamstring-stretching program. Stretches were performed 5 d x wk (-1), once per day, held for 30 s, and for 3 repetitions. The control group did not stretch over the 6-wk intervention period. Measurements of hamstring extensibility were repeated at the end of the 6-wk intervention. After the intervention period, significant (P < 0.05) increases in knee extension range of motion, passive resistive force, and stiffness were observed in the experimental group. No significant differences were observed in the control group's findings for the same variables.

2.5 STUDIES ON MARTIAL ARTS

Chapman (1997) conducted a study on discriminant function analysis on participants of 142 male Tae Kwon-do competitors, they were completed the Competitive State Anxiety Inventory-2 about 1 hr. before competition.
Multivariate analysis of variance showed that the players who won reported lower cognitive and somatic anxiety and higher self-confidence than those who lost. Discriminant function analysis indicated that 89 (62.68%) participants could be correctly classified as winners or losers on the basis of their precompetition Competitive State Anxiety Inventory-2 scores.

Glass, et al. (2002) examined the caloric cost of martial arts training in novice participants. Eighteen novice martial artists (9 men, 9 women age=19.7±1.9 yrs, Ht =174.8±11.1 cm, Mass=74.6±18.6 kg, Resting HR=79.9±10.3 beats/min, Resting SBP=120.8±11.8 mmHg, Resting DBP=76.3±8.4 mmHg, % fat=23.1±8.8) were given instructions as to proper technique for basic kicking and arm strike techniques. Subjects then completed 2 exercise bouts consisting of: 1. front kicks 2. butterfly stretch 3. forearm strikes 4. sit-ups 5. side-kicks 6. quadriceps stretch and 7. push-ups. Total time for the martial art activity was 7.6±0.9 min. All strikes were against a large padded target. Subjects were asked to pace themselves. During the activities subjects' VO2, RER, VE as well as telemetry heart rate were measured. Results indicated substantial cardiopulmonary strain (HR=157.4±18.9 beats/min, % Max HR=78.5±9.2, VE=55.2±24.4 L/min, RER=1.1±0.1) as well as energy expenditure (mean VO2=1.67±0.7 L/min; 8.1±3.5 Kcals/min). However there were large variations in caloric expenditure, indicating that martial arts provides a unique opportunity for both fit and unfit individuals to participate, while clients can self select the training intensity.

Imamura et al (1997) conducted a study on heart rate, blood lactate responses and ratings of perceived exertion to 1,000 punches and 1,000 kicks in collegiate karate practitioners with the purpose of: 1) to investigate the responses of heart rate (HR), blood lactate and ratings of perceived exertion (RPE) to 1,000 punches and 1,000 kicks in collegiate highly skilled (BB Group) and novice (WB Group) karate practitioners; and, 2) to compare RPE obtained
from the subjects to RPE expected by their coaches. The mean values of HR, percent of maximal HR (% HRmax), percent of maximal HR reserve (% MHRR), blood lactate and RPE in 1,000 punches for the BB Group were 102.5 +/- 14.8 beats. Min-1, 53.1 +/- 8.5%, 27.1 +/- 12.7%, 0.8 +/- 0.2 mmol.1-1 and 12.2 +/- 1.2 respectively, and for the WB Group were 116.1 +/- 17.9 beats. min-1, 58.1 +/- 7.7%, 35.2 +/- 13.3%, 1.2 +/- 0.6 mmol.1-1 and 12.8 +/- 1.2, respectively. Likewise, the mean values in 1,000 kicks for the BB Group were 127.4 +/- 12.4 beats. min-1, 66.0 +/- 8.0%, 47.0 +/- 12.5%, 1.3 +/- 0.4 mmol.1-1 and 14.2 +/- 1.2, respectively, and for the WB Group were 137.0 +/- 14.4 beats.min-1, 70.1 +/- 7.4%, 52.0 +/- 12.8%, 2.4 +/- 0.8 mmol. 1-1 and 16.3 +/- 1.5, respectively. These responses to 1,000 punches and 1,000 kicks were moderate, and the RPE for 1,000 punches in both BB and WB Groups and for 1,000 kicks in the BB Group were significantly lower than the RPE expected by their coaches.

Imamura et. al (1996) conducted a study on Heart rate response and perceived exertion during twenty consecutive karate sparring matches. This study investigated the changes in heart rate (HR) and perceived exertion ratings (RPE) of 20 consecutive karate sparring matches each of 2 minutes duration. The resting and maximal HR (HRmax) responses to the maximal treadmill test were 69.8 +/- 2.9 beats.min-1 and 198.5 +/- 8.2 beats.min-1, respectively. The resting HR before the 20 sparring matches was 83.5 +/- 11.3 beats min-1. The mean HR during the 20 sparring matches was 191.8 +/- 9.4 beats.min-1 which was equal to 96.7 +/- 4.2% of HRmax. At the end of the 20 sparring matches, the mean RPE obtained was 19 +/- 2. The results of this study suggest that the subjects could continue the 20 sparring matches for about 40 minutes at the intensity close to the HRmax.

Melhim (2001) conducted a study on Aerobic and Anaerobic power responses to the practice of taekwon-do. Practising the martial art of taekwon-
do (TKD) has been proposed to have beneficial effects on cardiovascular fitness as well as general physical ability. Furthermore, TKD masters and participants have promoted TKD as a total fitness programme. Nineteen TKD practitioners with an average age of 13.8 years and 10.4 months of TKD training experience were recruited to participate. Measurements included resting heart rate, aerobic power, anaerobic power, and anaerobic capacity. Paired t test analysis showed no significant differences in either resting heart rate or aerobic power after training. However, significant differences were observed in anaerobic power and anaerobic capacity ($p = 0.05$). The increases in anaerobic power and anaerobic capacity were 28% and 61.5% respectively. The practice of TKD promotes anaerobic power and anaerobic capacity, but not aerobic power, in male adolescents.

Reynes and Lorant (2004) conducted a study on competitive martial arts and aggressiveness: a 2-yr. longitudinal study among young boys. The data obtained after a second year of practice, 14 judoka, 9 karateka, and 20 control participants who filled out the Buss-Perry Aggression Questionnaire three times, 1 year apart. At the first assessment, all participants, born the same year, were 8 yr. old and at the third they were 10 yr. old. Analysis indicated that after two years of practice, karate training seemed to have neither positive nor negative effects on aggressiveness scores, while judo training seemed to have a negative effect on anger scores. However, the results suggested the importance of kata or meditation in training sessions on self-control acquisition for such young boys.

Toskovic et. al (2002) conducted a study on the effect of experience and gender on cardiovascular and metabolic responses with dynamic Tae Kwon Do exercise. This study, conducted at the Exercise Physiology Laboratory of Auburn University, AL, addressed and compared the acute cardiovascular and metabolic effects elicited by novice and experienced men and women.
participants during a single bout of dynamic Tae Kwon Do exercise and investigated whether or not dynamic Tae Kwon Do practice is an exercise modality that provides sufficient cardio respiratory demand for enhancing aerobic fitness and promoting weight and fat loss. Twenty-eight men and women (aged 19-42) were assigned to 1 of the following 4 groups: Tae Kwon Do experienced and trained men (ME), Tae Kwon Do experienced and trained women (FE), novice Tae Kwon Do men (MN), and novice Tae Kwon Do women (FN). The results of this investigation indicate that this form of exercise can be performed for an extended period of 20 minutes. All 4 groups achieved the recommended stimulus for effective initiation of cardiovascular adaptations and conditioning. The mean exercise heart rate responses (88.3-92.2% of maximal heart rate [HR max]) were similar for all groups. The observed exercise intensity ranged from 67.9 to 72.1% VO2max, and no significant difference based on the experience and gender and exercise oxygen uptake could be established. Data in this study indicate a high caloric expenditure for this mode of exercise. Total caloric cost of 20 minutes of dynamic Tae Kwon Do, 194.8 and 201.6 kcal for novice women and experienced women, respectively, was significantly lower in comparison with that of their men counterparts (316.5 and 286.5 kcal, respectively), but no significant relationship between experience and energy cost was found. The conclusion of this study indicates that dynamic Tae Kwon Do is an exercise modality that can be appropriately prescribed for cardiovascular conditioning, weight control, and fat loss.

Toskovk et. al (2004) conducted a study on Physiologic profile of recreational male and female novice and experimented Tae Kwon Do practitioners. Results of multiple testing procedures and comparison across groups indicated that Tae Kwon Do black belts were more athletically fit as compared with that of novice Tae Kwon Do practitioners of the same sex in
spite of the fact that male and female black belts were older than their novice counterparts. Experienced Tae Kwon Do subjects were stronger as measured by lower body strength and showed better aerobic performance capacity as well as lower percent body fat. Additionally, MT subjects demonstrated higher flexibility. The highly diverse training, repeated and continuous use of the legs and arms alone or combined with maximal stretching, and high intensity exercise may account for observed differences among groups.

2.6 STUDIES ON ANXIETY AND PERFORMANCE

Miguel Humara, M.A. (2006) examined the Relationship between Anxiety and Performance: A Cognitive-Behavioral Perspective. This paper examines the relationship between anxiety and performance from a cognitive-behavioral perspective. Previous research in the field has suggested that the majority of consultations conducted by sport psychologists are related to anxiety. Included is a discussion on the theoretical underpinnings of anxiety and how it relates to performance. Research conducted on the relationship between anxiety and performance is also discussed. A review of the cognitive-behavioral treatments that have been used for anxiety reduction and performance enhancement within the field of athletics is included. The research indicates that anxiety has a considerable impact on performance. Early research was limited due to a lack of clear operational definitions for the construct of anxiety. The development of the catastrophe model provides future researchers with a theoretical framework for better understanding the relationship between cognitive anxiety and somatic anxiety and their effect on performance. Furthermore, we now have the tools for better understanding the components of anxiety in the athletic context. The development of the CSAI-2 and the SAS allows researchers to reliably measure the following constructs: cognitive anxiety, somatic anxiety, self-confidence, and concentration disruption. Furthermore, the development and increased popularity of multiple baseline
research designs provide a method for examining anxiety reduction interventions through cognitive-behavioral interventions with small sample sizes. Today's managed care environment has led to the development of manualized treatments for many anxiety disorders in clinical populations. Future researchers should focus on the development of manualized treatments within the athletic environment. However, this should be done with a consideration for the athlete's needs if our interventions as sport psychologists are to have their maximum impact.

Pijpers et al (2002) studied the two experiments were conducted to investigate manifestations of anxiety at the subjective, physiological, and behavioral level of analysis. In Experiment 1 we investigated the manifestations of state anxiety at the first two levels by comparing low- and high-anxiety conditions during climbing. Results indicated that anxiety indeed manifested itself at three levels. A possible explanation for the effects of anxiety that is also found in the literature is that a temporary regress may occur to a movement execution that is associated with earlier stages of motor learning.

Raudsepp L (2004) conducted a study on the influence of competitive anxiety and self-confidence state responses upon athletic performance. 66 male beach volleyball players completed the translated and modified Competitive State Anxiety Inventory-2 Players' performance was scored from the video records using a standard rating scale. Correlations indicated scores on Direction subscale of modified Competitive State Anxiety Inventory-2 and Self-confidence were moderately positively (r=.27 to .51) correlated with different skill components and sum of skill components of beach volleyball. Stepwise multiple regressions indicated that, as anticipated, directional perceptions of cognitive and somatic anxiety and self-confidence were significant predictors of beach volleyball performance but accounted for only 42% of variance.
Saral L Elgin (2008) conducted a study on state anxiety of women basketball players prior to competition. The purpose of this study was to use the third version of the Mental Readiness Form (MRF-3) to examine the state anxiety levels of women basketball players prior to a scheduled competitive event. College women basketball players (N=34) from Midwestern colleges were asked to fill out the MRF-3 three hours before (pretest) and again thirty minutes before (posttest) a competitive event. The education level and starter status of each player was used to examine their effects on anxiety levels. A freshman starter was thought to have higher anxiety levels than a sophomore, junior, or senior. Inconsistent with the hypothesis, 4x2 and 2x2 mixed design Analysis of Variances indicated that education level and starter status had no effect on the anxiety levels. A 2x2 mixed design ANOVA indicated the significance of the main effect for starter status with respect to confidence levels (p<.05). Static stretching

According to Susan Milam (2000) an athlete's level of self-confidence is often a determining factor of whether or not he or she has a peak performance. However, an athlete's positive self-confidence doesn't just happen; it has to be developed over many years. It is often the result of a positive learning environment and positive self-talk. A positive learning environment is important in the development of self-confidence because people learn by watching. One way to start building self-confidence is to improve physical skill. Physical skill typically improves through practice. There are two general types of practice that can be used, blocked practice and random practice. With blocked practice, the athlete practices the skills over and over. It is a great technique used for beginners to help build self-confidence. The other type of practice is referred to as random practice, and tends to be used with more skilled athletes. This is where the athlete practices different skills.
Terry et. al., (1995) conducted a study on the Male Shotokan karate players (karateka) (N = 208) who completed the Competitive State Anxiety Inventory-2 and the Profile of Mood States about 40 minutes before a competition. Single-factor multivariate analysis of variance of pre performance mood and anxiety scores indicated significant differences between winning and losing competitors. Winners scored higher on Vigor, Anger, and Self-confidence, and lower on Tension, Depression, Fatigue, Confusion, Cognitive Anxiety, and Somatic Anxiety. Discriminate function analysis showed that 91.96% of participants could be correctly classified as winners or losers on the basis of pre performance mood scores. This figure rose to 93.47% when scores on the anxiety subscales were also included in the discriminant function analysis. Anxiety scores alone produced 78.89% discrimination. Mood profiles for winning karateka were in line with the "mental health" profile of Morgan except for above-average scores on Anger. This result supports the view of McGowan and Miller that anger may facilitate performance in karate competition. The capacity of measures of psychological state to discriminate performance exceeds previous reports, suggesting that karate performance may be exceptionally mood-dependent. These results suggest that interventions which increase scores on vigor and anger and reduce scores on tension, depression, fatigue, and confusion may be particularly efficacious for Shotokan karate performance.

Tsutsumi et al (1997) examined psychological and behavioral adaptations in response to 12-weeks of strength training on medically healthy but sedentary 42 older adults (mean age = 68 years Subjects were randomly assigned to high intensity/low volume (EXH: 2 sets of 8 to 10 repetitions for 75 to 85% of 1 RM), low intensity/high volume (EXL: 2 sets of 14 to 16 repetitions for 55 to 65% of 1 RM), or no exercise control programs. Prior to and following the 12-week program, subjects underwent comprehensive
physiological and psychological evaluations. Physiological assessment included measurements of blood pressure, heart rate, arm and leg muscle strength, body composition, and oxygen consumption (VO$_2$max). Psychological measures included evaluations of mood, anxiety, and physical self-efficacy as well as cognitive functioning. The results of this study indicated that both high and low intensity strength programs were associated with marked improvements in physiological fitness and psychological functioning. Specifically, subjects in the strength training programs increased overall muscle strength by 38.6% and reduced percent body fat by 3.0%. Favorable psychological changes in the strength-trained subjects included improvements in positive and negative mood, trait anxiety, and perceived confidence for physical capability. The treatment effects of neurocognitive functioning were not significant. In summary, this study demonstrated that participation in 12-weeks of high or low intensity strength training can improve overall physical fitness, mood, and physical self-efficacy in older adults while cognitive functioning remains constant.

2.7 STUDIES ON SKILL PERFORMANCE

Baker (2001) examined the effect of an in-season of concurrent training on the maintenance of maximal strength and power in professional and college-aged rugby league football players. Fourteen professional and fifteen college-aged rugby league players were observed during a lengthy in-season period to monitor the possible interfering effects of concurrent resistance and energy-system conditioning on maximum strength and power levels. All subjects performed concurrent training aimed at increasing strength, power, speed, and energy-system fitness, as well as skill and team practice sessions, before and during the in-season period. The college-aged rugby league players group significantly improved 1 repetition maximum bench press (IRM BP) strength, but not bench throw (BT Pmax) or jump squat maximum power (JS Pmax) over their 19-week in-season.
Sawyer et al (2002) studied on the relationship between football playing ability and performance measures. The relationships between football playing ability (FPA) and selected anthropometric and performance measures were determined among NCAA Division I-A football players (N = 40). Football playing ability (determined by the average of coaches' rankings) was significantly correlated with vertical jump (VJ) in all groups (offense, defense, and position groups of wide receiver-defensive back, offensive linemen-defensive linemen, and running back-tight end-linebacker). Eleven of fifty correlations (groups by variables), or 22%, were important for FPA. Five of the eleven relationships were related to VJ. Forward stepwise regression equations for each group explained over half of the criterion variable, FPA, as indicated by the $R^2$ values for each model. Vertical jump was the prime predictor variable in the equations for all groups. Strength and conditioning programs that facilitate the capacity for football players to develop forceful and rapid concentric action through plantar flexion of the ankle, as well as extension of the knee and hip, may be highly profitable.