Chapter II

Review of Related Literature
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REVIEW OF RELATED LITERATURE

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

Markovic Goran and; Newton Robert (2007) conducted a study of effect of plyometric training (PT) on vertical jump height in healthy individuals. Meta-analyses of randomised and non-randomised controlled trials that evaluated the effect of PT on four typical vertical jump height tests were carried out: squat jump (SJ); countermovement jump (CMJ); countermovement jump with the arm swing (CMJA); and drop jump (DJ). Studies were identified by computerised and manual searches of the literature. Data on changes in jump height for the plyometric and control groups were extracted and statistically pooled in a meta-analysis, separately for each type of jump. A total of 26 studies yielding 13 data points for SJ, 19 data points for CMJ, 14 data points for CMJA and 7 data points for DJ met the initial inclusion criteria. PT provides a statistically significant and practically relevant improvement in vertical jump height with the mean effect ranging from 4.7% (SJ and DJ), over 7.5% (CMJA) to 8.7% (CMJ). The results justify
the application of PT for the purpose of development of vertical jump performance in healthy individuals.

Michael et al (2006) conducted a study on The Effects of a 6-week Plyometric Training Program on Agility. The purpose of the study was to determine if six weeks of plyometric training can improve an athlete's agility. Subjects were divided into two groups, a plyometric training and a control group. The plyometric training group performed in a six week plyometric training program and the control group did not perform any plyometric training techniques. All subjects participated in two agility tests: T-test and Illinois Agility Test, and a force plate test for ground reaction times both pre and post testing. Univariate ANCOVAs were conducted to analyze the change scores (post - pre) in the independent variables by group (training or control) with pre scores as covariates. The Univariate ANCOVA revealed a significant group effect $F_{2,26} = 25.42$, $p=0.0000$ for the T-test agility measure. For the Illinois Agility test, a significant group effect $F_{2,26} = 27.24$, $p = 0.000$ was also found. The plyometric training group had quicker 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.
Nicole et al (2004) To evaluate the effects of plyometric training on muscle-activation strategies and performance of the lower extremity during jumping exercises. Twenty healthy National Collegiate Athletic Association Division I female athletes. A pre-test and post-test control group design was used. Experimental subjects performed plyometric exercises 2 times per week for 6 weeks. We used surface electromyography to assess preparatory and reactive activity of the vastus medialis and vastus lateralis, medial and lateral hamstrings, and hip abductors and adductors. Vertical jump height and sprint speed were assessed with the vertec and infrared timing devices, respectively. Multivariate analyses of variance revealed significant ($P < .05$) increases in firing of adductor muscles during the preparatory phase, with significant interactions for area, mean, and peak. A Tukey honestly significant difference post hoc analysis revealed significant increases in preparatory adductor area, mean, and peak for experimental group. A significant $(P = .037)$ increase in preparatory adductor-to-abductor muscle coactivation in the experimental group was identified, as well as a trend $(P = .053)$ toward reactive quadriceps-to-hamstring muscle coactivation in the experimental group. Pearson correlation coefficients revealed significant between-groups adaptations in muscle activity patterns pre-test to post-test. Although not significant, experimental and control subjects had average increases of 5.8% and 2.0% in vertical jump height, respectively. The increased preparatory adductor activity and abductor-to-adductor coactivation represent pre-programmed motor
strategies learned during the plyometric training. These data strongly support the role of hip-musculature activation strategies for dynamic restraint and control of lower extremity alignment at ground contact. Plyometric exercises should be incorporated into the training regimens of female athletes and may reduce the risk of injury by enhancing functional joint stability in the lower extremity.

Kubo et al (2007) conducted a study on the Effects of Plyometric and Weight Training on Muscle-Tendon Complex and Jump Performance. Purpose: The purpose of this study was to investigate the effects of plyometric and weight training protocols on the mechanical properties of muscle-tendon complex and muscle activities and performances during jumping. Methods: Ten subjects completed 12 wk of a unilateral training program for plantar flexors. They performed plyometric training on one side (PT; hopping and drop jump using 40% of 1RM) and weight training on the other side (WT; 80% of 1RM). Tendon stiffness was measured using ultrasonography during isometric plantar flexion. Three kinds of unilateral jump heights using only ankle joint (squat jump: SJ; countermovement jump: CMJ; drop jump: DJ) on sledge apparatus were measured. During jumping, electromyography activities were recorded from plantar flexors and tibia anterior muscle. Joint stiffness was calculated as the change in joint torque divided by the change in ankle angle during eccentric phase of DJ. Results: Tendon stiffness increased significantly for WT, but not for PT. Conversely, joint stiffness increased
significantly for PT, but not for WT. Whereas PT increased significantly jump heights of SJ, CMJ, and DJ, WT increased SJ only. The relative increases in jump heights were significantly greater for PT than for WT. However, there were no significant differences between PT and WT in the changes in the electromyography activities of measured muscles during jumping. Conclusion: These results indicate that the jump performance gains after plyometric training are attributed to changes in the mechanical properties of muscle-tendon complex, rather than to the muscle activation strategies.

Reyment et al (2007) conducted a study of Effects of a four-week plyometric training program on measurements of power in male collegiate hockey players. The purpose of the study was to examine the effects of plyometric training following a 4-week training program on vertical jump height, 40-yard dash, and anaerobic power. Subjects were 17 in number, healthy, Division 3 male hockey players. All subjects were tested in the vertical jump, 40-yard dash, 10-yard dash, and anaerobic power using the Wingate Bike test prior to starting the plyometric program. The subjects then completed a 4-week plyometric training program and were retested. There were significant differences in the mean anaerobic power drop percentage, peak relative power, peak power, right foot vertical jump height, left foot vertical jump height. Overall the findings indicated that two days/week of plyometric training for 4-weeks is sufficient to elicit improvements in single leg vertical jump height and overall power endurance. In conclusion,
plyometric training significantly improves anaerobic power and single leg vertical jump height independent of one another.
Robert et al (2002) conducted a study on the effect of plyometric training on distance running performance. This study examined whether changes in running performance resulting from plyometric training were related to alterations in lower leg musculotendinous stiffness (MTS). Seventeen male runners were pre- and post-tested for lower leg MTS, maximum isometric force, rate of force development, 5-bound distance test (5BT), counter movement jump (CMJ) height, RE, \( V'O_{2\text{max}} \), lactate threshold and 3-km time. Subjects were randomly split into an experimental (E) group which completed 6 weeks of plyometric training in conjunction with their normal running training, and a control (C) group which trained as normal. Following the training period, the E group significantly improved 3-km performance (2.7%) and RE at each of the tested velocities, while no changes in \( V'O_{2\text{max}} \) were recorded. CMJ height, 5BT, and MTS also increased significantly. No significant changes were observed in any measures for the C group. The results clearly demonstrated that a 6-week plyometric programme led to improvements in 3-km running performance. It is postulated that the increase in MTS resulted in improved RE. We speculate that the improved RE led to changes in 3-km running performance, as there were no corresponding alterations in \( V'O_{2\text{max}} \). Plyometrics Running economy Musculotendinous stiffness Distance running.
Kelly Lockwood and Patrick Brophey (2008) conducted a study of the effect of a Plyometrics Program Intervention on Skating Speed in Junior Hockey Players. The present study was designed to look at the effects of a 4-week, eight session, plyometric training program intervention on skating speed. Six male subjects (18.8 ± .98 years) that engaged in the training program completed pre and post 40 meter on-ice sprinting tests. The training group showed significant time improvements (p<.05) in the 40 meter skating distance. The results suggested that plyometric training has a positive effect on skating speed in junior hockey players such that a reduction in on-ice sprinting times is evident.

At the junior level, ice hockey can be characterized by intense bouts of on-ice play lasting up to 90 seconds in duration. Games are made up of three 20 minute periods with typically 12-15 minutes of rest in between periods. Developing muscular strength, power, and speed, in addition to training both the aerobic and anaerobic energy systems have become crucial if players wish to advance to elite levels of hockey (Cox et al, 1995). According to Montgomery (1988), a major difference between junior and professional players is their upper and lower body muscular strength and power. In addition, Greer et al (1992) reported that the fastest skating speeds are seen at the professional level. Therefore, developing muscular strength and speed should be emphasized in training programs for aspiring junior players. Plyometrics are explosive movement exercises which aim to improve both

Plyometrics may be defined as “jumping exercises that involve a rapid deceleration of body mass followed immediately by rapid acceleration of that body mass in an opposing direction” (Wathen, 1993). These jumping exercises force a rebound action known as the myostatic reflex, that elicit the contraction of the both homonymous and synergist muscles while inhibiting antagonist muscles in an effort to produce a fast response to an applied stimulus (Chu, 1984). The myostatic reflex contributes to an increase in muscular force generation due to the effects of voluntary contraction and the involuntary contraction resulting from the reflex itself. The main objective of these hopping and bounding exercises is to convert elastic energy generated by both the force of gravity and body weight during eccentric or lengthening muscle contraction into an opposite force during the concentric or shortening contraction. A lengthening or eccentric contraction followed by a concentric contraction utilizes the elastic energy stored in the muscle during the stretching phase. When released this elastic energy can make a substantial contribution to the efficiency of the muscle contraction resulting in greater power output (Koutedakis, 1989). Muscle spindles located within the muscles react to sudden stretch by sending signals to the spinal cord, resulting in muscular contraction to resist the sudden stretch. Given the above
information, it is understood that plyometric training has the potential to assist help athletes in increasing movement speed and power by developing quicker reaction times.

Research investigating the effects of plyometrics on speed in ice hockey players is somewhat limited. Rimmer and Sleivert (2000) conducted an eight week study to determine the effects of a sprint-specific plyometrics program on sprint performance. Results showed that the plyometric group significantly reduced both their 10m and 40m sprint times. Polhemius et al (1980) looked at the effects of weighted plyometric exercises had on conventional sprint training practices in university level track athletes. Pre and post measures of 40 meter sprint times revealed those participating in the additional plyometric exercises, three times per week for six weeks in combination with their conventional training programs, decreased their 40m sprint times. Plyometric training in both studies was credited for improving the sprinting acceleration phase due to a specificity training response, where ground contact times decreased and force production rates increase. We can therefore hypothesize that because ice contact times and stride force production rates are also critical components in skating at top speed, plyometric training should be able to address these critical components as it did in sprinters. If players are able to decrease contact time with the ice while improving stride force production, the result would be faster, more powerful skating ability, beneficial in all aspects of the game. Therefore the purpose of
this study is to determine the effect of a four week, eight session plyometric program intervention on skating speed in junior hockey players.

Fergenbaum and Marino (2004) conducted a study on The Effects of an Upper-Body Plyometrics Program on Male University Hockey Players. The relationship between plyometrics training, upper-body isometric strength, stick velocity and puck velocity for the slap shot was examined for male university hockey players over 10 weeks. Twenty-one volunteers were divided into either an experimental or a control group. The experimental (plyometrics) group was pre- and post-tested for upper-body isometric strength and slap shot puck and stick velocity. Results showed that puck velocity increased (p<0.05) from pre- to post-testing, with no differences between groups. Stick velocity increased 13% (p<0.05) for the experimental group at post-testing. No significant correlations were found between isometric strength, stick velocity and puck velocity; however, a positive correlation was found between changes in stick velocity (off-ice) and changes in puck velocity (on-ice). Results suggest that plyometrics may improve ballistic coordination between the upper and lower limbs in as little as 6 sessions.

Ronnestad et al (2008) conducted a study on Short-Term Effects of Strength and Plyometric Training on Sprint and Jump Performance in Professional Soccer Players. The purpose of this study was to compare the
effects of combined strength and plyometric training with strength training alone on power-related measurements in professional soccer players. Subjects in the intervention team were randomly divided into 2 groups. Group ST (n = 6) performed heavy strength training twice a week for 7 weeks in addition to 6 to 8 soccer sessions a week. Group ST+P (n = 8) performed a plyometric training program in addition to the same training as the ST group. The control group (n = 7) performed 6 to 8 soccer sessions a week. Pre-tests and post-tests were 1 repetition maximum (1RM) half squat, countermovement jump (CMJ), squat jump (SJ), 4-bounce test (4BT), peak power in half squat with 20 kg, 35 kg, and 50 kg (PP20, PP35, and PP50, respectively), sprint acceleration, peak sprint velocity, and total time on 40-m sprint. There were no significant differences between the ST+P group and ST group. Thus, the groups were pooled into 1 intervention group. The intervention group significantly improved in all measurements except CMJ, while the control group showed significant improvements only in PP20. There was a significant difference in relative improvement between the intervention group and control group in 1RM half squat, 4BT, and SJ. However, a significant difference between groups was not observed in PP20, PP35, sprint acceleration, peak sprinting velocity, and total time on 40-m sprint. The results suggest that there are no significant performance-enhancing effects of combining strength and plyometric training in professional soccer players concurrently performing 6 to 8 soccer sessions a week compared to strength
training alone. However, heavy strength training leads to significant gains in strength and power-related measurements in professional soccer players.

Craig Twist et al (2008) conducted a study on the effects of plyometric exercise on unilateral balance performance. The purpose of this study was to determine the effects of plyometric exercise on unilateral balance performance. Nine healthy adults performed baseline measurements on the dominant limb that consisted of: a 20-s unilateral stability test on a tilt balance board, where a higher stability index represented deterioration in balance performance; isokinetic plantar flexion torque at 0.52 and 3.14 and \( \cdot \) s\(^{-1}\); muscle soreness in the calf region; and resting plantar flexion angle. Plyometric exercise consisted of 200 counter-movement jumps designed to elicit symptoms of muscle damage, after which baseline measurements were repeated at 30 min, 24, 48, and 72 h. Perceived muscle soreness of the calf region increased significantly following the plyometric exercise protocol. Peak torque was significantly reduced after the plyometric exercise protocol, with greater loss of force at the lower angular velocity, while resting plantar flexion angle was not significantly altered compared with baseline values. The stability index was significantly increased above baseline (mean 2.3, \( s = 0.3 \)) at 24 h (3.3, \( s = 0.4 \)), after which values recovered. These results indicate that there is a latent impairment of balance performance following a bout of plyometric exercise, which has implications for both the use of skill-
based activities and for increased injury risk following high-intensity plyometric training.

Leah and Michael Bird (2004) and Faculty Mentor Using Horizontal and Vertical Plyometric Training to Compare Increases in Speed and Vertical Jump Height. This study examined the effect of horizontal and vertical plyometrics on sprint performance and vertical jump height. Varsity athletes’ ages 19-22 years participated in a seven week plyometrics program. One group completed horizontal plyometric exercises (n=26) and one group completed vertical plyometric exercises (n=26). A pretest and posttest included three trials of 40 meter sprints, recording times at 20 and 40 meters, and a vertical jump test. The best height and time for each subject was used for analysis. A repeated measures ANOVA was used to compare the means between pretest and posttest and for interaction effects. All three variables improved significantly from pretest to posttest for the groups (p<0.001), but with no interaction effects (p>0.05). Plyometric exercises may improve both vertical jump height and sprinting speed. It does not appear necessary to train only with vertical exercises for vertical events and horizontal exercises for horizontal events.

Leah and Robinson (2001) conducted a study on Effects of Land and Aquatic Plyometrics of Power, Strength, Speed, and Muscle Damage. The aim of this study is to compare eight weeks of land versus aquatic plyometrics on
power, strength, speed, and injury risk. Plyometrics create improvements in power and speed and enhances the central nervous system. However, plyometrics carry an increased risk of injury due to the intense pliometric (lengthening) contraction, external forces acting on the muscles, bones, and connective tissue, and the impact forces generated at ground contact. Recently, found greater delayed onset muscle soreness in plyometric and pliometric (lengthening) contractions compared to miometric (shortening) contractions. Plyometric training in an aquatic environment could reduce the risk of injury because water provides a “non-impact medium” and produces little strain on the muscle, bones, and connective tissue.

The Proposed experimental study will be conducted with physically active college-age female students (n = 40) with varied sport experience and no previous orthopedic or musculoskeletal injuries to the lower extremities. Participants will be matched on pretest vertical jump and randomly assigned to an 8-week land plyometric or an 8-week aquatic plyometric program. Pre-training assessment will involve administration of questionnaires to measure demographic variables, general medical history, musculoskeletal medical history, and level of physical activity using Parffenbarger Physical Activity Questionnaire, and measurement of height (cm), body mass (kg), percentage body fat, and anthropometric leg measurement (cm). Dependent variables will consist of performance outcome variables and injury risk and will be assessed pre-training, at Week-4 of training, and post-training. Performance outcome
variables are power [vertical jump distance in cm using a vertical (squat jump) jump test], strength [force produced in kg using BIODEX strength testing] and speed [time (sec) for 40-meter sprint]. Injury risk will be estimated using levels of serum plasma creatine kinase as an index of muscle damage and self-report of muscle soreness using an established ordinal scale. The exercise protocols involve three exercise sessions per week lasting 50-55 min. each, including a 10-min. warm-up for 8-weeks. The training protocols are identical except that land plyometrics will be conducted on a gymnasium floor and the aquatic plyometrics will be conducted in 4 to 4 ½ feet of water. The following statistical analyses will be used to analyze the data: 2-way (2 X 3, 2 treatments by 3 times points) multivariate analysis of covariance (MANCOVA) post-hoc, set at a statistical significance of $p > 0.05$.

Timothy Hewett (1996) conducted a study on Plyometric Training in Female Athletes Decreased Impact Forces and Increased Hamstring Torques. The purpose of this study was to test the effect of a jump-training program on landing mechanics and lower extremity strength in female athletes involved in jumping sports. These parameters were compared before and after training with those of male athletes. The program was designed to decrease landing forces by teaching neuromuscular control of the lower limb during landing and to increase vertical jump height. After training, peak landing forces from a volleyball block jump decreased 22%, and knee adduction and abduction moments (medially and laterally directed torques) decreased
approximately 50%. Multiple regression analysis revealed that these moments were significant predictors of peak landing forces. Female athletes demonstrated lower landing forces than male athletes and lower adduction and abduction moments after training. External knee extension moments (hamstring muscle-dominant) of male athletes were threefold higher than those of female athletes. Hamstring-to-quadriceps muscle peak torque ratios increased 26% on the nondominant side and 13% on the dominant side, correcting side-to-side imbalances. Hamstring muscle power increased 44% with training on the dominant side and 21% on the nondominant. Peak torque ratios of male athletes were significantly greater than those of untrained female athletes, but similar to those of trained females. Mean vertical jump height increased approximately 10%. This training may have a significant effect on knee stabilization and prevention of serious knee injury among female athletes.

Ashley et al (2008) conducted a study on the effects of plyometric, sprint, and agility training. Plyometric training has been reported to improve muscle power, linear speed and agility. The purpose of our study was to examine the effects of plyometric, sprint, and agility training on aerobic and anaerobic power, hamstrings to quadriceps isokinetic peak torque ratio (H/Q ratio), muscle power, linear speed and agility. 43 young healthy males without history of plyometric training were randomly assigned to the plyometric (n=15), sprint (n=15) or agility (n=13) group. Each subject participated in pre-
training testing, 2 training sessions per week (3-4 days apart) for 8 weeks followed by post-training testing. The plyometric group preformed Rimmer et al.'s program of spring specific plyometric exercises and the sprint group used Rimmer et al.'s maximal effort sprint training. Agility group followed Young et al.'s protocol, 3-5 changes of direction of 100°. Aerobic power was measured using a grade-incremented, treadmill-running GXT and anaerobic power was measured using the Wingate test. Isokinetic peak-torque data was obtained for the knee extensors and flexors. A multivariate analysis of variance was used to determine whether differences existed between groups. Within each group, paired-T-test with a Bonferroni adjustment tested for significance. Plyometric training resulted in significant improvements in H/Q ratio, muscle power, linear speed and agility. The sprint training group showed significant improvement in linear speed, but not in H/Q ratio, muscle power or agility. Agility training resulted in significant improvements in H/Q ratio, agility and linear speed, but not in muscle power. Aerobic and anaerobic power did not change. Our results found both plyometric and agility training induced positive changes in the H/Q ratio and possibly reduce the risk of non-contact anterior cruciate ligament injury. However, plyometric training is superior to sprint and agility training across the skill related components of fitness.

Kuamg-jung Lu (2007) conducted a study of Effects of Core Muscle Training and Plyometric Training on The Selected Sports Performance in Junior High School Rugby Players. The purpose of this study was to
investigate the Affect of an 8-week core muscle training with plyometric training on junior high school rugby players' motor ability and to investigate whether the core muscle training can improve the Affect of the plyometric training. The subjects were the rugby players in Shin-Men Junior High School, Taoyuan, Taiwan. There were 11 rugby players in the experimental group 1(EG1), 10 rugby players in the experimental group 2(EG2), and 10 rugby players in the control group(CG). EG1 and EG2 had to receive the core muscle training and the plyometric training of 3 days per week for 8 weeks. They did different kinds of motor ability test before, during, and after the above training. CG just had no other additional training but the basic training. Two-way ANOVA mixed design was used to analyze the data of the fluctuation in every motor ability. The alpha level was set at .05.

The findings were the 8-week plyometric training improved the speed and explosive strength of the subjects. The 8-week core muscle training with plyometric training can significantly improve the coordination, speed, and explosive strength of the subjects. The 8-week core muscle training can improve the Affect of the plyometric training. Based on the findings, the 8-week plyometric training can improve every motor ability of rugby players in junior high schools. The 8-week core muscle training with plyometric training had more significant affect. Therefore, if one needs to improve coordination, speed, explosive strength can follow the method we used. And one rugby coach wants to improve these motor abilities of use the method, too.
Gary et al (2004) conducted a study on Neuromuscular Changes in Female Collegiate Athletes Resulting From a plyometric Jump-Training Program. To assess performance changes induced by a 6-week plyometric jump-training program. We used a quasiexperimental design to compare groups formed on the basis of team membership. Testing was conducted in an athletic training research laboratory, both before and after a 6-week period of preseason basketball conditioning. Nineteen female collegiate basketball players from a National Collegiate Athletic Association Division I program (8 subjects) and a National Association of Intercollegiate Athletics Division II program (11 subjects) who had no history of anterior curiae ligament injury and who had no history of any lower extremity injury during the preceding 6 months. The variables of primary interest were hamstrings and quadriceps isokinetic peak torque. Of secondary interest were 5 variables derived from step-down and lunging man oeuvres performed on a computerized force plate system and 4 variables derived from tracking the position of the body core during performance of a T-pattern agility drill with a computerized infrared tracking system. A significant group x trial interaction was found for hamstrings peak torque, and the proportion of total variance attributable to the treatment effect produced by the jump-training program was relatively large. None of the other variables demonstrated statistically significant changes.

Kramer et al (1993) conducted a study onto compare standard (S-weight plus rowing ergo meter training) and standard plus plyometric
(S+P-weight plus rowing ergo meter training, plus plyometric exercises) programs on sport-specific and non sport-specific tests. Twenty-four female rowers completed the weight training or the weight training plus plyometric exercises three times per week and rowing ergo meter training four times per week, 1 hr per session for 9 wks. Analysis of variance tests were used to compare S (n = 11; 5 novice and 6 experienced rowers) and S+P (n = 13; 7 novice and 6 experienced rowers) programs on the following sport-specific tests: 1) time to row 2,500 m and 2) distance rowed in 90 s; and on the following non sport-specific tests: 1) leg press, 1 RM, 2) leg press endurance, 3) bench pull 1 RM, 4) bench pull endurance, 5) vertical jump, 6-9) isokinetic knee extensor peak and average power during concentric and eccentric muscle actions and 10) angle of occurrence of peak torque during concentric muscle actions (isokinetic knee extension). Although experienced oarswomen scored significantly higher than did novice oarswomen on eight of 12 tests (p < 0.04), both levels of rower responded similarly to training. No significant differences were observed post-training between the S and S+P training programs (p > 0.05). These results do not discount the value of plyometric exercises, but indicate that the jump exercises used offered no advantages to intercollegiate oarswomen.

Kathleen Swanik (2002) conducted a study on the effects of shoulder plyometric training on proprioception and selected muscle performance characteristics. The purpose of this study was to determine the effect of
proprioception, kinaesthesia, and selected muscle performance characteristics in female swimmers. Twenty-four female division I swimmers were evaluated before and after a 6-week plyometric training program.

Proprioception and kinaesthesia were assessed for internal and external rotation at 0°, 75°, and 90% of the subject’s maximum external rotation. The Biodex II was used to assess strength characteristics at 60°/s, 240°/s, and 450°/s. Plyometric training sessions (2 times/week) involved 3 sets of 15 repetitions with a trampoline, weighted balls, and elastic tubing. A 2-way analysis of variance revealed significant improvement (P < 0.05) in proprioception at 0° moving into external rotation, as well as 75° and 90% moving into both internal and external rotation. Kinesthesia demonstrated significant improvement for all test conditions after plyometric training. Significant gains in selected muscle performance characteristics included time to peak torque (60°/s and 240°/s), amortization time (450°/s), and torque decrement (240°/s). This study suggests that plyometric activities may facilitate neural adaptations that enhance proprioception, kinesthesia, and muscle performance characteristics. Significant neuromuscular benefits may be attained if they are implemented earlier into shoulder rehabilitation programs (J Shoulder Elbow Surg 2002).
Jeffery et al (2000) conducted a study on Comparison of Dynamic Push-Up Training and Plyometric Push-Up Training on Upper-Body Power and Strength. The purpose of this study was to compare dynamic push-up (DPU) and plyometric push-up (PPU) training programs on 2 criterion measures: (a) the distance achieved on a sitting, 2-handed medicine ball put, and (b) the maximum weight for 1 repetition of a sitting, 2-handed chest press. Thirty-five healthy women completed 18 training sessions over a 6-week period, with training time and repetitions matched for the DPU (n = 17) and PPU (n = 18) groups. Dynamic push-ups were completed from the knees, using a 2-second-up–2-second-down cadence. Plyometric push-ups were also completed from the knees, with the subjects allowing them to fall forward onto their hands and then propelling themselves upward and back to the starting position, with 1 push-up completed every 4 seconds. The PPU group experienced significantly greater improvements than the DPU group on the medicine ball put (p = 0.03). There was no significant difference between groups for the chest press, although the PPU group experienced greater increases.

John et al (2000) conducted a study on Comparison of 1 Day and 3 Days Per Week of Equal-Volume Resistance Training in Experienced Subjects. This study compared 1 day versus 3 days of resistance training per week in recreational weight trainers with the training volume held constant between the treatments. Subjects were randomly assigned to 1 of 2 groups: 1
day per week of 3 sets to failure (1DAY) or 3 days per week of 1 set to failure (3DAY). Relative intensity (percent of initial 1 repetition maximum [1RM]) was varied throughout the study in both groups by using a periodized repetition range of 3–10. Volume (repetitions × mass) did not differ ($p \leq 0.05$) between the groups over the 12 weeks. The 1RMs of various upper- and lower-body exercises were assessed at baseline and at weeks 6 and 12. The 1RMs increased ($p \leq 0.05$) significantly for the combined groups over time. The 1DAY group achieved ~62% of the 1RM increases observed in the 3DAY group in both upper-body and lower-body lifts. Larger increases in lean body mass were apparent in the 3DAY group. The findings suggest that a higher frequency of resistance training, even when volume is held constant, produces superior gains in 1RM. However, training only 1 day per week was an effective means of increasing strength, even in experienced recreational weight trainers. From a dose-response perspective, with the total volume of exercise held constant, spreading the training frequency to 3 doses per week produced superior results.

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

Michaelhl et al (2000) conducted a study on Comparison of the Effects of Three Different Weight-Training Programs on the One Repetition Maximum Squat. This study compares the effects of 3 weight-training programs on the 1 repetition maximum (1RM) squat (SQ). Subjects were 21 college-age men. The criteria for subject inclusion was initial 1RM >110 kg and >1.3 × body mass and the ability to complete >80% of the programmed repetitions. The groups were Group 1 ($n = 5$) 5 × 6RM, Group 2 ($n = 9$)
stepwise periodized model, and Group 3 (n = 7) overreaching periodized model. Groups 1 and 2 were equalized on programmed repetitions (720 and 732), and Group 3 was programmed at 18 and 19.4% fewer repetitions (590). Actual repetitions achieved for Groups 1–3 were 619, 629, and 529, respectively. The 1RM squat was measured before and after 12 weeks. Within-group analysis showed that only Groups 2 and 3 increased significantly (p < 0.05) in the 1RM (kg ± SD). Derived variables were squat (SQ) × body mass$^{-1}$ and SQ gain score × Sinclair coefficient (the method of obviating differences in body mass). Percent differences between groups for Groups 1 and 2 were SQ = 33, SQ × body mass = 53, and Sinclair formula = 33. For Group 3, SQ = 46, SQ × body mass = 67, and Sinclair formula = 109. These data indicate that periodized models increased the 1RM squat to a greater extent than a constant repetition scheme, even when the repetitions were equalized (Group 1 vs. Group 2) or when the repetitions were substantially fewer (Group 1 vs. Group 3).

Ludo et al (1997) conducted a study on effect of an 18-wk weight-training program on energy expenditure and physical activity. The purpose of this study was to examine the effect of an 18-wk weight-training program on average daily metabolic rate (ADMR). Before the intervention and in weeks 8 and 18 (T<sub>0</sub>, T<sub>8</sub>, and T<sub>18</sub>, respectively) data on body composition, sleeping metabolic rate (SMR), food intake, energy cost of the weight-training program (EE<sub>ex</sub>), and nontraining physical activity (accelerometer) were collected in the
exercise group (EXER, n = 18 males). ADMR was determined in a subgroup (EX12, n = 12) by using doubly labelled water. At T₀ and T₁₈, data (except ADMR) were also collected in a control group (Con, n = 8). Body mass did not change in EXER or Con. Fat-free mass increased only in EXER with 2.1 ± 1.2 kg, whereas fat mass decreased in EXER as well as Con (2.0 ± 1.8 and 1.4 ± 1.0 kg, respectively). Nontraining physical activity did not change in both groups. In conclusion, although of modest energy cost, weight-training induces a significant increase in ADMR
Simon and Gabriel (2000) conducted a study on Effects of Squat Lift Training and Free Weight Muscle Training on Maximum Lifting Load and Isokinetic Peak Torque of Young Adults without Impairments. The purpose of this study was to examine the effects of a squat lift training and a free weight muscle training program on the maximum lifting load and isokinetic peak torque in subjects without known neuro-muscular or musculoskeletal impairments. Subjects. Thirty-six adults (20 male, 16 female) without known neuromuscular or musculoskeletal impairments participated. The subjects’ mean age was 21.25 years (SD=1.16, range=20–24). Methods. Subjects were divided into 3 groups. Subjects in group 1 (n=12) performed squat lift training. Subjects in group 2 (n=12) participated in free weight resistance training of their shoulder abductors, elbow flexors, knee extensors and trunk extensors. Subjects in group 3 (n=12) served as controls. The maximum lifting load and isokinetic peak torques of the trunk extensors, knee extensors, elbow flexors, and shoulder abductors of each subject were measured before and after the study. Training was conducted on alternate days for 4 weeks, with an initial load of 80% of each subject's maximum capacity and with the load increased by 5% weekly. All groups were comparable for all measured variables before the study. After 4 weeks, subjects in groups 1 and 2 demonstrated more improvement in maximum lifting load and isokinetic peak torque of the back extensors compared with the
subjects in group 3, but the 2 training groups were not different. The findings demonstrate that both squat lift and free weight resistance training are equally effective in improving the lifting load and isokinetic back extension performance of individuals without impairments.
K. Cullinen (2003) conducted a study on the effects of a weight training program on the resting metabolic rate, fat-free mass, strength, and dietary intake of untrained young women. Design A 12-week weight training program was completed by 20 previously untrained women aged 19 through 44 years. Twenty-three study subjects and 14 control subjects were recruited on a volunteer basis. Twenty study subjects and 10 control subjects completed the study. Interventions Study subjects participated in a 12-week moderate-intensity, progressive resistance weight training program consisting of 2 supervised sessions per week with 6 types of lifting exercises per session. Resting metabolic rate, fat-free mass, strength, and dietary intake were measured before and immediately after the study. Statistical analyses Repeated measures analysis of variance and t tests (unequal variance and paired) were used to determine interaction effects and differences within and between groups. The study group increased their fat-free mass (mean standard deviation) from 44.2±5.4kg to 46.2±6.0kg (P<.001). Elbow flexion, elbow extension, and knee flexion strength all increased from 28.9±5.3 to 34.5±3.8, 16.9±4.9 to 22.1±5.3, and 39.5±8.6 to 48.6±7.3 ft-lb, respectively (P<.001). Percent body fat decreased from 29.8±2.8 to 27.2±2.6 (P<.001) without a significant change in body weight. Resting metabolic rate did not change significantly (P>.05).
Carpenter, David and Nelson (1999) conducted a study on Low back strengthening for the prevention and treatment of low back pain. Chronic low back pain (CLBP) remains one of the most difficult and costly medical problems in the industrialized world. A review of nineteenth and early twentieth century spine rehabilitation shows that back disorders were commonly treated with aggressive and specific progressive resistance exercise (PRE). Despite a lack of scientific evidence to support their efficacy, therapeutic approaches to back rehabilitation over the past 30 yr have focused primarily upon passive care for symptom relief. Recent spine rehabilitation programs have returned to active reconditioning PRE centered around low back strengthening to restore normal musculoskeletal function. Research has shown that lumbar extension exercise using PRE significantly increases strength and decreases pain in CLBP patients. It appears that isolated lumbar extension exercise with the pelvis stabilized using specialized equipment elicits the most favorable improvements in low back strength, muscle cross-sectional area, and vertebral bone mineral density (BMD). These improvements occur with a low training volume of 1 set of 8 to 15 repetitions performed to volitional fatigue one time per week. CLBP patients participating in isolated lumbar extension PRE programs demonstrate significant reductions in pain and symptoms associated with improved muscle strength, endurance, and joint mobility. Improvements occur independent of diagnosis, are long-lasting, and appear to result in less re-utilization of the
health care system than other more passive treatments. Low back strengthening shows promise for the reduction of industrial back injuries and associated costs.

Jaimie Grossnickle (2008) conducted a study on the effect of variable training intensities on total net oxygen consumption during circuit weight-training among college-age women. Among the recent studies that address total net oxygen consumption or TNOC (TNOC = [exercise O2 – resting O2 ] + net recovery O2) following circuit weight-training, few have focused on the effect of variable training intensity (strictly defined as the amount of weight lifted) in which the training volumes (intensity X total repetitions) are equal.

Purpose: This study was designed to monitor the potential differences in TNOC following circuit weight-training under two different intensities, in which training volumes were equal. Methods: Nine physically active, college-age females (mean age = 20.7 yr.) were tested using a 3-station weight-training circuit (seated chest-press, supine leg-press, and seated lat pull down), minimum 3 sets, with one minute rest between sets, under two intensities (70% and 85% of 1 repetition maximum). Training volumes were equated for total pounds lifted by adjusting the intensity, sets, and repetitions during each trial. Trials were conducted in random order, on separate days, with a minimum of 48 hr. between each. VO2 was monitored using a Cosmed™ K4b2 portable system for 15 minutes pre-exercise (resting), during exercise, and post-exercise until VO2 returned to resting values. TNOC
values were significantly higher during 85% intensity trials (9.97 ± 2.36 liters of O2) than 70% trials (8.94 ± 2.66 liters of O2) with higher repetitions in the latter equalizing training volume (P = 0.052). Conclusions: These results suggest that heavier resistance with fewer repetitions creates a greater metabolic demand, relative to TNOC, than lower resistance with more repetitions, despite equal training volumes.

Brown (1986) conducted a study on 13 freshmen and sophomore, high school male basketball players were tested for vertical jump performance before and after 12 weeks of plyometric training. 13 other players engaged in basketball training only and served as control group. Depth jumps are performed from a 50cm bench in sets of 10 repetitions 3 times per week. Depth jumping produced significant greater gains in vertical jump performance. Plyometric training co-coordinated arm movement with leg drive to enhance vertical jump during the basketball season.

Schulte-Edelman et al. (2005) examined the effectiveness of a 6-week plyometric training period on power production of the posterior shoulder and elbow musculature. Twenty-eight normal college-aged volunteers (5 men, 23 women) were divided into control and plyometric training groups. Both groups were pre- and post-tested using shoulder and elbow isokinetic tests and the Closed Kinetic Chain Upper Extremity Stability Test. The plyometric training group (n = 13) showed significant improvement in the power
generated in the elbow extensor muscles; however, no other significant changes were observed within this group. The control group (n = 15) showed no significant changes in power output over the course of this study. It was concluded that plyometric training of the upper extremity enhances power production of the elbow extensor muscles. The authors conclude that plyometrics may help to improve performance in overhead sports that require power.

Cronin and Henderson (2004) conducted a study the purpose of which was to investigate whether changes in maximal strength and power output occurred over time in the absence of strength and power training in novice weight trainers. It also investigated whether differences existed between upper- and lower-body assessments and unilateral and bilateral assessments. The power output and maximal strength (1 repetition maximum [1RM]) of 10 male novice subjects were measured on 4 occasions, each assessment 7-10 days apart. The exercises used to measure the upper- and lower-body strength and power outputs were the bench press and supine squat, respectively. Significant (p < 0.05) changes in unilateral (9.8-16.8%) and bilateral 1RM (6.8-15.0%) leg strength were found, the first assessment being significantly different from all other assessments and assessment 2 significantly different from assessment 4. Changes in the upper body (10-13.6%) were also observed. The only significant difference was between assessment 1 and the other testing occasions. No differences in power output were observed for
both the upper and lower body during the study. It would seem that considerable changes in maximal strength occur rapidly and in the absence of any formal strength training program in novice weight trainers.

Izquierdo et. al (2004) studied the effects of a 16-week training period (2 days per week) of resistance training alone (upper- and lower-body extremity exercises) (S), endurance training alone (cycling exercise) (E), or combined resistance (once weekly) and endurance (once weekly) training (SE) on muscle mass, maximal strength (1RM) and power of the leg and arm extensor muscles, maximal workload (W(max)) and sub maximal blood lactate accumulation by using an incremental cycling test were examined in middle-aged men [S, n=11, 43 (2) years; E, n=10, 42 (2) years; SE, n=10, 41 (3) years]. During the early phase of training (from week 0 to week 8), the increase 1RM leg strength was similar in both S (22%) and SE (24%) groups, while the increase at week 16 in S (45%) was larger (P <0.05) than that recorded in SE (37%). During the 16-week training period, the increases in power of the leg extensors at 30% and 45% of 1RM were similar in all groups tested. However, the increases in leg power at the loads of 60% and 70% of 1RM at week 16 in S and SE were larger (P <0.05) than those recorded in E, and the increase in power of the arm extensors was larger (P <0.05) in S than in SE (P <0.05) and E. No significant differences were observed in the magnitude of the increases in W(max) between E (14%), SE (12%) and E (10%) during the 16-week training period. During the last 8 weeks of training,
the increases in $W(\text{max})$ in E and SE were greater ($P < 0.05-0.01$) than that observed in S (N.S). No significant differences between the groups were observed in the training-induced changes in sub maximal blood lactate accumulation. Significant decreases ($P < 0.05-0.01$) in average heart rate were observed after 16 weeks of training in 150 W and 180 W in SE and E, whereas no changes were recorded in S. The data indicate that low-frequency combined training of the leg extensors in previously untrained middle-aged men results in a lower maximal leg strength development only after prolonged training, but does not necessarily affect the development of leg muscle power and cardiovascular fitness recorded in the cycling test when compared with either mode of training alone.

Fletcher and Hartwell (2004) investigated to determine the effect of a combined weights and plyometrics program on golf drive performance. Eleven male golfers' full golf swing was analyzed for club head speed (CS) and driving distance (DD) before and after an 8-week training program. The control group ($n = 5$) continued their normal training, while the experimental group ($n = 6$) performed 2 sessions per week of weight training and plyometrics. Controls showed no significant ($p > \text{or} = 0.05$) changes, while experimental subjects showed a significant increase ($p < \text{or} = 0.05$) in CS and DD. The changes in golf drive performance were attributed to an increase in muscular force and an improvement in the sequential acceleration of body parts contributing to a greater final velocity being applied to the ball. It was
concluded that specific combined weights and plyometrics training can help increase CS and DD in club golfers.

Izquierdo et al (2001) investigated the effects of 16-wk strength training on maximal strength and power performance of the arm and leg muscles and serum concentrations [testosterone (T), free testosterone (FT), and cortisol] in 11 middle-aged (M46; 46 +/- 2 yr) and 11 older men (M64; 64 +/- 2 yr). During the 16-wk training, the relative increases in maximal strength and muscle power output of the arm and leg muscles were significant in both groups (P < 0.05-0.001), with no significant differences between the two groups. The absolute increases were higher (P < 0.01-0.05) in M46 than in M64 mainly during the last 8 wk of training. No significant changes were observed for serum T and FT concentrations. Analysis of covariance showed that, during the 16-wk training period, serum FT concentrations tended to decrease in M64 and increase in M46 (P < 0.05). However, significant correlations between the mean level of individual serum T and FT concentrations and the individual changes in maximal strength were observed in a combined group during the 16-wk training (r = 0.49 and 0.5, respectively; P < 0.05). These data indicate that a prolonged total strength-training program would lead to large gains in maximal strength and power load characteristics of the upper and lower extremity muscles, but the pattern of maximal and power development seemed to differ between the upper and lower extremities.
in both groups, possibly limited in magnitude because of neuromuscular and/or age-related endocrine impairments.

Chirakkal Sreedharan Nair (1998), a well gurukkal, has written a basic book under the title Kalarippayattu. The author attempts to give historical perspective of the kalarippayattu of Kerala. He views this traditional martial art as part of kerala’s culture. In the context, he refers to the legendary exploits of the great gurukkals of Kerala such as Thacholie Othenan and Aromal Chekavar, Unniarcha in the North and Iravikutty Pillai in the South. Apart from its description of the construction of Kalari in the traditional style, the book refers to the religious values which kalari in the traditional style; the book refers to the religious values, which kalari held high in those days. The book alludes to the prevalent tradition of the worship of Bhadrakali, the Goddess of war, by the people of the state. The book is noted for its reference to the ballads of Kerala which mention the kalari traditions such as Parusakalipattu, Parusamuttu kalarippatt, Margamkalipatt, Chengannur Athi patt, Idanandan patt, Parasurama and kalarippattu. Chitakkal’s book does not discuss the uniqueness of the kalari martial art. Nor does the compare or contrast kalari techniques with other martial arts prevalent in India.

Thattum Maramani Chikilsayum by Kanara Gurukkal (1998) written in Malayalam, deals with vital spot attack in kalarippayattu. The vital spot attack is most deadly form of attack in fighting one’s opponents. It is more
closely related to freehand fighting. It is used more frequently in the Southern Style of kalarippayattu. There are a total of 107 vital sports and all these 107 vital sports are subsumed fewer than 43 general names. Kanara Gurukkal explains that vital sport are located in muscles, bones, tendons, veins, arteries and joints. The secret system of vital sports points to the depth and antiquity of kalarippayattu.

Philip B. Zarilli (1998) has recently published an ethnographic study of kalarippayattu under the title *when the body becomes*. All eyes brought out by Oxford University Press. This ethnographic monograph provides the first comprehensive account of kalarippayattu as an integral part of Kerala’s culture evolving Malayali identity. It is based on extensive interview, fieldwork and personal engagement in long-term training and practice conducted in Kerala in the years 1976-1998. The title of the book sums up the aim of every kalari master to equip his body with maximum efficiency so that one is able to make the body movements as quick as those of the batting eyelids, which have maximum speed to react in their reflex action. In the process the body is able to respond to the opponents moves so quickly as the eyes can see them. However the book does not explain anything much the efficiency of kalarippayattu and the book fails to prove how the body becomes the eyes by a detailed description of kalari technique in comparison and contrast with other martial arts.
Aravindakshan Nair (1997) has contributed a paper on The Ancient Martial Art of Kerala at the World Malayalam Conference held in 1977. His study is valuable for the following points. He establishes a relationship between the kalarippayattu, kathakali and other folk arts of Kerala. He observes that dramatic and cultural performances like kathakali, Theyyam, Chavittu Nadakam, Velakali are the variations of kalarippayattu. He points out the kalarippayattu lost its significance when the British came to India and used the guns in the warfare. He explains the relationship with massage or uzhichil and kalarippayattu, it is meant to give the body suppleness and agility.

The Kalarippayattu - The Martial Art of Kerala by K.K.N.Kurup and K. Vijayakumar (1997), published by Department of Public Relation Government of Kerala, offers a brief account kalarippayattu. The book is written with a view to introducing martial art to the foreign scholars who want to further investigate Kerala’s martial traditions. The book begins with a discussion of the social background of the ancient South India, which made kalarippayattu possible. He speaks of ankam culture in the Kerala of the first five centuries after the birth of Christ, which was basically a heroic period. Justice was determined in favour of the winner or the winner’s party. He also speaks of the role of Nair community in developing kalarippayattu in the state of Kerala. However the contribution of the members of other communities like Muslims and Christians is left out, a point to which Philio B. Zarrilli
refers. One of the interesting aspects of the book is the author's discussion of the relationship between kalarippayattu and folk arts of Kerala. The institution of the kalari had influenced many of these performing folk arts. He observes that Kalarippayattu influences the kathakali. Both the Kalarippayattu trainee and the kathakali artist undergo the same kind of physical training such as oil massage or uzhichil. Stretching legs to both sides and sama suchi is an essential training for a kalari combatant and a kathakali artist. Body movements are essential for an artist as well as for a kalari combatant. This brief fifty five page monograph is a short handbook for ready reference to kalarippayattu. However the authors Kurup and Vijayakumar take for granted the uniqueness of kalarippayattu and do not try to prove it in contrast and comparison with other martial art forms.

Balakrishnan's (1995) Kalarippayattu the Ancient Martial Art of Kerala, published by C.V.N. Kalari, Trivandrum, describe different facets of kalarippayattu especially its various techniques. The book is based on his own experiences as a kalari-trained master. He has taken pains in tracing the origin and development of kalarippayattu. Particular interest is his description of the use of various weapons in the kalari system and the way they are used in several techniques. He starts with discussion of Meippayattu. Meippayattu is a series physical exercise enabling a person to attack and defend himself. Meippayattu helps one acquire maximum ability, suppleness and ability to turn and twist the body in every conceivable manner or bound in the air with
ease. He divides Meippayattu into eight leg exercise, eight poses of vadvus and five foot positions or chuvadus. Of the weapons, kettukari, cheruvadi, otta and gadha are the main division. He also speaks of metallic weapons or ankathari. They consist of dagger, sword and shield, spear and urumi. Verumkaiprayogam or free hand fighting is the last phase of the kalari training. Balakrishnan makes a clear discussion of the kalarippayattu, kathakali and other folk arts of Kerala. He observes that dramatic and cultural performances like kathakali, theyyam, chavittu nadakam are the variations of kalarippayattu. He point out that kalarippayattu lost its significance when British came to India and used the guns in the warfare. He explains the relationship with massage or uzhichil and kalarippayattu, it is meant to give the body suppleness and agility.

Kalarippayattu is one of the oldest living traditions of martial training in Kerala. The martial training and self-discipline through a ritualistic and spiritual process of learning is synthesis in the kalarippayattu tradition, which found its roots in Kerala. The word kalari signifying the training premises is derived from Sanskrit term “Khaloorika” which stands for military training group.

There are certain types of jumping exercise used in kalarippayattu trainess to get the leg power and jumping ability. There are 1 Thirinchuchadal 2 Chavitti pongal 3 Thirinju pongal 4 vaangi thirinchu chadai 5 Vaiathu
chavitty edmpiri malannu chadal, 6 Edathu chavity valathamalannu chadal. These exercises were definitely contributing positively in the vertical jumping ability of kalarippayattu.

Richardson Freeman's (1991) recent research on the nature of teyyam worship in North Malabar to which kalarippayattu practice and martial heroes are integrally linked, it is clear that, for the medieval Malayali practitioners of kalarippayattu, the "world" within which they exercised their martial skills was shaped by a religious and socio-political ideology in which "battle serves as a dominant metaphor for conceptualizing relations of spiritual and

Shaji John (2007) considered Kalaripayattu one of the most ancient martial art forms in the world, Kalaripayattu traces its roots back to the state of Kerala in South India. Finding a mention in texts as ancient as the Sangam literature (dated between the years 200 BCE and 300 CE), Kalari encapsulates body controlling exercises, breathing and meditation techniques, kalari weapon training and self defence techniques. Broadly divided into the northern, central and southern styles, Kalari is characterised by several stages of training. Meithari is the first stage with rigorous body exercises, like the meippayattu exercises for balance and flexibility; Kolthari is the second stage, where the student is introduced to fighting with wooden weapons, like the long stick (Kettukari staff), short stick (Muchan) and a short curved stick (Otta); Ankathari involves fighting with metal weapons like daggers, swords
and shield; and the final stage is Verumkai, which is bare-handed techniques of combat. Kalaripayattu also includes the science of Kalari massage and Marmam or Marma Adi. Marmam defines the susceptible parts of the human body, which when attacked or touched can prove fatal, while Kalari massage is used to treat muscle injuries.

Chandran and Kesava (2004) Kalaripayattu, an ancient traditional martial art form of Kerala, is considered as the basis for all martial arts viz. Karate, Kungfu, etc. physiological studies are more concentrated on Karate, Kungfu and other martial arts due to their global acceptance. Considering the limited knowledge available regarding the physiological profiles of Kalaripayattu practitioners, the present study was taken up for filling the lacunae in the field. Lung function tests were carried out in ten Kalari practitioners. Residual volume was measured by indirect method. Higher lung volumes and flow rates were achieved in Kalari practitioners compared to age and height-matched controls. Better mechanical factors and lower airway resistance influenced during Kalari practice might have benefited in improving hung volumes and flow rates.