CHAPTER II

REVIEW OF RELATED LITERATURE
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A review of literature related to the study of physical and motor performance correlates of spike jump and block jump in volleyball available in the library of Netaji Subhash National Institute of Sports, Patiala, Lakshmibai National College of Physical Education, Thiruvananthapuram. Netaji Subhash Southern Centre, Bangalore, Lakshmibai National Institute of Physical Education, Gwalior and from the internet have been presented in this chapter in an abstract form to provide the background material to evaluate the significance of this study as well as to interpret its significance.

Deane, et.al., (2005) investigated the effects of hip flexor training on sprint, shuttle run, and vertical jump performance. This study aimed to determine whether a hip flexor resistance training performance could improve performance on a variety of tasks. Thirteen men and eleven women completed an 8 week hip flexion resistance training programme, eleven men and thirteen served as controls. Isometric hip flexion strength, 40 yards, 4 x 5.8 meter shuttle run time, and vertical jump height were evaluated at the beginning and end of the training. Improvements were observed in the training group but not in the group,
Individuals in the training group improved hip flexion strength by 12.2% and decreased their 40 yards and shuttle run times by 3.8% and 9.0% respectively. An increase in hip flexion strength can help to improve sprint and agility performance for physically active, untrained individuals. The hypothesis that the hip flexor resistance training would significantly improve counter movement jump performance was not supported.

Cronin, John B and Hansen, Keir T., (2005) identified the relationship between strength and power and measures of first step quickness (5 meter time), acceleration (10 meter time), and maximal speed (30 meter time). The maximal strength (3 repetition maximum [3RM]), power (30kg jump squat, countermovement jump, and drop jump), isokinetic strength measures (hamstring and quadriceps peak torques and ratios at 60 degrees/second and 300, degrees/second) and 5meter, 10 meter, and 30 meter sprint times of 26 part time and full time professional rugby league players (age 23.5 + - 3.3 years) were measured. To examine the importance of the strength and power measures on sprint performance, a correlational approach and a comparison between means of the fastest and slowest players was used. Correlation between the jump squat (height and relative power
output) and countermovement jump height and the 3 speed measures were significant ($r = -0.43$ to -0.66, $p<0.05$). The squat and countermovement jump heights as well as squat jump relative power output were the only variables found to be significantly greater in the faster players.

Stockbrugger and Haennel (2003) examined the factors contributing to performance of a backward overhead medicine ball throw across 2 types of athletes. Twenty male volleyball players (jump athletes) and twenty wrestlers (non jump athletes) were evaluated on 4 measures of power, including, chest medicine ball throw, countermovement jump, and power index. The athletes also completed 3 measures of strength: a. 1-repetition maximum, bench press, repetition maximum leg press, and combined bench press plus 1-repetition maximum leg press strength. Jump athletes demonstrated greater absolute scores for countermovement jump, chest medicine ball throw, and backward overhead medicine ball throw ($p<0.05$), where as non jump athletes demonstrated greater strength scores for bench press and for bench press plus 1-repetition maximum leg press ($p<0.05$). When performances were examined on a relative basis, jump athletes achieved superior scores for chest medicine ball throw.
(p<0.05), whereas non jump athletes had greater scores for bench press, 1-repetition maximum leg press, and bench press plus 1-repetition maximum leg press (p<0.05).

Caruso et al., (2003) examined the impact of two predictor variables (estimated knee extensor fast-twitch fiber percentage, body mass) on performance measures (vertical jump, power output, leg press peak angular velocity). 25 men and 27 women performed 5 workouts involving 2 vertical jump, leg press, 50 repetition isokinetic tests (to estimate knee extensor fast-twitch fiber percentage). Multivariate regression determined the following significant (p<0.05) vertical jump equations: predicted male power output = -59.3464 + 1.566 (estimated knee extensor fast-twitch muscle fiber percent) + 15.7884 (body mass), predicted female power output 36.1576 - 3.4248 (estimated knee extensor fast-twitch muscle fiber percent) + 9.8633 (body mass). Leg press peak angular velocity equations were insignificant by gender.

Stone et al., (2003) investigated the relationship of the 1 repetition maximum (1RM) squat to power output during countermovement and static weighted vertical squat jumps. The training experience of subjects (N=22) ranged from 7 weeks to 15+ years. Based on the 1RM squat, 22 subjects were further divided into 5
strongest and 5 weakest subjects. Squat jumps were performed with a countermovement or statically at 2 different sessions spaced 1 week apart. Jumps were performed with weights ranging from 10 to 100% of the 1 RM squat. A maximum effort was made for each trial; subjects performed jumps (feet left the floor) with weights up to approximately 90% of 1RM. Squat jump power was determined using the V-scope 120. Results indicate strong correlations ($r = 0.77$ to 0.94) between the 1 RM squat and both countermovement and static jump power up to 90% of 1 RM. The highest power outputs for both jump conditions occurred at 10% of the 1 RM and decreased as the relative intensity increased, comparison of weak and strong subjects indicates that as maximum strength increases the percentage of 1 RM at which peak power also increases (40 vs. 10% of 1 RM).

Lees, Vanrenterghem and Clercq (2004) investigated the contribution that each of the major lower limb joints makes to vertical jump performance as jump height increases and to comment on the previously mentioned uncertainty. Adult males ($N = 20$) were asked to perform a series of sub maximal (LOW and HIGH) and maximal (MAX) vertical jumps while using an arm swing. Force, used and electromyographical data were recorded during each performance and
used to compute a range of kinematic and kinetic data, including ankle, knee, and hip torques, powers, and work done. It was found that the contribution to jump height made by the ankle and knee joints remain largely unchanged as jump height increases and that superior performance in vertical jump is achieved by a greater effort of the hip extensor muscles. It was concluded that the role of submaximal and maximal jumps can be differentiated in terms of their effect on ankle, knee, and hip joint muscles.

Ugarkovic, et.al., (2002) examined anthropometric measures, maximal vertical jump, maximal isometric voluntary force, and force development of hip and knee extensors of 33 elite male junior athletes to predict maximal vertical jump performance. Standard anthropometric and body composition measures included height, lean body mass, as well as the percentage of fat and muscle tissue. Except maximal isometric forces, all correlation coefficients between the selected variables and jump heights were insignificant. As a consequence, the corresponding multiple correlation coefficient, R=0.71, also suggested a moderate predictability of jumping performance by the standard strength tests and anthropometric and body composition variables. The results are in line with the concept
that a reliable performance assessment in homogeneous groups of athletes requires predominantly movement specific testing.

Weiss and Fry (2002) explored the possibility of predicting vertical jumping performance from explosive strength deficit. Variables predictive of vertical jumping performance can account for only part of its total variability. A potential additional source of variation called Explosive Strength Deficit (ESD) was described in 1995 by Zatsiorsky (Science and Practice of Strength Training. Champaign, IL,: Human Kinetics, 1995,pp.34-35.). ESD is determined by measuring the maximum force generated under ideal circumstances and under task-relevant conditions (Fm). Data were analysed using forward stepwise multiple regression. Mean ESD for men was 29.7 % (SD = 11.7) and for women was 49.3% (SD=11.2). Zero order correlations for ESD with Restricted Vertical Jumping (RVJ) distance were -0.35 and -0.63. However, when the previously identified predictors were taken into account, ESD was not a significant predictor (p>0.05) of either type of jump. Therefore, it was concluded that ESD on the basis of velocity regulated squats does not augment the explained variance previously established for vertical jumping performance.
Young, Macdonald, and Flowers (2001) conducted a study to determine the validity of vertical jump tests for assessment of leg extensor muscle function. Twenty eight men were assessed on tests of shoulder power, leg extensor muscle function, and vertical jump performance using jumps performed from a standing position, a three stride run up, and double and single leg take offs. A shoulder and hip flexor training group (n=14) improved significantly more than a non-training control group (n =12) in shoulder power and vertical jump performance tests, but not in the test of leg extensor muscle function. It was concluded that the arm swing and free leg drive significantly influence vertical jump performance and therefore, vertical jump tests are not valid for assessment of leg extensor muscle function.

Hennessy, Liam and Kilty, James (2001) assessed the relationship of long and stretch-shortening cycle test scores to sprint performances in trained female athletes. Seventeen trained, females from high school, competitive sprinters completed the following tests: countermovement jump for vertical distance, bounce drop jump for height with minimum ground contact time, and ground reaction time during the bounce drop jump for height with minimum ground contact time and a 5 step bound test. Sprint performances at 30, 100, 300
meter distances were assessed. Significant correlations (p<0.05) existed between countermovement jump for vertical distance and 30 meter (r = -0.60), 100 meter (r = -0.64), and 300 meter (r = -0.55) sprint times. Multiple regression analysis found significant T values for BDJ index with 30 and 100 meter sprints and CMJ and PF with 300 meter. Result indicated that the countermovement jump for vertical distance test was significantly related to sprint performance.

Theoharopoulos, et.al (2000) evaluated professional basketball players' concentric strength of knee extension and flexion and the full range of motion, using an isokinetic dynamometer at 60 and 180 degrees per second. The sample consisted of 12 male basketball players, all members of the same professional basketball team that has players in all playing positions. According to the results, there was no statistically significant difference between the dominant and non-dominant limb on the measure of peak torque, peak torque per body weight, work per repetition, and work per repetition to body weight ratio. There was a statistically significant increase in the ratio of peak torque in concentric flexion and extension of the knee with the increase in velocity. At the velocity of 180 degrees per second in flexion and extension, the values of peak torque and peak torque per
body weight demonstrate greater strength in the non dominant limb in relation to the dominant. These results provide information about the existing relation between the dominant and the nondominant limb and the relation of flexors and extensors in concentric action, which seems to increase with the increase of velocity.

Unger, Caroline L., and Wooden, Michael J, (2000) selected 15 subjects, 21 to 62 years old and conducted a 6 week toe flexor strengthening programme using the archixerciser. Pre and post training data for toe strength, vertical jump height simultaneously using the just jump and vertex, and horizontal jump distance were collected for both control and exercise legs. Post-hoc paired sample t-tests (p<0.05) indicated significant improvement in all categories. This supported the hypothesis that the unconventional method of strength training the toe flexors should be considered a valuable adjunct in a training programme designed to enhance vertical and horizontal jump ability. The relationship of different testing methods was also assessed. A Pearson correlation coefficient showed a significant (0.001 level) correlation when simultaneously using vertex and just jump to quantify vertical jump performance. A significant (0.01 level) correlation between individual performance
in the vertical and horizontal jump was also identified.

Baker and Nance (1999) investigated the relationship between running and common strength and power tests, in absolute terms and in relation to body mass. Twenty professional rugby league players were assessed for 10 and 40 meters running speed, maximum strength in a three repetition maximum squat and three repetition maximum powers clean from the hang, and leg power. Power was assessed by the Plyometric Power System (PPS) during the barbell jump squats with loads of 40, 60, 80, and 100 kg. The result indicated, while 10 and 40 meters sprint performances were highly related (r =0.72), there still remains considerable variation in the factors that contribute to the performance over each sprint distance. Although no absolute strength or power score was significantly related to either sprint performance, almost all scores relative to body mass were significantly related to sprint performance. For 10 meter sprint, the significant relations ranged from r=0.52 to r=-0.61. For the 40 meter sprint, the significant relations ranged from r = - 0.65 to r = -0.76.

Weiss, et.al, (1997) developed two equations to predict distance in a Restricted standing Vertical Jump (RVJ). Body composition and strength related variables generated via velocity spectrum squats were
obtained on 52 men and 50 women. Eight squat variables at four velocities were selected as potential predictors of RVJ performance. These variables along with body fat, body weight, and gender were used to generate two explanatory regressions. R values ranged from 0.80 to 0.83. Variables with a positive relationship to RVJ were relative peak power at each individual's optimal velocity for power production and at 1.43 m/s. Variables with negative relationship were relative peak force and percentage of fat. It appears that (a) the more relative squatting power a person can generate at moderately fast squatting velocities, the greater the RVJ distance and (b) excessive body fat and the ability to generate high relative squatting forces at slow velocities reduce the predicted distance.

Johnson, Doug L., and Bahamonde, Rafeal (1996) devised a simple mechanical power formula for both peak and average power using a countermovement jump and reach test from a force platform. College athletes (49 females and 69 males) were measured for height, weight, thigh circumference, thigh skin fold, thigh length, and fore leg length. A vertex was used to measure vertical jump height, and the force platform was used to help determine power output. Eight anthropometric measurements, vertical jump height, and gender were
used in a stepwise multiple regression to develop the prediction equations. Vertical jump height, mass, and body weight were significant variables selected by stepwise multiple regression to predict both peak and average mechanical power, accounting for 91 and 82% of the variance in peak and average power output, respectively.

Ashley, Candi D, and Weiss, Lawrence W, (1994) investigated the association between two countermovement vertical jumps and variety of structural and functional musculoskeletal variables in fifty healthy university women. A squat incorporating restricted upper body motions served as the countermovement preceding the first style of jumping, while the second jumping style involved a depth jump with unrestricted upper body motions. Also nine functional measurements for each of six isokinetic squat speeds ranging from 25 to 100 degree/second were obtained. The squat exercises were modifications of previously reported protocols, therefore the reliabilities of all 54 measurements were assessed prior to their use as potential factors associated with jumping ability. Reliability coefficients ranged from very high to moderate, except for rise time at 180 degrees/second and peak hold time at 25 degrees/second being
low, all force and power variables were significantly correlated with jumping performance.

Smith, Roberts and Watson (1992) compared teams at the two uppermost levels of men's volleyball in Canada for differences in physical, physiological and performance characteristics. The subjects were members of the national (n=15) and university teams (n=24). The parameters examined included percent body fat, maximal oxygen in (Vo2 max), anaerobic power, bench press, 20 meters sprint time and vertical jumping ability. The only significant difference in physical characteristics between two teams was age. Despite similarities in standing and reach height, the national team players had significantly higher block (3.27 vs 3.21 m) and spike (3.43 vs 3.39 m) jumps. An evaluation of anaerobic power measures produced similar power outputs during a modified wingate test, yet the national team members had higher scores for spike and block jump differences as well as 20 meters sprint time. The large aerobic component of elite volleyball play was supported by the high V02 max value recorded for the national team players (56.7 vs 50.3 m 1kg^{-1} min^{-1}). The results suggest that either years of specific physical conditioning and playing or the selection of individuals to the national team who possess more
desirable characteristics as a consequence of genetic endowment, plays a significant role in the preparation of volleyball players of international caliber.

Wenzel and Perfetto (1992) investigated the effect of speed training versus strength training approach in power development. It was hypothesised that a speed training programme would be more efficient in power development than a strength training programme. Sixty five football players participated in an off season weight training programme. All lifted three times per week and used the same programme with one exception. Fifteen athletes performed a timed sled programme, while the remaining 40 athletes performed a squat programme designed to develop strength. The Margaria Kalamen (M.K) power test was used as a measure of power in watts. Baseline and follow up weight/height, power clean, push press, squat and vertical jump measures were recorded. Using group comparison and paired T-tests, and analysis of covariance and ordinary least squares mathematical modeling procedures, no difference could be found between the two groups on any of the measures. Modeling was used to test the effect of the training group on power development. While controlling for initial differences; no differences in training effect
were found. It was concluded that while speed training was not found to be superior to strength training, it could be an equivalent substitute. Future studies should evaluate a combined speed and strength approach for maximum efficiency in power development.

Harman, et.al., (1991) investigated the success of utilising a variety of different motor and physical ability measures to predict volleyball performance in a game situation. Eighteen female volleyball players were assessed for reaction time. Response time, visual activity, contrast sensitivity, anaerobic capacity and power, agility, vertical jumping, ability and basketball throwing ability. These predictor variables were tested within one week prior to the first day of competition and all tests were collected in a single session. Performance evaluation was carried out over a period of four weekends of tournament play. Volleyball match play was videotaped and later evaluated by an evaluator. A five point index and evaluation was constructed for the skills of serving, setting, blocking, attacking, serve reception, and digging. The physical and motor ability measures were entered into a stepwise multiple regression to assess the strength of predicting each of the volleyball performance variables. Significant prediction equations (p<0.05) were developed for the skills of serving
(R=0.53), blocking (R=0.74), attacking (R=0.69), digging (R=0.59), and serve receiving (R=0.64). No significant prediction equation could be constructed for the skill of setting. Visual contrast sensitivity was found to be the single best predictor for the performance of digging and the maximum vertical block jump was the best predictor for blocking success. Success in attacking, serve receiving, and serving was best predicted using results from the anaerobic capacity and power test (Wingate protocol). These findings suggest that there are specific parameters which might be used to predict success in women's volleyball at the collegiate level.

Fry, et.al., (1991) monitored fourteen female NCAA division 1 collegiate volleyball players during a 12 week off season strength and conditioning programme. Physical characteristics included age, height, weight, training included resistance exercises, plyometrics, aerobic endurance exercise and on court volleyball practice. At the beginning of the study, starters (n=6) were compared with non-starters (n=8), and were found to be faster, more flexible and stronger, Starters were still stronger when one Repetition Maximum (1RM) values were, correlated for Fat Free Mass (FFM). Ten subjects completed the 12 week strength and conditioning programme and participated in the post training tests.
Starters and non-starters responded similarly to the training programme for all physical and performance tests. Significant improvements were observed for, vertical jump, shoulder flexibility, 1RM strength and for the isokinetic leg extension torque at 1.05 and 3.14 radians/sec. Shoulder flexibility was increasingly related to sport specific isometric strength. Isokinetic testing did not reflect the magnitude of changes in 1RM tests.

Alan (1989) compared the relationships among isometric, isotonic and isokineic concentric and eccentric quadriceps and hamstring force and athletic performance measured by 40 yard dash time, vertical jump and agility run time. Peak and average quadriceps and hamstring forces were measured by using a Kin Coo for each method of strength assessment. Force per body weight (f/bw) data were determined for each subject. The f/bw data was entered into a regression equation in a step wise fashion with each performance measure to determine which force f/bw measure or measures best predicted 40 yard dash time, vertical jump and agility run time. The force which was the best predictor for 40 yard dash time was the right peak isokinetic concentric hamstring force at 60 degrees/second (R= 0.570). There were no significant (p> 0.05) correlations between any measured force and vertical jump.
Viitasalo (1982) examined fourteen Finnish and ten Russian elite male volleyball players for their anthropometric dimensions, maximal isometric trunk extension and flexion, leg extension strength and vertical jumping height. In addition, the height of rise of centre of gravity of the body (C.G), and the height of the hand and ball were analysed from a video tape in spike and block jumps taken during actual competition. The two teams were found to differ significantly in the height of centre of gravity during a vertical jumping test where a preliminary counter movement was allowed and in the lengths of lower limbs and legs; the Russian volleyball players jumped higher and had longer lower extremities. In actual competition, the hands of the Russian players while performing a spike were on the average ten centimeters higher than the hand of the Finnish players.

Mayhew, et.al, (1981) evaluated fifty three football players to determine the contributions of speed, agility and body composition to anaerobic power output. Speed was evaluated from the 10 and 40 yard dashes. Agility was measured from a specifically designed pattern requiring change of direction, Body imposition was estimated from skinfolds using general and sports specific equations. Power was determined from the Margarita- Kalumna stair run test. Body weight
made the biggest contribution to power estimation ($r = 0.82$). Ten yard dash speed ($r = 0.16$) and agility ($r = 0.21$) made only minor contributions to power output; however, when the effect of body weight was removed statistically, faster ($r = -0.54$) and more agile ($r = -0.31$) players produced greater power outputs, The relationship between strength as measured from the bench press, and power ($r = 0.68$) was reduced substantially when controlled for the effect of body weight $= 3.33$. Multiple regression analysis indicated that body size and speed were the major contributing factors to power production.

Shoaled, (1971) identified the physical and anthropometric traits possessed by successful volleyball players. An initial group of 23 tests and measurements was selected to measure the characteristics of a successful player. A jury of four judges served to provide the criterion which was overall volleyball performance. 93 subjects completed all 23 items. Statistical techniques utilised provided inter correlation coefficient of the independent variables, correlation coefficients between the independent variables and the dependent variable, step wise regression coefficients and constants, and the square of the multiple correlation coefficients for the regression equation at each step. Reliability coefficients of all items were computed by using extra class correlation
technique. Power appeared to be the most significant factor and strength did not seem to be a factor in successful volleyball performance.

Smith, David J., Strokes, Shelly and Brad, Kilb (1987) examined the effect of semi accommodating resistance training on isokinetic and performance measures of female volleyball players. Ten intervarsity players participated in the training programme in addition to their volleyball practice schedule; A control group of five players participated in volleyball practice only. The training programme consisted of 10 second exercise intervals and 10 second rest intervals at six speed settings on each of three upper bodies and three lower body semi-accommodating resistance devices. The players performed the resistance training three times per week during the first three weeks and twice per week during the second three weeks. The control group did not demonstrate significant improvement on any of the parameters measured. The experiment group, however, demonstrated significant improvement in the block jump and knee extension at 180 degrees/second over the training time.