CHAPTER II

REVIEW OF RELATED LITERATURE

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

The researcher came across several books, periodicals and journals and published thesis, while searching for relevant facts and finding that were related to this present study, such as those were given below or the better understanding and to justify the study.

2.1 STUDIES AMONG NETBALL PLAYERS
Kausar A et.al (2016) compared aerobic capacity of university volleyball players from the region with that of matched sedentary controls. The secondary objective was to compare the findings with the aerobic capacity data reported in literature for the volleyball players and sedentary population. Sample size was calculated for detecting a large effect size (Cohen's $d = 0.8$) with $\alpha$ as 0.05 and power of study as 80% for two tailed hypothesis testing. By using Queen's college step test, VO2 max was measured in 30 male volleyball players in the age group of 20 to 25 years and was compared with 30 age and socio-economic status matched controls with sedentary lifestyle. The mean predicted VO2 max was $52.99 \pm 5.13$ ml/kg/min in volleyball players and $37.01 \pm 3.94$ ml/kg/min in controls. The difference in mean values of VO2 max (ml/kg/min) in volleyball players and controls was statistically highly significant with p-value less than 0.001. The volleyball players showed a superior aerobic capacity compared with age and socio-economic status matched controls with sedentary lifestyle.

Trubachev VV et al. (2015) studied of cardiorespiratory coupling by method of paced breathing and the analysis of heart rate variability in men. Heart rhythm of 14 athletes and 12 non-athletes, 21 ± 1.4 years old, was registered in 3 minute sessions during spontaneous and paced breathing 14, 10, 9, 8, 7, 6, 5, 4 times/minute. The subjects were following breathing rate from a display. Initial heart rate being more slow in athletes ($p < 0.05$) was retained during episodes of controlled breathing. The power of FFT spectra peaks of RR-intervals was growing quasilinearly during reduction of breathing rate, reaching its peak value at 5-4 breaths/minute in athletes. More pronounced modulations of RR intervals were observed in HF spectral band ($p < 0.05$) of athletes breathing 14-10 times/minute compared to non-athletes. The power of LF band of the spectrum in athletes breathing 8-4 times/minute was 2 times higher: variability of RR-intervals "shrunked" accordingly to paced breathing rate. The dominant role in slow oscillations
of heart rate manifested by paced respirations with involvement of vagus baroreflex afferentations of lungs and chest is hypothesized to be the consequence of breathing under attentional control.

Grabara M (2015) documented that due to high training loads and frequently repeated unilateral exercises, several types of sports training can have an impact on the process of posture development in young athletes. The objective of the study was to assess and compare the postures of adolescent male volleyball players and their non-training peers. The study group comprised 104 volleyball players while the control group consisted of 114 non-training individuals aged 14-16 years. Body posture was assessed by the Moiré method. The volleyball players were significantly taller, and had greater body weight and fat-free mass. The analysis of posture relative to symmetry in the frontal and transverse planes did not show any significant differences between the volleyball players and non-athletes. Postural asymmetries were observed in both the volleyball players and the control participants. Lumbar lordosis was significantly less defined in the volleyball players compared to non-training individuals while no difference was observed in thoracic kyphosis. All athletes demonstrated a loss of lumbar lordosis and an increase in thoracic kyphosis. Significant differences in anteroposterior curvature of the spine between the volleyball players and the non-athletes might be associated with both training and body height. Considering the asymmetric spine overloads which frequently occur in sports training, meticulous posture assessment in young athletes seems well justified.

Mielgo-Ayuso J et.al. (2014) analyzed the anthropometric and physical performance profiles of elite female volleyballers, to determine any differences in these features among different playing positions. A further aim was to examine any relationship between anthropometric measures and measures of performance. This study assessed 42 female
professional volleyball players (Age: 27.2±5.4 years). Players were categorized according to playing position: middle blockers (n=12), opposite hitters (n=6), outside hitters (n=12), setters (n=8), and liberos (n=4). Anthropometric measurements assessed were: height, weight, fat mass (5 skinfolds) musculoskeletal mass (5 corrected girths). Additionally, the physical performance parameters examined were: jump tests (vertical-jump and spike-jump), speed, agility, and strength tests (crunches test and overhead medicine ball throw). In terms of height middle blockers were the tallest (186.5±1.4 cm), while liberos were the shortest (166.7±8.1 cm). There were significant differences in body mass among positions.

Dávila-Romero C et al. (2015) divided the study into three sequential stages: identification of fitness and game performance profiles (individual player performance), an assessment of the relationship between these profiles, and an assessment of the relationship between individual player profiles and team performance during play (in championship performance). The overall study sample comprised 525 (19 teams) female volleyball players aged 12-16 years and a subsample (N.=43) used to examine study aims one and two was selected from overall sample. Anthropometric, fitness and individual player performance (actual game) data were collected in the subsample. These data were analyzed through clustering methods, ANOVA and independence chi-square test. Then, we investigated whether the proportion of players with the highest individual player performance profile might predict a team's results in the championship. Cluster analysis identified three volleyball fitness profiles (high, medium, and low) and two individual player performance profiles (high and low). The results showed a relationship between both types of profile (fitness and individual player performance). Then, linear regression revealed a moderate relationship between the number of players with a high volleyball fitness profile and a team's results in the championship (R2=0.23).
The current study findings may enable coaches and trainers to manage training programs more efficiently in order to obtain tailor-made training, identify volleyball-specific physical fitness training requirements and reach better results during competitions.

Sattler T et al. (2015) documented that Vertical jump (VJ) performance is an important element for successful volleyball practice. The aims of the study were (a) to explore the overall VJ performance of elite volleyball players of both sexes, (b) to explore the differences in VJ performance among different competition levels and different playing positions, and (c) to evaluate the sex-related differences in the role of the arm swing and 3-step approach with arm swing on the jump height. We assessed the VJ capacity in 253 volleyball players (113 males and 140 females) from Slovenian first and second Volleyball Division. The height of squat jump (SJ), countermovement jump, block jump, and attack jump was tested using an Optojump system. We observed significant differences ($p \leq 0.05$) in VJ height between different levels of play that were most pronounced in the SJ. Position-related differences in VJ performance were observed in male players between receivers and setters ($p \leq 0.05$), whereas in females, VJ performance across different playing positions seems equal. Finally, we found that male players significantly better use the arm swing during VJ than females ($p \leq 0.05$), whereas the use of eccentric part of the jump and approach before the spike to improve VJ performance seem to be equally mastered activity in both sexes. These results could assist coaches in the development of jumping performance in volleyball players. Furthermore, presented normative data for jump heights of elite male and female volleyball players could be useful in selection and profiling of young volleyball players.

Scribbans TD et al.; (2015) developed and, cross-validate equations appropriate for accurately predicting oxygen cost (VO2) and energy expenditure from HR during intermittent
sport participation. Eleven healthy adult males (19.9±1.1yrs) were recruited to establish the relationship between %VO2peak and %HRmax during low-intensity steady state endurance (END), moderate-intensity interval (MOD) and high intensity-interval exercise (HI), as performed on a cycle ergometer. Three equations (END, MOD, and HI) for predicting %VO2peak based on %HRmax were developed. HR and VO2 were directly measured during basketball games (6 male, 20.8±1.0 yrs; 6 female, 20.0±1.3yrs) and volleyball drills (12 female; 20.8±1.0yrs). Comparisons were made between measured and predicted VO2 and energy expenditure using the 3 equations developed and 2 previously published equations. The END and MOD equations accurately predicted VO2 and energy expenditure, while the HI equation underestimated, and the previously published equations systematically overestimated VO2 and energy expenditure. Intermittent sport VO2 and energy expenditure can be accurately predicted from heart rate data using either the END (%VO2peak=%HRmax x 1.008-17.17) or MOD (%VO2peak=%HRmax x 1.2-32) equations. These 2 simple equations provide an accessible and cost-effective method for accurate estimation of exercise intensity and energy expenditure during intermittent sport.

Zapolska J et. al (2014) characterized the mode of nutrition, including dietary supplements and to assess somatic indices in female volleyball players of the AZS Bialystok team. The study involved 17 women. Research tools included a questionnaire consisting of 24-hour recall, a questionnaire survey concerning supplement intake and body composition analysis performed using a bioimpedance analyzer InBody 220. Data analysis indicates that the anthropometric characteristics and body composition of the AZS Bialystok players meet the recommendations associated with the somatic features in volleyball. Daily diet of the volleyball players were of low-energy with regard to the recommendations for physically
active people, with very low supply of carbohydrates and dietary fiber, excessive proportion of saturated fatty acids and dietary cholesterol, and too low content of monounsaturated and polyunsaturated fatty acids. Supply of vitamins and minerals was found to be alarmingly low, especially of iron and calcium; diet supplementation was insufficient. No significant abnormalities were noted in body composition of the study athletes. However, they are recommended to increase muscle mass and slightly reduce body fat. Results of diet evaluation show the need for education in the field of nutrition and the necessity of further research into dietary habits among sportsmen.

Sterkowicz-Przybycin K and Sterkowicz S, Zak S. (2014) provided an answer to the question whether and how age, body height, body mass, body mass index and results from fitness tests are related to sport skill level and gender of the participants of the Olympic volleyball tournament. Two-Way ANOVA was used to find the dependency of the variables on the factor of sport skill level (A--teams which took places 1 to 4, B--places from 5 to 8; C--places from 9 to 12) and gender (F--female; M--male). Statistical significance was set at p < 0.05. The Bonferroni's adjustment was carried out for three p = 0.017 and fifteen p = 0.003 pairs of comparisons). The M and F athletes included in A-C groups (N = 48 in each group) were than compared to the classification in the neural network of Probabilistic Neural Network (PNN). A combined effect of the factors of sports level and gender on the height of attack jump (F = 4.13; p = 0.02) and block jump (F = 9.22; p < 0.001) was identified. The level of achievement was modified by the differences between the men and women. A significant advantage over the groups B and C was found for attack height and block height. In the group A, the differences between the results obtained for women and men in the ranges of attack and block with respect to the net height were not significant. Mean range of block jump did not match up to attack jump,
particularly in women. The application of PNN network showed that age, BMI, relative attack
jump and block jump are good predictors of sport results. The percentage of properly classified
players in the group of men was lower than in women (42.4 vs. 56.3%). In this regard, big
differences were found at the lower level of sport results: A (77.1 vs. 79.2%), B (25.0 vs. 25.0%)
and C (25.0 vs. 64.6%). In conclusion, selection for national teams should take into consideration
the players with long competitive experience with adequate weight/height ratios, who exhibit
good training adaptations to jumping exercise.

Hadzic V et.al (2014) evaluated shoulder strength asymmetry and a history of shoulder
injury in a large sample of professional volleyball players of both sexes across different playing
positions and skill levels. A sample of 183 volleyball players (99 men, 84 women) were
assessed shoulder internal-rotator and external-rotator concentric strength at 60°/s using an
isokinetic dynamometer and dominant-nondominant differences in shoulder strength and
strength ratios using repeated-measures analyses of variance. Peak torque was normalized for
body mass and external-rotation/internal-rotation concentric strength. Internal-rotation strength
was asymmetric in favor of the dominant side in both sexes, regardless of previous shoulder
injury status. Male volleyball players had a lower shoulder strength ratio on the dominant side,
regardless of previous shoulder injury status. However, this finding was valid only when hand
dominance was taken into account. Female volleyball players playing at a higher level (ie, first
versus second division) were 3.43 times more likely to have an abnormal strength ratio. Playing
position was not associated with an abnormal shoulder strength ratio or strength asymmetry. In
male volleyball players, the external-rotation/internal-rotation strength ratio of the dominant
shoulder was lower, regardless of playing position, skill level, or a previous shoulder injury. In
female players, the ratio was less only in those at a higher skill level. Although speculative,
these findings generally suggest that female volleyball players could have a lower risk of developing shoulder-related problems than male volleyball players. Isokinetic shoulder testing may reveal important information about the possible risk factors for shoulder injuries, so we recommend including it in the functional screening of volleyball players.

Mroczek D et. al (2013) reported that Prior studies have found that reaction time and movement time increase with fatigue (measured by blood lactate concentration) in laboratory situations. The study tested whether these relationships occurred for reaction time and movement time of elite volleyball players during a training game. Components of the players' psychomotor performance (reaction time, movement time) and physiological parameters (heart rate, blood lactate concentration) were analyzed. Fourteen male, adolescent volleyball players participated in the study. Reaction time and movement time were measured with the Optojump measurement system during the game in off-the-court periods. All measurements were performed during a pre-game test and during each of the four sets of the game. During Set 1, players' reaction time decreased significantly compared with the pre-game test indicating a likely warm-up effect. Blood lactate concentration increased significantly across sets. However, the players' reaction times remained constant across sets. The studied players did not exceed the psychomotor fatigue threshold anytime during the entire game. These findings indicate that the amount of training (20 hours a week) done by elite players is sufficient to prevent threshold fatigue levels that create significant decreases in psychomotor performance.

Mroczek D et al. (2014) assessed motor activity of volleyball players using an original video recording method developed by the authors. Twenty-eight volleyball players taking part in 4 matches of the Polish Volleyball League were examined. The recorded data were analyzed in view of the mean total distance covered by volleyball players on different court positions during
a match, set, and rally. The results showed that volleyball players cover the mean total distance of 1221 ± 327 m (mean ± SD) in a 3-set match, and 1757 ± 462 m in a 4-set match. A statistically significant difference (p ≤ 0.005) was found between the distance covered by the middle blockers and setters, defenders, spikers, and libero players in a match and in a set. The study revealed a tendency to lengthen the distance by the players in the final sets, which is indicative of the extended time of individual rallies. The mean distance covered in a single rally amounted to 10.92 ± 0.9 m in 4 matches (between 9.12 and 12.56 m). Considering the limited size of the field of play, volleyball players cover relatively long distances during a match and individual sets, with the shortest distance covered by middle blockers, and the longest by setters. From a practical application point of view, detailed topographic analysis of a player's movements on the court as well as precise data on the time of activity and rest breaks provide the coach with valuable information on the ways of development of arrhythmic, changing and dynamic training loads.

Buško K et.al. (2013) investigated the relationship between somatotype, muscle torque, maximal power output and height of rise of the body mass centre measured in akimbo counter movement jump (ACMJ), counter movement jump (CMJ) and spike jump (SPJ), and power output measured in maximal cycle ergometer exercise bouts in female volleyball players. Fourteen players participated in the study. Somatotype was determined using the Heath-Carter method. Maximal muscle torque was measured under static conditions. Power output was measured in 5 maximal cycle ergometer exercise bouts, 10 s each, at increasing external loads equal to 2.5, 5.0, 7.5, 10.0 and 12.5% of body weight (BW). All jump trials (ACMJ, SPJ and CMJ) were performed on a force plate. The mean somatotype of volleyball players was: 4.9-3.5-2.5. The value of the sum of muscle torque of the left upper extremities was significantly
correlated only with mesomorphic component. Mesomorphic and ectomorphic components correlated significantly with values of maximal power measured during ACMJ and CMJ. Power output measured in maximal cycle ergometer exercise bouts at increasing external loads equal to 2.5, 5.0 and 7.5% of BW was significantly correlated with endomorphy, mesomorphy and ectomorphy.

Martín-Matillas M et.al. (2014) described morphological characteristics of elite female volleyball players from the highest Spanish league, with special focus on differences by performance level and playing positions. Nearly all female players playing in the highest Spanish volleyball league during season 2003/2004 participated in this study (N=148 elite players, 92% of the total). Anthropometric, body composition and somatotype parameters according to performance and playing positions were analysed. The players' characteristics were as follows; body mass 72.3 ± 8.4 kg; stature 179.8 ± 7.1 cm; body fat 24.0 ± 3.1% and skeletal muscle mass 27.3 ± 2.9 kg. Mean somatotype was 3.1 ± 0.7; 3.4 ± 0.9; 3.1 ± 0.9 characterised as central with a tendency to balanced mesomorph. Top level players (whose teams were better classified in the team performance ranking) were taller, had higher skeletal muscle mass and ectomorphy, and had a lower level of adiposity markers, compared with lower level players. Players selected for their respective National teams (individual performance) were taller, heavier, had higher muscle mass and lower endomorphy than non-selected players. Differences according to playing positions were found. This study provides a complete set of reference data on anthropometry, body composition and somatotype of elite female volleyball players. Morphological differences have been identified according to performance level and playing position.
Milić M et al. (2013) used a set of 18 tests for assessing anthropometric characteristics and 12 tests for assessing motor abilities on a sample of 183 young female volleyball players (average age of 13.11 +/- 1.07 years). The main goal of this research was to determine the latent structure of biomotor status, as well as relations of that status to situational efficiency in female volleyball players. Situational efficiency of young volleyball players was assessed on a five-point Likert scale, in relation to each individual player's contribution to the performance of her team, and with regard to the result of that team achieved in the competition. By factor analysis, 3 anthropometric ("endo-mesomorphy", "longitudinal dimensionality of the skeleton" and "transverse dimensionality of the skeleton") and 4 motor factors ("explosive power of legs and agility", "precision", "explosive power of arms and flexibility" and "balance") were obtained. Significant impact of morphological-motor factors on situational efficiency of young female volleyball players was obtained by regression analysis. Set of predictor variables accounts for 40% of the total variance of the system. On a univariate level, all extracted factors, except precision and balance, had a significant impact on situational efficiency. Factors named "longitudinal dimensionality of the skeleton" and "explosive power of legs and agility" had the greatest partial contribution in explaining the criteria. Obtained results confirmed previous findings about the importance of individual dimensions of biomotor status for efficiency in volleyball.

Agostini V et.al. (2013) analyzed the postural sway of volleyball players in bipedal quiet stance. The center of pressure (CoP) was measured in 46 athletes and 42 non-athlete controls. Each subject was tested in 10 different conditions, 5 with their eyes open and 5 with their eyes closed. Volleyball players showed greater CoP ellipses, suggesting a different model of sensory integration in their postural stability. A multivariate approach to data analysis demonstrated that
the postural sway of the two groups was different when the subjects kept their eyes open, but it was not with visual deprivation. This could partially be explained by the better 'dynamic' visual acuity of athletes, since possible ('static') refractive errors were corrected for both groups. Furthermore, we expected that national players, engaged in more intensive training programs, were more different from controls than regional ones, and that defensive players, whose role requires the quickest reaction times, were more different from controls than hitters. Our results confirmed these hypothesis. The protocol presented might be useful to assess the efficacy of intensive sport training programs and/or to select elite players with an aptitude for a specific playing position.

Milić M et al. (2012) defined processes of orientation and/or selection towards sports game of volleyball in schoolgirls of Kastela, aged 10-12, by examining the relations between regular classes of physical education (PE) and extracurricular sport activities. For this purpose, two morphological measures were used (body height and body mass) and a set of 11 motor tests (6 basic motor abilities tests and 5 motor achievement tests) on a sample of 242 girls aged 10-12 was used, divided into a subsample of 42 girls participating in volleyball training (Volleyball players) and a subsample of 200 girls who do not participate in volleyball training (volleyball non-players). Based on the comparison of test results of schoolgirls from Kastela and Croatian norms, factor analysis of applied variables and discriminant analysis of these variables between volleyball players and non-players, processes and/or phases of selection in forming quality volleyball players were defined. Selection processes are preceded by orientation processes in physical education classes, i.e. choosing those sport activities which are in accordance with the biomotor status of students. Results have shown that orientation and initial selection in female volleyball needs to be executed based on the motor set of psychomotor speed,
repetitive strength of the trunk and flexibility (muscle tone regulation), and body height. Volleyball training has affected the muscle mass development and the development of strength factors, so that explosive strength of jumping and/or takeoff along with body height, has predominantly differentiated female volleyball players from non-players, aged 10 to 12, and serve and spike quality will have dominant influence on the match outcome.

Schaal M et al. (2013) examined physiologic performance test differences by competition level (high school and Division-I collegiate athletes) and player position (hitter, setter, defensive specialist) in 4 volleyball-related tests. A secondary purpose was to establish whether a 150-yd shuttle could be used as a field test to assess anaerobic capacity. Female participants from 4 varsity high school volleyball teams (n = 27) and 2 Division-I collegiate volleyball teams (n = 26) were recruited for the study. Participants completed 4 performance-based field tests (vertical jump, agility T-test, and 150- and 300-yd shuttle runs) after completing a standardized dynamic warm-up. A 2-way multivariate analysis of variance with Bonferroni post hoc adjustments (when appropriate) and effect sizes were used for the analyses. The most important findings of this study were that (a) college volleyball athletes were older, heavier, and taller than high school athletes; (b) high school athletes had performance deficiencies in vertical jump/lower-body power, agility, and anaerobic fitness; (c) lower-body power was the only statistically significant difference in the performance test measures by player position; and (d) the correlation between the 150- and 300-yd shuttle was moderate (r = 0.488). Female high school volleyball players may enhance their ability to play collegiate volleyball by improving their vertical jump, lower-body power, agility, and anaerobic fitness. Furthermore, all player positions should emphasize lower-body power conditioning. These physical test scores provide baseline performance scores that should help strength and conditioning coaches create
programs that will address deficits in female volleyball player performance, especially as they transition from high school to college.

Aouadi R et al. (2012) examined the association between physical and anthropometric profiles and vertical jump performance in elite volleyball players. Thirty-three elite male volleyball players (21±1 y, 76.9±5.2 kg, 186.5±5 cm) were studied. Several anthropometric measurements (body mass, stature, body mass index, lower limb length and sitting height) together with jumping height anaerobic power of counter movement jump with arm swing (CMJarm) were obtained from all subjects. Forward stepwise multiple linear regression analysis was performed to determine if any of the anthropometric parameters were predictive of CMJarm. Anaerobic power was significantly higher (P≤0.05) in the tallest players relative to their shorter counterparts. A significant relationship was observed between CMJarm and lower limb length (r²=0.69; P<0.001) and between the lower limb length and anaerobic power obtained with CMJarm (r²=0.57; P<0.01). While significantly correlated (P≤0.05) with CMJarm performance, stature, lower limb length/stature and sitting height/stature ratios were not significant (P>0.05) predictors of CMJarm performance. This study demonstrates that lower limb length is correlated with CMJarm in elite male volleyball players. The players with longer lower limbs have the better vertical jump performances and their anaerobic power is higher. These results could be of importance for trained athletes in sports relying on jumping performance, such as basketball, handball or volleyball. Thus, the measurement of anthropometric characteristics, such as stature and lower limb length may assist coaches in the early phases of talent identification in volleyball.

Nikolaidis PT et al. (2012) made a study of twofold: (a) to profile physical characteristics and physiological attributes of adolescent and adult Greek female volleyball players (n = 61)
who were members of the A (the best league for female volleyball players) and B (the second-best league for female volleyball players) Series clubs in Greece and (b) to examine the intraindividual variability among these players in all physical and physiological measurements that were undertaken in the study. The participants were divided into 3 age groups—under 14, 14-18, and over 18 years. They underwent a series of physical (e.g., height, body mass, and percentage of body fat) and physiological (e.g., aerobic profile, flexibility, and vertical jumping ability) tests. Three main findings emerged from the data analysis: (a) differences in physical characteristics and physiological attributes existed between the 3 age groups. For example, fat-free mass was lower in players under the age of 14 years (41.57 ± 6.06 kg) compared with that in players between the ages of 14-18 years (50.24 ± 6.96 kg) and players over the age of 18 years (52.03 ± 3.39 kg). In addition, the relative peak power as measured in the Wingate Anaerobic Test was the highest in the over-18 group (9.72 ± 0.65 W·kg), lower in the 14-18 group (8.95 ± 0.7), and the lowest in the under-14 group (8.32 ± 0.78 W·kg), (b) large intraindividual variability existed in most physical characteristics and physiological attributes measured in the study, and (c) the intraindividual variability was observed in all the 3 groups. These findings emphasize the need for coaches to examine the intraindividual variability within the players on their teams and to use this information when designing training programs and strength and conditioning programs.

Fonseca-Toledo C et al. (2010) investigated the anthropometrics characteristics of male Brazilian junior volleyball players, organised into 3 sports requirement groups: high qualification (HQ) formed by the national team, middle qualification (MQ) formed by athletes playing in the Brazilian national championships and low qualification (LQ) formed by players at school level. 101 athletes were observed, HQ (n=16), MQ (n=68) and LQ (n=17), aged 16.7 ±
0.5; 16.6 ± 0.5 and 16.2 ± 0.7 years, respectively. The following were evaluated: body mass, height, standing reach height, % body fat and Heath & Carter somatotype. The statistical analysis was descriptive and inferential, the Kruskal Wallis test being used for detecting differences between groups (p<0.05 significance) and Spearman correlation coefficient for establishing association between anthropometric characteristics and requirement levels, considering p<0.05 e p<0.01 to be significant and highly significant, respectively. Significant differences (p<0.05) were detected between athlete groups for body mass, height, standing reach height and ectomorphy. A "strong" correlation for height and "regular" correlation for standing reach height, body mass and ectomorphy were observed, according to players' height or classification. The results gave normative data for athletes which will allow coaches and physical instructors to use such information during training as a sports' selection instrument for young talented volleyball players.

2.2 STUDIES AMONG VOLLEYBALL PLAYERS

Thomas C et al. (2017) evaluated the height, body mass and physical characteristics of female academy netball players by position (centers, defenders and shooters). Data were collected on 43 regional academy players during the preseason period and comprised of height and body mass, and physical characteristics (single-leg hop [SLH], squat jump [SJ], countermovement jump [CMJ], 5- and 10-m sprint, 505 and cardiorespiratory fitness). Defenders and shooters demonstrated significantly (p = < 0.05; d ≥ 1.1) greater body mass compared to centers. Defenders demonstrated significantly (p = < 0.05; d = 1.6) greater height compared to centers, however no significant differences were noted between centers and shooters (p = 0.19; d
and defenders and shooters ($p = 0.70; d = 0.5$). Centers performed better during the SLH left leg ($p = 0.01; d = 1.0$), SJ ($p = 0.03; d = 1.1$), CMJ ($p = 0.01; d = 1.4$), 5 m ($p = 0.04; d \geq -0.9$) and 10 m sprint ($p = 0.01; d = -1.2$), 505 left ($p \leq 0.03; d \geq 1.0$), 505 right ($p \leq 0.03; d = 1.3$), and cardiorespiratory fitness ($p = 0.01; d \geq 1.2$), compared to other positions. No other significant differences were observed. These findings demonstrate that height, body mass and physical characteristics differ between positions in female netball players, and provide normative data for English academy netball players. Strength and conditioning coaches should consider the specific demands on individual positions when training female netball players.

Bailey JA et al. (2017) documented that previous investigations of player load in netball have utilised subjective methodologies, with few utilising objective methodologies. Whilst all studies report differences in player activities or total load between playing positions, it is unclear how the differences in player activity explain differences in positional load. The aim of this study was to objectively quantify the load associated with typical activities for all positions in elite netball. The player load of all playing positions in an elite netball team, was measured during matches using wearable accelerometers. Video recordings of the matches were also analysed, to record the start-time and duration of 13 commonly reported netball activities. The load associated with each activity was determined by time-aligning both datasets (load and activity). Off-ball guarding produced the highest player load per instance, while jogging produced the greatest player load per match. Non-locomotor activities contributed least to total match load for attacking positions (GS, GD and WA) and most for defending positions (GK, GD and WD). Specifically, C produced the greatest jogging load, WA and WD accumulated the greatest running load, while GS and WA accumulated the greatest shuffling load. WD and C accumulated the greatest guarding load, while WD and GK accumulated the greatest off-ball
guarding load. All positions exhibited different contributions from locomotor and non-locomotor activities towards total match load. Additionally, the same activity can have different contributions towards total match load, depending on the position. This has implications for future design and implementation of positional specific training programs.

Hopper A et al. (2017) examined the effects of a neuromuscular training (NMT) program on movement competency and measures of physical performance in youth female netball players. It was hypothesized that significant improvements would be found in movement competency and physical performance measures after the intervention. Twenty-three junior female netball players (age, 12.17 ± 0.94 years; height, 1.63 ± 0.08 m; weight, 51.81 ± 8.45 kg) completed a test battery before and after a 6-week training intervention. Thirteen of these athletes underwent 6 weeks of NMT, which incorporated plyometrics and resistance training. Trained athletes showed significant improvements in 20-m sprint time, 505 agility time, countermovement jump height, and peak power (p ≤ 0.05, g > 0.8). In addition, trained athletes significantly improved their score in the Netball Movement Screening Tool (NMST) (p < 0.05, g > -1.30); while the athletes also demonstrated increased reach in the anterior and posteromedial directions for the right leg and left leg, and in the posterolateral direction for the left leg only in the Star Excursion Balance Test (SEBT) (p < 0.05, g > -0.03). Control subjects did not exhibit any significant changes during the 6-week period. Significant negative correlations were found between improved score on the NMST and decreased 5-, 10-, and 20-m sprint time, and 505 change of direction time (r > 0.4, p ≤ 0.05). Results of the study affirm the hypothesis that a 6-week NMT intervention can improve performance and movement competency in youth netball players.
Bruce L and Moule S. (2016) assessed the suitability of the 30-15 IFT as a test in netball using female athletes. 26 female sub-elite netballers (mean age = 19.7 ± 4.6 years, mean height = 176.0 ± 6.1 cm, mean body mass = 69.7 ± 9.3 kg) completed the yo-yo intermittent recovery test level 1 (yo-yo IRT1) and the 30-15 Intermittent Fitness Test (30-15 IFT). Participants performed both assessments one week apart prior to the intervention and both tests one week apart following the training intervention (for a total of four testing sessions). A six-week training intervention occurred between the test occasions. Pearson's correlations revealed significant very large relationships between the 30-15 IFT and yo-yo IRT on both test occasions (test occasion 1: \( r = 0.71, p = 0.003 \) (95% CI 0.35 - 0.89), magnitude of effect, most likely; test occasion 2: \( r = 0.72, p = 0.001 \) (95% CI 0.42 - 0.88), magnitude of effect, most likely). Repeated measures ANOVAs examining the effect of position on performance changes revealed main effects for test occasion and a position x test occasion interaction for both the 30-15 IFT and the yo-yo IRT1 (30-15 IFT: test occasion \( (F(1,14) = 28.68, p = 0.001, \eta^2 = .67) \), position x test occasion interaction \( (F(2,14) = 9.38, p = 0.003, \eta^2 = .57) \); yo-yo IRT1: test occasion \( (F(1,15) = 11.72, p = 0.004, \eta^2 = .44) \), position x test occasion interaction \( (F(2,15) = 9.96, p = 0.002, \eta^2 = .57) \). Results show that the 30-15 IFT is a suitable test for female netballers as it was able to detect improvements in performance after a training intervention, in addition to having a very large significant relationship with the yo-yo IRT1.

Thomas C et al. (2016) investigated (a) the relationships between maximal isometric strength, vertical jump (VJ), sprint speed, and change of direction speed (CODS) in academy netball players, and (b) determine whether players who have high performance in isometric strength testing would demonstrate superior performance in VJ, sprint speed, and CODS measures. Twenty-six young female netball players (age = 16.1 ± 1.2 years; height =
173.9 ± 5.7 cm; body mass = 66.0 ± 7.2 kg;) from a regional netball academy performed isometric mid-thigh pull (IMTP), squat jumps (SJs), countermovement jumps (CMJs), 10-m sprints, and CODS (505). Isometric mid-thigh pull measures displayed moderate-to-strong correlations with sprint and CODS performance (r = -.41 to -.66). The VJs, which included SJ and CMJ demonstrated strong correlations with 10-m sprint times (r = -.60 to -.65; p < 0.01) and CODS (r = -.60 to -.71; p = .01). Stronger players displayed significantly faster sprint (ES = 1.1 - 1.2) and CODS times (ES = 1.2 - 1.7), and greater VJ height (ES = 0.9 to 1.0) compared to the weaker players. The results of this study illustrate the importance of developing high levels of lower-body strength to enhance VJ, sprint, and CODS performance in youth netball players, with stronger athletes demonstrating superior VJ, sprint, and CODS performances.

Young CM et al. (2016) measured and analyzed player load in elite netballers during matches and training sessions. The primary research question was, How does player load vary between playing positions in a match and between matches and training sessions? Various measures of player load were recorded in 12 elite professional netballers with a mean ± SD age of 26 ± 4.9 y and height of 183.2 ± 8.7 cm. Player load was assessed using a published method that uses accelerometry. Load was represented as total load in arbitrary units (au), playing intensity (au/min), and relative time spent in each of 4 playing intensity zones (low, low to moderate, moderate, and high). Data from 15 games and up to 17 training sessions were analyzed for each player. Player load in matches for the goal-based positions (goal shooter, goal keeper, and goal defense) tended to be lower than the attacking and wing-based positions (goal attack, wing attack, wing defense, and center). The difference was largely due to the amount of time spent in low-intensity activity. Playing intensity of matches was greater than in training sessions; however, the total time spent in moderate- to high-intensity activities was not
practically different. Accelerometry is a valuable method of measuring player load in netball, and the present results provide new information about the activity profile of different playing positions.

Ashton RE and Twist C. (2015) investigated whether an increased number of changes in direction altered the metabolic, cardiovascular, perceptual, and neuromuscular responses to intermittent shuttle running (ISR). Using a randomized crossover design, 10 female netball players completed 30 minutes of ISR over a 10-m (ISR10) and 20-m (ISR20) linear course. Measures of expired air, heart rate (HR), rating of perceived exertion, blood lactate concentration ([BLa]), and peak torque of knee extensors and flexors were measured. Differences (%change ± 90% CL) in VO2 (1.5 ± 5.6%) was unclear between conditions, whereas HR was possibly higher (1.5 ± 2.5%) and [BLa] very likely lower in ISR20 compared with ISR10 (-32.7 ± 9.9%). Rating of perceived exertion was likely lower in the ISR20 compared with the ISR10 condition at 15 (-5.0 ± 5.0%) and most likely lower at 30 minutes (-9.4 ± 2.0%). Sprint times over 20 m were likely slower during ISR20 at mid (3.9 ± 3.2%) but unclear after (2.1 ± 5.4%). Changes in muscle function were not different between ISR10 and ISR20 conditions for knee extension (-0.2 ± 0.9%) but were likely different for knee flexion (-5.7 ± 4.9%). More directional changes during shuttle running increase the physiological and perceptual load on female athletes, which also cause a greater reduction in knee extensor torque. These findings have implications for the effective conditioning and injury prevention of female team sport athletes.

Chandler PT et al. (2014) investigated the physical demands of netball match play and different training activities. Eight collegiate netball players participated in the study. Heart rate (HR), rating of perceived exertion (RPE), and accelerometer player load (PL) data were collected
in 4 matches and 15 training sessions. Training sessions were classified as skills, game-based, traditional conditioning, or repeated high-intensity effort training. Accelerometer data were collected in 3 planes and were normalized to match play/training time (PL per minute, forward per minute, sideward per minute, and vertical per minute). Centers had a higher PL per minute than all other positions (effect size; ES = 0.67-0.91), including higher accelerations in the forward (ES = 0.82-0.92), sideward (ES = 0.61-0.93), and vertical (ES = 0.74-0.93) planes. No significant differences (p > 0.05) were found between positions for RPE and peak HR. Skills training had a similar PL to match play. However, the mean HR of skills training was significantly lower than match play and all other modes of training (ES = 0.77-0.88). Peak HR for skills training (186 ± 10 b·min) and traditional conditioning (196 ± 8 b·min) was similar to match play (193 ± 9 b·min). There were no meaningful differences in RPE between match play and all modes of training. The center position produces greater physical demands during match play. The movement demands of netball match play are best replicated by skills training, whereas traditional conditioning best replicates the HR demands of match play. Other training modes may require modification to meet the physical demands of match play.

Reid DA et al. (2015) established the inter- and intra-rater reliability of the Netball Movement Screening Tool, for screening adolescent female netball players. Forty secondary school netball players were recruited to take part in the study. Twenty subjects were screened simultaneously and independently by two raters to ascertain inter-rater agreement. Twenty subjects were scored by rater one on two occasions, separated by a week, to ascertain intra-rater agreement. Inter and intra-rater agreement was assessed utilising the two-way mixed inter class correlation coefficient and weighted kappa statistics. No significant demographic differences were found between the inter and intra-rater groups of subjects. Inter class
correlation coefficients' demonstrated excellent inter-rater (two-way mixed inter class correlation coefficients 0.84, standard error of measurement 0.25) and intra-rater (two-way mixed inter class correlation coefficients 0.96, standard error of measurement 0.13) reliability for the overall Netball Movement Screening Tool score and substantial-excellent (two-way mixed inter class correlation coefficients 1.0-0.65) inter-rater and substantial-excellent intra-rater (two-way mixed inter class correlation coefficients 0.96-0.79) reliability for the component scores of the Netball Movement Screening Tool. Kappa statistic showed substantial to poor inter-rater (k=0.75-0.32) and intra-rater (k=0.77-0.27) agreement for individual tests of the NMST. The Netball Movement Screening Tool may be a reliable screening tool for adolescent netball players; however the individual test scores have low reliability. The screening tool can be administered reliably by raters with similar levels of training in the tool but variable clinical experience. On-going research needs to be undertaken to ascertain whether the Netball Movement Screening Tool is a valid tool in ascertaining increased injury risk for netball players.

Pruyn EC, Watsford ML, and Murphy AJ. (2015) documented that There are many notable differences in physical and skill attributes between competition levels, especially in team sports. Stiffness is an important mechanical factor to measure when considering athletic performance and injury incidence. Active vertical stiffness (K(vert)) during hopping and passive stiffness during lying and standing were measured during the preseason period for 46 female netballers (24.0 ± 3.7 years, 72.2 ± 7.6 kg, 175.2 ± 6.7 cm). Participants were classified as elite, sub-elite, representative or recreational based on their current level of competition. A 1-way analysis of variance revealed that elite players possessed significantly higher K(vert) than recreational players (p = 0.018). Large effect sizes (ES) suggested that elite players also
possessed higher K(vert) than sub-elite (d = 1.11) and representative (d = 1.11) players. A number of large and moderate ES were also present when comparing the passive stiffness of elite players to their lower-ranked counterparts. The results of this study suggest that elite players possess higher levels of active stiffness when compared with their lower-ranked counterparts. The differences in stiffness levels may contribute to a player's ability to physically perform at an elite level and also provide one explanation into elevated rates of injury at higher levels of competition.

Cormack SJ et al. (2014) determined differences in load/min (AU) between standards of netball match play. Load/min (AU) representing accumulated accelerations measured by triaxial accelerometers was recorded during matches of 2 higher- and 2 lower-standard teams (N = 32 players). Differences in load/min (AU) were compared within and between standards for playing position and periods of play. Differences were considered meaningful if there was >75% likelihood of exceeding a small (0.2) effect size. Mean (± SD) full-match load/min (AU) for the higher and lower standards were 9.96 ± 2.50 and 6.88 ± 1.88, respectively (100% likely lower). The higher standard had greater (mean 97% likely) load/min (AU) values in each position. The difference between 1st and 2nd halves' load/min (AU) was unclear at the higher standard, while lower-grade centers had a lower (-7.7% ± 10.8%, 81% likely) load/min (AU) in the 2nd half and in all quarters compared with the 1st. There was little intrastandard variation in individual vector contributions to load/min (AU); however, higher-standard players accumulated a greater proportion of the total in the vertical plane (mean 93% likely). Higher-standard players produced greater load/min (AU) than their lower-standard counterparts in all positions. Playing standard influenced the pattern of load/min (AU) accumulation across a match, and individual vector analysis suggests that different-standard players have dissimilar movement
characteristics. Load/min (AU) appears to be a useful method for assessing activity profile in netball.

Fox A et al. (2013) reported that in elite sport, to remain competitive at the international level, it is critical to understand the game demands on players to ensure sport specific training programmes are designed for optimal athlete preparation and conditioning. In netball, recent research examining the activity patterns of players at the elite level is lacking, with only one study undertaken on this level of competition in the past 30 years. Therefore, the aim of this study was to provide coaches with up to date knowledge of player activity patterns as a basis for the design of optimal sport specific training programmes. The Australian female netball team were analysed using video footage of three international test matches. Player activity was categorised into five movement and eight game-based activities; and further classified as work or rest. Results suggest that differences in the current game exist when compared to the previous analysis. Positional differences were also found with regard to player activity confirming the need for an individualised component of training based on player position.

Cook CJ et al. (2012) compared the baseline free testosterone (T) and cortisol (C) concentrations of elite and non-elite female athletes. Eighteen females from different sports (track and field, netball, cycling, swimming, bob skeleton) were monitored over a 12-week period. Baseline measures of salivary free T and C concentrations were taken weekly prior to any training. The elites (n = 9) and non-elites (n = 9) were classified as international and national level competitors, respectively, with both groups matched by sport. The pooled free T concentrations of the elites (87 pg/ml) were significantly higher than the non-elites (41 pg/ml)
and consistently so across all weekly time points \( P < 0.001 \). Pooled free C concentrations were also greater in the elite group (2.90 ng/ml) than the non-elites (2.32 ng/ml) \( P < 0.01 \). The pooled baseline T and C measures were higher in elite female athletes than non-elites. Higher free T and C concentrations could indicate a greater capacity for physical performance at higher work rates, which is commensurate with the demands of elite sport. Speculatively, the T differences observed could influence female behavior and thereby help to regulate sporting potential.

Broad EM et al. (1996) documented that Fluid losses (measured by body weight changes) and voluntary fluid intakes were measured in elite basketball, netball, and soccer teams during typical summer and winter exercise sessions to determine fluid requirements and the degree of fluid replacement. Each subject was weighed in minimal clothing before and immediately after training, weights, and competition sessions; fluid intake, duration of exercise, temperature and humidity, and opportunity to drink were recorded. Sweat rates were greatest during competition sessions and significantly lower during weights sessions for all sports. Seasonal variation in dehydration \( \% \text{DH} \) was not as great as may have been expected, particularly in sports played indoors. Factors influencing fluid replacement during exercise included provision of an individual water bottle, proximity to water bottles during sessions, encouragement to drink, rules of the game, duration and number of breaks or substitutions, and awareness of personal sweat rates. Guidelines for optimizing fluid intakes in these three sports are provided.

Bell W et al. (1994) took physiological and anthropometric measurements from on 21 members of an under-21 international squad of mean age 18.9 years. The aims of the investigation were (i) to examine the physiological status of players according to playing unit;
and (ii) to quantify the changes arising from a four-month training programme. Maximal/peak oxygen uptake was assessed using an incremental test to exhaustion during treadmill running. Anaerobic performance was measured using the 30s Wingate test. Significant differences occurred between playing units in height (p < 0.001), body mass and FVC (p < 0.05), but not in skinfolds or any of the expressions of aerobic or anaerobic performance (p > 0.05). As a consequence of the training programme significant differences were evident in height (169.7 v 170.1 cm, p < 0.01), body mass (62 v 64 kg, p < 0.05), FVC (4.3 v 4.51, p < 0.01), and anaerobic performance (p < 0.01). Increases in VO2 max (3.3 v 3.51.min-1) were not significant (p > 0.05). Standard deviation scores illustrated that aerobic and anaerobic performances were of roughly the same magnitude before training (-0.35 v -0.29, p > 0.05), but that after training the dominant performance was anaerobic (+0.11 v +1.48, p < 0.01).

2.3 STUDIES ON PHYSICAL FITNESS VARIABLES

Ikeda Mariko et.al (2004) reported that it is well known that athletes participating in different sports vary in physique and physical fitness. Although several studies on the physique and physical fitness of athletes have been conducted on both sexes, research on physique and physical fitness of female handball player is lacking. The purpose of this study was to investigate the physical characteristics and motor performance of the college women handball players. For this purpose the physique and motor performances of the college women handball players to college women basketball players and college women volleyball players were compared. Basic anthropometric indices and physical fitness such as 20M shuttle-running, vertical jump, standing jump, handball-throw for distance, trunk flexion, side step, grip strength and back strength were determined for 6 handball players, 7 basketball players and 8 volleyball players aged from 19 to
22 years. The girth of upper arm of the handball players was significantly higher than that of basketball players, and the skinfold thickness of upper arm and %Fat was significantly lower in handball players than in volleyball players. The handball throw for distance, side step and back strength were significantly higher in handball players than in basketball players and volleyball players. In handball game, the transition from defense to offense occurs in about every 25-30 sec. and the transition is very speedy and the considerable body contact to the opponent is allowed, so that muscular strength, power, agility and aerobic power are strongly required for each player. When the handball game is compared with basketball game, the playing time is longer and the charged time-out is shorter, and the shooting motion is more dynamic. In comparison with volleyball, the considerable body contact to the opponent is allowed in handball game but that is not allowed in volleyball and the ball is very heavier. Therefore, it was concluded that the results of this study as stated above show the characteristics of female handball player.

Marko Sbila et.al. (2004) identified the differences in the volume and intensity of large-scale cyclic movement activities performed by handball players in different playing positions - backcourt players, wings, pivots and goalkeepers. For this purpose six experimental model matches (2x20min), played by the Slovenian male handball teams (youth, juniors and seniors), were analysed. The sample consisted of 84 players of twelve teams (average age 20.26 ± 4.28yrs; average height 182.51 ± 6.59cm; average body mass 80.61 ± 10.37kg) and was divided into four sub-samples by playing position. The collection of data on the cyclic loading of players in a handball match was based on the computer-aided automatic tracking method with the SAGIT system, based on computer vision methods. The output data on the cyclic movements obtained by the SAGIT programme were processed by the selected descriptive statistics methods in Excel and SPSS programmes. Statistically significant differences were registered between the groups
of players in different playing positions in terms of average distances walked or run during matches (volume). The greatest total distance was covered by the wings (3,855m), followed by the backcourt players (3,432m) and pivots (3,234m), whereas goalkeepers ran the least (1,753m). Differences also appeared in the intensity of large-scale cyclic movements, that is in the percentage of time spent in all the speed classes. In the first speed class statistically significant differences occurred among all the groups - the goalkeepers spent the highest percentage of time (86%) here, followed by the pivots (62%) and wings (58%). There were no statistically significant differences in the second speed class between the groups of wings (23%), backcourt players (25%) and pivots (25%); however, all three groups differed from the goalkeepers (11%). The highest percentage of time spent in the third speed class was that of the wings (14%) and backcourt players (14%). Nevertheless, there were no statistically significant differences between them. Pivots (10%) and goalkeepers (2%) did not spend much time in the third speed class, so statistically significant differences were registered for the latter two and the groups mentioned before. In the fourth speed class statistically significant differences occurred between all the groups of players. In this speed class the wings spent the most time (4%), followed by the backcourt players (3%) and pivots (2%), whereas the lowest percentage of time in this speed class was that of the goalkeepers (0.5%). There were statistically significant differences between all the groups of players in terms of average speed of movement - the fastest were the wings (1.60m/s), followed by the backcourt players (1.43m/s), pivots (1.34m/s), and goalkeepers (0.73m/s).

Sheppard et.al. (2008) examined the potential strength, power, and anthropometric contributors to vertical jump performances that are considered specific to volleyball success: the spike jump (SPJ) and counter-movement vertical jump (CMVJ). To assess the relationship
among strength, power, and anthropometric variables with CMVJ and SPJ, a correlation and regression analysis was performed. In addition, a comparison of strength, power, and anthropometric differences between the seven best subjects and the seven worst athletes on the CMVJ test and SPJ test was performed. When expressed as body mass relative measures, moderate correlations (0.53-0.65; p <= 0.01) were observed between the 1RM measures and both relative CMVJ and relative SPJ. Very strong correlations were observed between relative (absolute height-standing reach height) depth jump performance and relative SPJ (0.85; p <= 0.01) and relative CMVJ (0.93; p <= 0.01). The single best regression model component for relative CMVJ was the relative depth jump performance, explaining 84% of performance. The single best predictor for relative SPJ was also the relative depth jump performance (72% of performance), with the three-component models of relative depth jump, relative CMVJ, spike jump contribution (percent difference between SPJ and CMVJ), and relative CMVJ, spike jump contribution, and peak force, accounting for 96% and 97%, respectively. The results of this study clearly demonstrate that in an elite population of volleyball players, stretch-shortening cycle performance and the ability to tolerate high stretch loads, as in the depth jump, is critical to performance in the jumps associated with volleyball performance.

Chen et al. (2006) reported that the 3 min step test is a widely used method to evaluate physical fitness, but whether this method is valid when performed at altitude is unknown. The purpose of this study was to examine the effect of altitude on the fitness score of the 3 min step test, and the role of ambient temperature in this effect. In study I, 11 healthy volunteers (aged 18.1 +/- 1.1 years) performed a 3 min step test at sea level and at altitude (1950 m). Plasma lactate and stress hormones, as indicators of metabolic stress, were measured before and after the test. To determine the role of ambient temperature, we performed study II at sea level with the
same step test simulating the altitude temperature condition (24 degrees C at high altitude versus 32 degrees C at sea level) with 23 subjects (aged 20.4 +/- 0.4 y). In study I, plasma lactate of the subjects was elevated during the step test at sea level and to a greater extent at high altitude. Plasma cortisol and testosterone levels were elevated only at high altitude. However, the heart rate (HR) recovery after the step test was faster at high altitude than at sea level, producing a better physical fitness index. Furthermore, in study II, we demonstrated that the subjects who performed the 3 min step test at 24 degrees C exhibited faster HR recovery than at 32 degrees C. The current study therefore suggests that environmental conditions leading to temperature variation have strong confounding effects on the fitness score of the 3 min step test.

van de Vliet et.al (2006) investigated the physical fitness profile of high-performance athletes with intellectual disability (ID) in comparison with able-bodied individuals. Participants were 231 male and 82 female athletes. All evaluations were done using the EUROFIT physical fitness test. In comparison with population data, both male and female athletes with ID score better for flexibility and upper body muscle endurance, but have similar or lower values for running speed, speed of limb movement, and strength measures. Compared with age-matched physical education students, male athletes with ID score better for running speed and flexibility, and worse for strength. Female athletes with ID score not different from able-bodied individuals for flexibility, running speed, and upper body muscle endurance, but worse for strength measures. Athletes with ID also have poorer cardio respiratory endurance capacity compared with sportive peers without ID. Furthermore, male athletes have a more differentiated profile depending upon their sports discipline, compared with female athletes. It can be concluded that high-performance athletes with ID reach physical fitness levels that are equal to or lower than
those of able-bodied sportive counterparts. Further research should investigate the importance of reduced muscle strength to be the limiting factor.

Milde et.al (2006) assessed the physical fitness of short-statured boys aged 7 - 20 years by applying fitness norms established for the Polish population in relation to calendar or growth age. The results of EUROFIT fitness tests recorded in 3517 short-statured (below percentile 10 for body height) boys, aged 7-20 years, selected from a large (n=37 000) representative male cohort, were analysed. Individual results were confronted with the respective percentile norms related to calendar age (CA) or growth age (GA), since body height deficiency at given CA could have affected the results of fitness tests expected for that CA. The percentages of subjects below, the percentile 3 or above percentile 97 for given fitness test and CA or GA for the Polish population, were determined. No differences between the percentages computed for CA and GA were noted in case of the following tests: sit-and-reach (SAR) and bent-arm hang (BAH). Significant differences in percentages for both percentiles were found for the following tests: standing broad jump (SBJ), endurance shuttle run (ESR), handgrip (HGR) and plate tapping (PLT). In case of sit-ups (SUP) significant differences in percentages between CA and GA norms were found below the percentile 3, and in case of shuttle run (SHR) and flamingo balance (FLB) -- above percentile 97. Fitness tests were classified into two categories according to the differences between the results related to norms for calendar or growth age: those independent of whether CA or GA norms were applied (SAR and BAH), and those susceptible to the kind of norm (SBJ, HGR, PLT, SHR, FLB and SUP). The results of tests from the latter category should thus be evaluated by confronting them with the norms established for the growth age, and not calendar age.
Armstrong and Welsman (2006) reviewed the reviews the habitual physical activity of children and adolescents from member countries of the European Union in relation to methods of assessing and interpreting physical activity. Data are available from all European Union countries except Luxembourg and the trends are very similar. European boys of all ages participate in more physical activity than European girls and the gender difference is more marked when vigorous activity is considered. The physical activity levels of both genders are higher during childhood and decline as young people move through their teen years. Physical activity patterns are sporadic and sustained periods of moderate or vigorous physical activity are seldom achieved by many European children and adolescents. Expert committees have produced guidelines for health-related physical activity for youth but they are evidence-informed rather than evidence-based and where there is evidence of a relationship between physical activity during youth and health status there is little evidence of a particular shape of that relationship. The number of children who experience physical activity of the duration, frequency and intensity recommended by expert committees decreases with age but accurate estimates of how many girls and boys are inactive are clouded by methodological problems. If additional insights into the promotion of health through habitual physical activity during youth are to be made, methods of assessment need to be further refined and recommended guidelines re-visited in relation to the existing evidence base.

Yi-Ching Huang and Malina (2002) studied on the relationship between physical activity and health-related physical fitness was evaluated in 282 Taiwanese adolescents 12-14 years of age. The subjects were randomly selected from the 7th, 8th and 9th grades in two junior high schools in Taiwan. Physical activity was estimated as total daily energy expenditure and energy expenditure in moderate-to-vigorous physical activity from 24-hour activity records for three
days, two week days and one weekend day. Health-related fitness was assessed as the one-mile run (cardiorespiratory endurance), timed sit-ups (abdominal strength and endurance), sit-and-reach (lower back flexibility), and subcutaneous fatness (sum of the triceps, subscapular, suprailliac, and medial calf skinfolds). Physical activity is significantly and positively correlated with one-mile run performance and the sit-and-reach, but not with sit-ups and subcutaneous fatness. Overall, the strength of the relationships between estimated energy expenditure and specific fitness items in the total sample vary from low to moderate, with only 1% to 12% of the variance in fitness variables being explained by estimated energy expenditure. Comparisons of active versus inactive, and fit versus unfit adolescents provide additional insights. The more active (highest quartile) are also more fit in cardiorespiratory endurance and in the sit-and-reach than the less active (lowest quartile), and the more fit in the one-mile run (better time, lowest quartile) and the sit-and-reach (highest quartile) are more active than the less fit in each item, respectively.

Ciaran MacDonncha and Rhoda Sohun (2006) compared the physical fitness levels of Irish adolescents and reported that physical fitness data for males (n = 610) and females (n = 646) from Northern Ireland aged between 15 - 17 years for the following variables: height (males = 1728 cm, females = 1616 cm); weight (males = 63 kg, females = 56 kg); sit-ups in 30s (males = 26 reps, females = 20 reps); sit and reach (males = 22 cm, females = 25 cm); grip strength (males = 42 kg, females = 28 kg); standing long jump (males = 192 cm, females = 148 cm) and body fat percentage (males = 13.5%, females = 23.8%). When a comparison was made between adolescents from Ireland results demonstrated that large percentage differences exist between mean values for Irish adolescents and Northern Ireland adolescents for the following variables: sit-ups (30s); sit and reach flexibility and grip strength. The percentage body fat of Irish female
adolescents was also greater than their Northern Ireland counterparts. Healthy body fat values for males and females are 15% and 25% respectively.

Rode and Shephard (2005) made a study on physical characteristics, muscle strength, and predicted aerobic power were compared in two circumpolar populations aged 20-49 years at different stages in acculturation to a “modern” sedentary life-style: the Inuit of Igloolik (110 males, 80 females tested in 1989-90) and the Ganasan of Volochanka (29 males, 25 females tested in 1992-3). Both populations show short stature but normal body mass. Skinfold thicknesses (average of triceps, subscapular, and suprailiac) of the male Inuit (mean 10-11 mm, rising with age to 15 mm) are now much greater than in previous surveys, reflecting adoption of a mechanized, sedentary life-style. Recent estimates from Siberia suggest continuing substantial daily energy expenditures by the men but not the women of this region, and averaged values for the three skinfolds in the nGanasan males (mean 7-8 mm) are still low. In women, both Inuit (mean skinfolds 15 mm, rising to 29 mm with age) and nGanasan (mean 19 mm, rising to 25 mm) are now relatively obese. Compared to the nGanasan, male Inuit have greater handgrip force (probably due to snowmobile operation), but poorer knee extension strength (probably because they now do little walking through snow). In contrast, older nGanasan women have less knee extension strength than the Inuit (probably because the latter still carry babies on their backs). The aerobic power of both Inuit and nGanasan (mean of 48, declining with age to 38-40ml/[kg.min] in males, mean of 38-45 declining with age to 33-37 ml/[kg.min] in females) still corresponds to that of a moderately active urban population.

Özdirenç et.al.(2003) made a cross-sectional observational study of 98 rural and 74 urban healthy children (aged 9–11 years) was conducted in Turkey. A questionnaire was used in collecting information about the children's physical activity habits and their school's facilities.
The physical fitness of children was evaluated with EUROFIT test battery. The rural children preferred to play football and volleyball while the urban children had a tendency to prefer indoor sports. The percent of urban children not involved in any sports activity was 35%, while this rate was 30.6% for rural children. It was also found that the urban children watched TV more than the rural children (13.4 ± 2.7 h/week, 10.9 ± 2.7 h/week, respectively). The results showed that body mass index and skinfolds thickness were higher in the urban children (P < 0.05). There were no significant differences in the hip–waist ratio or the hip and waist circumference between the two groups. In cardiopulmonary and motor fitness, no difference was found between the two groups. In contrast, flexibility and muscle endurance were significantly higher in the rural children. The children living in the urban areas were more inactive and obese, which resulted in a decrease in their flexibility and muscle endurance fitness.

2.4 STUDIES ON PHYSIOLOGICAL VARIABLES

Luttnell and Potteigar (2004) examined a study on effects of short term training using power cranks on cardiovascular fitness and cycling efficiency”. The study examining the effect of training by using power cranks or normal cranks on maximal oxygen consumption (VO₂ max) an anaerobic threshold during a graded exercise test, and heart rate, oxygen consumption, respiratory exchange ratio and gross efficiency during a sub maximal one hour ride. The subjects were trained for an hour a day, three days a week for 6 weeks. No differences were found between or within groups for VO₂ max or anaerobic threshold, however the power cranks group had significantly higher gross efficiency, lower heart rate and VO₂ max at various times during the 3 hour ride post training. Thus the training appears to result in a decrease on energy expenditure and enhance physiological adaptations at a given work load, which may ultimately
enable cyclist to increase speed more readily during competition and thereby improves performance.

Voliantis et.al (2003) examined a study in which, “inspiratory muscle training improves rowing performance”. The study was conducted for 11 weeks for fourteen female competitive rowers of British National team. They used 6 minute all out test and a 5000 m test to measure rowing performance. The candidates were broken into two groups and undergone training. The training for experimental group was given twice a day using 30 breaths per session of a resistance equal to 50% of maximum inspiratory pressure. The control group also trained once a day 60 breaths with 15% resistance. The subjects were pre tested and after training of four weeks they were tested. They found the difference of 1.9% improvement between the two groups in 6 minute test as the result of the inspiratory muscle training. In addition the training group improved 5000 m test by 36 second while that of control groups by 11 seconds. Thus the study clearly suggests that a high level rower may benefit from respiratory muscle training.

Pearson et.al. (2004) investigated the physiological and anthropometric characteristics of junior volleyball players competing at the elite, semi-elite, and novice levels and to establish performance standards for these athletes. One hundred and fifty-three junior national (N = 14 males; N = 20 females), state (N = 16 males; N = 42 females), and novice (N = 27 males; N = 34 females) volleyball players participated in this study. Subjects underwent measurements of standard anthropometry (body mass, height, standing reach height, and sum of 7 skinfolds), lower-body muscular power (vertical jump and spike jump), upper-body muscular power (overhead medicine ball throw), speed (5-m and 10-m sprint), agility (T-test), and estimated maximal aerobic power (multistage fitness test) during the competitive phase of the season, after obtaining a degree of match fitness. Significant differences (p < 0.05) were detected among
junior national, state, and novice volleyball players for height, standing reach height, skinfold thickness, lower-body muscular power, agility, and estimated maximal aerobic power, with the physiological and anthropometric characteristics of players typically improving with increases in playing level. Male players were taller, heavier, leaner, and had greater standing reach height, speed, agility, muscular power, and estimated maximal aerobic power than female players. These findings provide normative data and performance standards for junior volleyball players competing at the elite, semi-elite, and novice levels. Given the improvements in lower-body muscular power, agility, and estimated maximal aerobic power with increased playing level, and given the importance of these qualities to competitive performances, conditioning coaches should train these qualities to improve the playing performances of junior volleyball players.

Justin et.al. (2003) , developed an effective testing battery for female field hockey by using anthropometric, physiological, and skill-related tests to distinguish between regional representative (Rep, n = 35) and local club level (Club, n = 39) female field hockey players. Rep players were significantly leaner and recorded faster times for the 10m and 40-m sprints as well as the Illinois Agility Run (with and without dribbling a hockey ball). Rep players also had greater aerobic and lower body muscular power and were more accurate in the shooting accuracy test, p < 0.05. No significant differences between groups were evident for height, body mass, speed decrement in 6 x 40-m repeated sprints, handgrip strength, or pushing speed. These results indicate that, sprinting speed, agility, dribbling control, aerobic and muscular power, and shooting accuracy can distinguish between female field hockey players of varying standards. Therefore talent identification programs for female field hockey should include assessments of these physical parameters.
In recent years researchers in education and related disciplines have begun to take a closer look at the relationship between perception and movement. The frequent appearance in the literature of the terms perceptual motor and sensory motor is indicative of the fact that the interactions of input to output are being scrutinized more and more by contemporary scholars. The studies in which the perceptual abilities of motor activities have been explored in motor skills, while other information emanating from these investigations contributes to more basic understanding of how humans perceive, move and develop during the earliest months of life.

Buskirk ER. (1999) reported that recommendations for endpoints in clinical trials of wasting that involve exercise should involve selection that clearly identifies the effects of exercise. Broad endpoints such as morbidity and mortality must be corrected for the effects of age, smoking, hypertension, etc. in order to gain adjusted information pertinent to exercise. Selection of variables related to physiological function although more specific i.e., maximal oxygen uptake, must still be viewed from the perspective that other variables may contribute to the values measured. Nevertheless, physiological information obtained from performance tests may well provide useful endpoints. In this regard, VO2 max, heartrate and pulmonary ventilation at fixed work loads, muscular strength, reaction time, flexibility, blood gases, cardiac output, stroke volume, serum lactate, and properties of skeletal muscle such as mitochondria concentration and components related to muscle energetics, e.g., adenosine triphosphate. In addition exercise will definitely impact body mass and composition as well as configuration. The latter is assessable through utilization of somatogramography. Analysis of muscle depends on muscle biopsy and magnetic resonance spectroscopy. Neither of these methods has been employed in clinical trials to the best of our knowledge. Thus, one needs evidence that exercise
in the clinical trial provides a discrete effect on performance capabilities, body status and biologically important variables.

Burnham TR, and Wilcox A. (2002) examine the effect of aerobic exercise on physiological and psychological function in patients rehabilitating from cancer treatment. A second purpose was to evaluate the differential effects of low- and moderate-intensity exercise on these variables. METHODS: Eighteen survivors of breast or colon cancer (15 female and 3 male, 40-65 yr of age) served as subjects. The subjects were matched by aerobic capacity and scores on a Quality of Life questionnaire, and then randomly assigned to a control, low- (25-35% heart rate reserve (HRR)), or a moderate- (40-50% HRR) intensity exercise group. The exercise groups performed lower-body aerobic exercise three times a week for 10 wk. After the exercise training, there were no statistically significant differences between the two exercise groups on any of the physiological variables. Therefore, the exercise groups were combined into one group for the final analysis. RESULTS: The results revealed statistically significant increases in aerobic capacity (P < 0.001) and lower-body flexibility (P = 0.027), a significant decrease in body fat (P < 0.001), and a significant increase in quality of life (P < 0.001) and a measure of energy (P = 0.038) in the exercise group when compared with the control group. CONCLUSION: Low- and moderate-intensity aerobic-exercise programs were equally effective in improving physiological and psychological function in this population of cancer survivors. Aerobic exercise appears to be a valuable and well-tolerated component of the cancer-rehabilitation process.

Joshi, et.al. (1998) selected thirty three normal male and forty two normal female subjects, of average age of 18.5 years, underwent six weeks course in 'Pranayam' and their ventilatory lung functions were studied before and after this practice. They had improved
ventilatory functions in the form of lowered respiratory rate (RR), and increases in the forced vital capacity (FVC), forced expiratory volume at the end of 1st second (FEV1%), maximum voluntary ventilation (MVV), peak expiratory flow rate (PEFR-lit/sec), and prolongation of breath holding time.

Makwana et.al. (1988) selected 25 normal male volunteers undergoing a ten weeks course in the practice of yoga have been studied by some parameters of ventilatory functions tests. The observations recorded at the end of ten weeks of the course have shown improved ventilatory functions in the form of lowered respiratory rate, increased forced vital capacity, FEV1, maximum breathing capacity and breath holding time, while tidal volume and %FEV1, did not reveal any significant change. Thus, a combined practice of yoga seems to be beneficial on respiratory efficiency.

Stewart et al. (2005) made a study on “Exercise effects on bone mineral density relationships to changes in fitness and fatness”. Weight loss typically reduces bone mineral density (BMD). Exercise may preserve or increase BMD even while reducing fatness. We examined the relationships among exercise-induced changes in fitness and fatness with BMD. DESIGN: Randomized controlled trial conducted between July 1999 and November 2003. Men and women (n=115) aged 55 to 75 years. Six months of exercise training. Fitness measured as peak oxygen uptake and muscle strength, body composition by anthropometry, dual-energy x-ray absorptiometry, and magnetic resonance imaging. A total of 51 men and 53 women completed the trial. Exercise increased aerobic and strength fitness and lean body mass, and reduced general and abdominal obesity. BMD did not change among men in either group. Among women exercisers, there were reductions in total skeleton BMD (p=0.02) and greater trochanter BMD (p=0.02). By bivariate correlation, among women, increased femoral neck BMD was associated
with increased aerobic fitness (p =0.01) and with reduced body weight (p =0.02) and BMI (p =0.02). In the final regression model, 13% of the change in femoral neck BMD was explained by the change in aerobic fitness (p <0.01). Among the men, increased total hip BMD and femoral shaft BMD were associated with increased lean mass and lower-body strength. In the final regression models, the change in lean mass explained 9% of the variance in total hip BMD (p =0.04). The change in lean mass explained 20% of the change in femoral shaft BMD (p <0.01), and the change in lower-body strength explained an additional 6% (p <0.04). When examined by group assignment, 6 months of exercise had no effect on BMD among men, and reduced BMD among women. When examined by change in fitness and fatness, women who had the greatest increases in aerobic capacity and men who had the greatest increases in strength and lean mass were more likely to increase their BMD. Exercise-induced reductions in fatness did not lead to bone loss.

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

Konrad et al. (2001) made a study on “Neuromuscular Evaluation of Trunk Training Exercises”. To evaluate the neuromuscular activation profiles of trunk muscles in commonly used gymnastic strength exercises with a polymyographic set-up and to describe the training effects of each exercise. Subjects performed 9 repetitions of each of 12 gymnastic exercises. Variations of 5 trunk flexions, 5 extensions, and 2 lateral-flexion movements were performed under standardized test conditions. Ten healthy subjects (men and women) who were familiar with the exercises participated in the study. We recorded surface electromyograms (EMGs) from the rectus abdominis, external oblique, rectus femoris, middle trapezius, erector spinae at T12 and L3, gluteus maximus, and semitendinosus and semimembranosus muscles. Recording of each repetition cycle was triggered by a flexible electronic goniometer attached to the trunk. The raw EMG signals were rectified, smoothed, amplitude normalized to maximal voluntary contraction (MVC), and averaged for the last 8 repetitions. Pure spine-flexion exercises, such as a curl-up, produced sufficient and isolated activation (greater than 50% MVC) of the abdominal muscles. When flexion of the spine was combined with hip flexion (sit-up), the peak activation was increased. Lateral-flexion tasks targeted primarily the external oblique muscle, which demonstrated high activity in side-lying flexion tasks. Back- and hip-extension exercises, such as bridging and diagonal hip and shoulder extension, produced only moderate mean activities (less than 35% MVC) in the trunk-extensor muscles. Trunk-extension exercises with combined hip extension increased the EMG activity to 50% MVC but only at the end of the extension. Individual responses to each exercise varied markedly, which complicated the classification of exercise effects. However, within the limitations of the study, we found that the chosen
abdominal exercises provided an effective training stimulus for the trunk-flexor muscles, whereas in the back- and hip-extension exercises, the neuromuscular activation tended to be too low or unspecific to qualify as muscle specific training.

Hubley-Kozey and Vezina (2002) studied the “Muscle activation during exercises to improve trunk stability in men with low back pain”. To evaluate the relative activation amplitudes from 3 abdominal and 2 trunk extensor muscle sites of persons with low back pain (LBP) performing the pelvic-tilt, the abdominal-hollowing, and level 1 of the trunk stability test (TST) exercises and to compare the activation amplitudes among muscle sites and exercises, A prospective, comparative, repeated-measures design. Motion analysis research laboratory. Fourteen men with LBP (mean duration, 8y; mean age +/-standard deviation, 39+/-5y). Subjects performed 3 exercises in random order while surface electromyograms were recorded from 5 muscle sites: lower and upper rectus abdominus, external oblique, erector spinae, and multifidus. The exercises were divided into 2 phases: a movement phase and a stabilization phase. The root-mean-square (RMS) electromyographic amplitude for each phase was calculated and normalized to the highest RMS amplitude from a series of 4 exercises, which attempted to elicit maximal voluntary isometric contractions (MVICs) for each muscle. A 2-factor, repeated-measures analysis of variance (ANOVA) tested the muscle by exercise interaction and the 2 main effects for each phase separately. Normalized RMS amplitude was the main dependent variable. The ensemble-average profiles for each muscle were calculated to examine the phasing of activation throughout the exercises. The ANOVA revealed a statistically significant muscle-by-exercise interaction (P<05) for both phases, which showed that the 3 exercises; recruited the 5 muscle sites using different patterns of relative amplitudes. The external oblique muscle site was activated to higher amplitudes than the other 4 muscle sites for all 3 exercises; the highest
normalized RMS activity occurred at the external oblique during the pelvic tilt (32% MVIC). The phasic patterns among the 5 muscle sites were not consistent for the TST but were consistent among the 5 sites for the other 2 exercises. None of the exercises recruited the abdominal muscles to intensities deemed adequate for strengthening. The TST challenges the coordination of muscle activity during the leg-loading task (stabilization phase) as evidenced by changes in amplitudes over the total exercise time for the external oblique site, but not the other 4 sites. All 3 exercises could be used as initial exercises in a dynamic stability progression when low-recruitment amplitudes of specific muscles were the objective but not for strengthening.

### 2.5 STUDIES ON ANTHROPOMETRIC VARIABLES

Pelin C, et.al. (2009) made comparative reports on the anthropometric characteristics of athletes are certainly important in modern sports and have long been studied by sports scientists. Studies on Turkish athletes however, are limited. In the present study physical characteristics of athletes active in various sports (American football, basketball, volleyball and football) were observed and compared to each other and to those of non-athlete individuals. 153 volunteer male subjects participated in the study. All of the athletes were licensed members of teams in inter-university leagues. All subjects were given information about the objectives of the study and were advised of the manner with which the anthropometric measurements would be obtained. In addition to 17 anthropometric values, body mass index (BMI) and somatotype components were calculated and evaluated. Length, breadth, and girth values were evaluated by ANCOVA and height and weight were used as co-variate factors. The other variables were evaluated by metric and non-metric ANOVA. The results of the study indicate that basketball and volleyball players were characteristic with their longer lower limb length; American football players were with their wider biiliac breadth and higher girth values; and football players with their small structure.
It was also observed that Turkish athletes have higher endomorphy and lower mesomorphy values when compared to athletes from other countries.

Jurimae T, et.al. (2009) examined the relationship of handgrip strength with basic anthropometric variables, hand anthropometric variables, total body and hand composition, total body and hand bone mineral density (BMD) and bone mineral content (BMC) in prepubertal children aged between 8 and 11 years (n=64, 27 boys, 37 girls). Height and body mass were measured and body mass index (BMI kg/m2) was calculated. Biceps and triceps skinfolds, arm relaxed, arm flexed, forearm and wrist girths, acromiale-radiale, radiale-stylion-radiale and midstylion-dactylion length and humerus breadth were measured. Specific hand anthropometric variables according to Visnapuu and Jurimae [2007. Handgrip strength and hand dimensions in young handball and basketball players. Five fingers' spans, fingers' lengths and perimeters of the hand were measured. Total body and right-hand fat percentage, fat mass and lean mass (LBM) were measured by dual-energy X-ray absorptiometry (DXA). Right-hand BMC and BMD were analysed from the bone variables. Maximal handgrip strength of the right hand was measured with the hand dynamometer. Stepwise multiple regression analysis indicated that the most important predictive value from the basic anthropometric variables was body height, explaining 76.1% (R2 x 100), 40.7% and 50.6% of the handgrip strength in boys, girls and total group, respectively. Measured skinfold thicknesses and breadths were not related to handgrip strength in any group. Forearm girths significantly predicted handgrip strength in boys (30.8%), girls (43.4%) and total group (43.4%). As a rule, handgrip strength was more dependent on the anthropometric and body composition variables in boys than girls. It was concluded that body height, forearm girth, midstylion-dactylion and acromiale-radiale length and hand LBM and BMC are the most limiting factors influencing handgrip strength in prepubertal children.
Mikulic P. (2009) examined the anthropometric and metabolic determinants of performance during 6,000-m of rowing on an ergometer. The sample comprised 25 internationally successful male heavyweight rowers (mean +/- SD: age 22.2 +/- 4.8 years, rowing experience 8.8 +/- 4.6 years, stature 1.91 +/- 0.05 m, body mass 91.7 +/- 5.9 kg, maximal oxygen uptake 5.53 +/- 0.30 L x min(-1)). The rowers completed an incremental maximal exercise test on a rowing ergometer and, within 2 weeks of this test, also completed a 6,000-m rowing ergometer time trial (mean +/- SD: 1195.4 +/- 36.1 seconds). The strongest correlates (r > 0.5, p < 0.05) with performance were lean body mass (r = -0.767), power output at ventilatory threshold (r = -0.743), power output at maximal oxygen uptake (r = -0.732), body mass (r = -0.693), chest girth (r = -0.598), relaxed arm girth (r = -0.574), forced vital capacity (r = -0.519), and arm span (r = -0.505). Stepwise multiple linear regression procedures indicated that the model comprising a combination of anthropometric and metabolic variables is the best predictor of performance (adjusted R2 = 0.722), followed by models comprising anthropometric (adjusted R2 = 0.575) and metabolic (adjusted R2 = 0.530) variables alone. The results suggest that 6,000-m ergometer performance is determined mainly by power output at ventilatory threshold (58.7% of explained variance). Based on the obtained correlations and regression models, it can be concluded that rowers competing over a 6,000 m distance on a rowing ergometer should devote their training time to the improvement of lean body mass and to the improvement of power output corresponding to ventilatory threshold.

Vucetić V, et.al. (2008) presented the morphological characteristics of 54 Croatian national level track-and-field athletes. 21 anthropometric body measures were taken on a sample of 15 sprinters (S), 16 endurance sprinters (S4), 10 middle-distance runners (MD) and 13 long-distance runners (LD). Body fat percentage, body mass index and somatotype were also
calculated. Canonical discriminative analysis showed significant difference between the athletes of various running events, in the measures of body volume and body fat, while no significant difference was found in the variables of longitudinal and transversal dimensions of the skeleton. ANOVA and Student t-test for independent samples showed statistically significantly higher thigh and lower leg circumference in sprinters, as well as greater upper arm skinfold in middle-distance runners. The mesomorphic component is a dominant characteristic of somatotype of the runners in all events, whereas the ectomorphic component is the least marked.

Sheppard JM, et.al. (2008) examined the potential strength, power, and anthropometric contributors to vertical jump performances that are considered specific to volleyball success: the spike jump (SPJ) and counter-movement vertical jump (CMVJ). To assess the relationship among strength, power, and anthropometric variables with CMVJ and SPJ, a correlation and regression analysis was performed. In addition, a comparison of strength, power, and anthropometric differences between the seven best subjects and the seven worst athletes on the CMVJ test and SPJ test was performed. When expressed as body mass relative measures, moderate correlations (0.53-0.65; p < or = 0.01) were observed between the 1RM measures and both relative CMVJ and relative SPJ. Very strong correlations were observed between relative (absolute height-standing reach height) depth jump performance and relative SPJ (0.85; p < or = 0.01) and relative CMVJ (0.93; p < /= 0.01). The single best regression model component for relative CMVJ was the relative depth jump performance, explaining 84% of performance. The single best predictor for relative SPJ was also the relative depth jump performance (72% of performance), with the three-component models of relative depth jump, relative CMVJ, spike jump contribution (percent difference between SPJ and CMVJ), and relative CMVJ, spike jump contribution, and peak force, accounting for 96% and 97%, respectively. The results of this study
clearly demonstrate that in an elite population of volleyball players, stretch-shortening cycle performance and the ability to tolerate high stretch loads, as in the depth jump, is critical to performance in the jumps associated with volleyball performance.

Ricarte Batista G, et.al. (2008) compared the anthropometric profile and the vertical jumps of two groups of Brazilian male high performance beach volleyball players. The sample consisted of 38 male beach volleyball players from the Brazilian Beach Volleyball Circuit of 2006, allocated to two groups according to national ranking of their teams. Anthropometric measures and performance in vertical jumps were assessed using a specific methodology. Results: The anthropometric results of the groups showed no statistically significant differences. The players of group 1 (G1) were better in the spike jump (P<0.01), block jump (P<0.01) and block difference (P<0.01) than the players of group 2 (G2). The prediction model of the spike jump for G2 included body mass and standing spike reach (adjusted R2=0.77) while for the block jump model it was body mass and standing block reach (adjusted R2=0.73). The regression models for G1 were not statistically significant. Conclusion: It is likely that vertical jump height (spike and block) influences the performance of beach volleyball players, and consequently the performance of their teams, since the present study found higher values in G1 than in G2 for the spike jump, block jump and block difference. However, an athlete's success is not related only to the variables investigated in this study; technical skill, tactics, psychology and physical conditioning can also play a role.

Sánchez-Muñoz C, et.al. (2007), described the anthropometric characteristics, body composition and somatotype of elite male and female junior tennis players, to compare the anthropometric data, body composition and somatotype of the first 12 elite junior tennis players on the ranking with the lower ranked players, and to establish an anthropometric profile chart for
elite junior tennis players. A total of 123 (57 males and 66 females) elite junior tennis players participated in this study. The athletes were divided into two groups, the first 12 and the lower ranked players, according to gender. A total of 17 anthropometric variables were recorded of each subject. There were no significant differences in height and weight between the first 12 and the lower ranked boys, while the first 12 girls were significantly taller than the lower ranked girls ($p = 0.009$). Significant differences were found for humeral and femoral breadths between the first 12 and the lower ranked girls ($p = 0.000; p = 0.004$, respectively). The mean (SD) somatotype of elite male junior tennis players could be defined as ectomesomorphic (2.4 (0.7), 5.2 (0.8), 2.9 (0.7)) and the mean (SD) somatotype of elite female junior tennis players evaluated could be defined as endomesomorphic (3.8 (0.9), 4.6 (1.0), 2.4 (1.0)). No significant differences were found in somatotype components between the first 12 and the lower ranked players of both genders. Conclusions: When comparing the first 12 and the lower ranked elite junior tennis players of both genders, no significant differences were observed in any measured item for the boys. By contrast, significant differences were observed in height and humeral and femoral breadths between the first 12 and the lower ranked girls, whereby the first 12 were taller and had wider humeral and femoral breadths than the lower ranked players. These differences could influence the playing style of junior female players.

Knechtle B, et.al. (2007) investigated the influence of anthropometric variables on race performance in ultra-endurance triathletes in an ultra-triathlon. Descriptive field study. The "World Challenge Deca Iron Triathlon 2006" in Monterrey, Mexico, in which everyday for 10 consecutive days athletes had to perform the distance of one Ironman triathlon of 3.8 km swimming, 180 km cycling and 42.195 km running. Eight male ultra-endurance athletes (mean (SD) age 40.6 (10.7) years, weight 76.4 (8.4) kg, height 175 (4) cm and body mass index (BMI)
interventions: none. main outcome measures: direct measurement of body mass, height, leg length, skinfold thicknesses, limb circumference and calculation of BMI, skeletal muscle mass (SM), percentage SM (%SM) and percentage body fat (%BF) in order to correlate measured and calculated anthropometric variables with race performance. Results: Race time was not significantly (p>0.05) influenced by the directly measured variables, height, leg length, body mass, average skinfold thicknesses, or circumference of thigh, calf or upper arm. Furthermore, no significant (p>0.05) correlation was observed between race time and the calculated variables, BMI, %SM and %BF. Conclusions: In a multistage ultra-triathlon over 10 Ironman triathlon distances in 10 consecutive days, there was no effect of body mass, height, leg length, skinfold thicknesses, limb circumference, BMI, %SM or %BF on race performance in the only eight finishers.

Angyán L, (2007) examined the relationship between body balancing functions and body characteristics, motor abilities and reaction time. Subjects were 33 university students and 11 professional basketball players sorted into four groups of athletic and non-athletic women and men. Each group consisted of eleven subjects. The body height, weight was measured and the body mass index (BMI) calculated. A bioelectrical device computed the body fat (%). Static and dynamic motor tests, as well as static and dynamic balance tests were used. The reaction time (RT) to sound and light stimuli was measured. The regression analysis of the data revealed significant linear relationship between the amplitude of body sways (BS) and BMI in all groups. Also high correlation was found between back muscle strength and BS in all groups except the non-athletic women. Negative correlation was found between endurance capacity and BS in basketball players, i.e. at higher endurance capacity smaller amplitude BS occurred (r = -0.620, p < 0.04). The RT values showed significant correlations with BS only in the basketball players (r
It is concluded that increase in BMI, back muscle strength and endurance capacity is associated with better postural stability. Some motor abilities (hip flexibility, vertical jumping) show no significant correlations with body balancing, while other motor performances (static hanging) and RT values correlate well with BS only in the well-trained elite basketball players.

Bayios IA, et.al. (2006) made a study a) to determine the anthropometric profile, body composition and somatotype of elite Greek female basketball (B), volleyball (V) and handball (H) players, b) to compare the mean scores among sports and c) to detect possible differences in relation to competition level. Methods: A total of 518 female athletes, all members of the Greek first National League (A1 and A2 division) in B, V and H sport teams participated in the present study. Twelve anthropometric measures required for the calculation of body composition indexes and somatotype components were obtained according to the established literature. Results: V athletes were the tallest (P<0.001) among the three groups of athletes, had the lowest values of body fat (P<0.001) and their somatotype was characterized as balanced endomorph (3.4-2.7-2.9). B athletes were taller (P<0.01) and leaner (P<0.001) than H players, with a somatotype characterized as mesomorph-endomorph (3.7-3.2-2.4). H athletes were the shortest of all (P<0.01), had the highest percentage of body fat (P<0.001) and their somatotype was mesomorph-endomorph (4.2-4.7-1.8). In comparison with their A2 counterparts the A1 division players were taller (P<0.001) and heavier (P<0.01), but at the same time leaner (P<0.001), and exhibited higher homogeneity in somatotype characteristics (P<0.05). Conclusions: Anthropometric, body composition and somatotype variables of Greek female elite teamball players varied among sports; selection criteria, hours of training and sport-specific physiological
demands during the game could explain the observed differences. More data are certainly needed to define the anthropometric profile of B, V and H female athletes internationally.

Wang YT, et.al. (2005) determined the contributions of selected fundamental factors, such as arm length, sitting height, simple vision reaction time (SVRT), choice vision reaction time (CVRT), muscle strength, and range of motion (ROM) at the shoulder, elbow, and wrist joints to wheelchair basketball (WCB) performance as measured by season statistics and coaches' evaluation. Methods: Thirty-seven Paraolympic WCB players from seven countries participated in this study. A computerized reaction time system was used to test the SVRT and CVRT. The ROM and muscle strengths of the shoulder, elbow, and wrist joints were measured using a goniometer and MP DA100B BioPac force measurement system, respectively. Stepwise regression analysis was used to identify the contributions of these fundamental factors and "dimensional variables" (DV) derived from the selected factors fundamental to WCB performance. A DV represented a dimension or category of the factor, for example, the wrist flexion/extension DV represented the ROM of the wrist in flexion and extension, and the WCB performance DV represented average points, rebounds, assists, blocks, and steals per game. Results: The results of this study demonstrated that elbow extension and wrist extension had significant contributions to average points. Sitting height, shoulder internal rotation, and elbow flexion had significant contributions to the average rebounds. Arm length had a significant contribution to average assists, and SVRT had a significant contribution to the average blocks. Wrist flexion/extension ROM DV and wrist flexion/extension strength DV had significant contributions to the WCB performance DV. Conclusion: Shoulder internal rotation, elbow extension, and wrist flexion/extension ROM, CVRT, and wrist flexion/extension muscle strength are important to WCB performance and should be addressed in WCB training.
E.M. Gorostiaga et al. (2005) compared anthropometric and physical characteristics (body height, body mass [BM], body fat [BF], and free fatty mass [FFM]), one repetition maximum bench-press (1RM$_{BP}$), explosive strength (VJ), handball throwing velocity, power-load relationship of the leg and arm extensor muscles, 5- and 15-m sprint running time, and running endurance in two handball male teams: elite team, one of the world's leading teams (EM, n = 15) and amateur team, playing in the Spanish National Second Division (AM, n = 15). EM had similar values in body height, BF, VJ, 5- and 15-m sprint running time and running endurance than AM. However, the EM group gave higher values in BM (95.2 ± 13 kg vs. 82.4 ± 10 kg, p < 0.05), FFM (81.7 ± 9 kg vs. 72.4 ± 7 kg, p < 0.05), 1RM$_{BP}$ (107 ± 12 kg vs. 83 ± 10 kg, p < 0.001), muscle power during bench-press (18 - 21%, p < 0.05) and half squat (13 - 17%), and throwing velocities at standing (23.8 ± 1.9 m·s$^{-1}$ vs. 21.8 ± 1.6 m·s$^{-1}$, p < 0.05) and 3-step running (25.3 ± 2.2 m·s$^{-1}$ vs. 22.9 ± 1.4 m·s$^{-1}$, p < 0.05) actions than the AM group. Significant and AM between individual values of velocity at 30% of 1RM$_{BP}$ and individual values of ball velocity during a standing throw. Significant correlations were observed in EM, but not in AM, between the individual values of velocity during 3-step running throw and the individual values of velocity at 30% of 1RM$_{BP}$ (r = 0.72, p < 0.05), as well as the individual values of power at 100% of body mass during half-squat actions (r = 0.62, p < 0.05). The present results suggest that more muscular and powerful players are at an advantage in handball. The differences observed in free fatty mass could partly explain the differences observed between groups in absolute maximal strength and muscle power. In EM, higher efficiency in handball throwing velocity may be associated with both upper and lower extremity power output capabilities, whereas in AM this relationship may be different. Endurance capacity does not seem to represent a limitation for elite performance in handball.
Williams AG, and Wilkinson M. (2007) reported that Box-lifting ability is an important characteristic of military personnel. The purpose of this paper was to determine the usefulness of the upright row free weight exercise and simple anthropometric tests to predict maximal box-lifting performance that simulates the loading of military supply vehicles. Two groups of adults performed maximal box lifts to 1.4 m (study 1) and 1.7 m (study 2), respectively. All subjects were also tested for upright row 1 repetition maximum (1RM) strength, body mass, height, and body composition. In study 1, a remarkably good prediction of maximal box-lift performance to 1.4 m (42 +/- 12 kg) was obtained from a regression equation including the variables body mass, body composition, and upright row 1RM. Approximately 95% of the variation in 1.4-m box-lifting performance could be accounted for. In contrast, in study 2, only 80% of the variation in 1.7-m box-lifting performance (51 +/- 15 kg) could be accounted for by the best predictor equation. Upright row 1RM strength appears to be a useful tool in the prediction of box-lifting ability to approximately chest height for most adults, probably due to a close match between the muscle groups and contraction modes required during both tasks. Military or other organizations could use the data reported here to substitute simple anthropometry and a 1RM test of strength and for the direct assessment of 1.4-m box-lifting performance.

Gamelin FX, et.al. (2006) reported that Critical velocity (CV) represents, theoretically, the highest velocity that can be sustained without fatigue. The aim of this study was to compare CV computed from 5 mathematical models in order to determine which CV estimate is better correlated with 1-hour performance and which model provides the most accurate prediction of performance. Twelve trained middle- and long-distance male runners (29 +/- 5 years) performed 3 randomly ordered constant duration tests (6, 9, and 12 minutes), a maximal running velocity test for the estimation of CV, and a 1-hour track test (actual performance). Two linear, 2
nonlinear, and 1 exponential mathematical models were used to estimate CV and to predict the highest velocity that could be sustained during 1 hour (predicted performance). Although all CV estimates were correlated with performance ($0.80 < r < 0.93$, $p < 0.01$), it appeared that CV estimated from the exponential model was more closely associated with performance than all other models ($r = 0.93; p < 0.01$). Analysis of the bias +/- 95% interval of confidence between actual and predicted performance revealed that none of the models provided an accurate prediction of the 1-hour performance velocity. In conclusion, the estimation of CV allows us to rank middle- and long-distance runners with regard to their ability to perform well in long-distance running. However, no models provide an accurate prediction of performance that could be used as a reference for coaches or athletes.

Biddle SJ, et.al. (1999) predicted physical activity intentions in 12 to 16-year-old Hungarian adolescents with two samples. Theoretical predictions established a model that was tested through path analysis. Beliefs thought to underpin goal orientations were hypothesised to predict ego orientation (general and gift beliefs) and task orientation (learning and incremental beliefs). Task orientation was hypothesised to predict intentions directly, while ego orientation was hypothesised to predict intentions indirectly through perceived competence. Results from the first sample ($n=301$) suggested that the model could be improved by adding paths between general beliefs and perceived competence and between task orientation and perceived competence. This modified model was shown to fit data from a second sample ($n=422$) very well. Multi-group analysis confirmed a good fit and so the two samples were combined. The model fitted the data well for the total sample ($n=723$). Overall, results showed that 20.8% of the variance in intentions was explained by the model, and that sport ability beliefs were moderately associated with task orientation but only weakly associated with ego orientation. The
motivational importance of a task orientation was confirmed with its direct prediction of intentions.

Lintunen T, et.al. (1999) studied physical activity intentions in 12- to 16-year-old Finnish girls (n= 186) and boys (n=215). Theoretical predictions were used to establish a model that was then tested separately for each sex using path analysis. Firstly, it was hypothesised that malleable conceptions of the nature of sport ability positively influence enjoyment in physical activity and intentions to participate in physical activity, mediated by a task-oriented achievement goal independent of variations in perceptions of competence. Secondly, it was hypothesised that fixed conceptions of the nature of ability decrease enjoyment in physical activity and intentions to participate, mediated by an ego-oriented achievement goal and by perceived competence. The modified models were shown to fit the data. Overall, the results showed that 63% (boys) and 45% (girls) of the variance in intentions was explained by the model. The motivational importance of task orientation and, among the boys, perceived physical competence was confirmed with their direct prediction of intentions.

Falk B, et.al. (2004) reported that The processes of talent detection and early development are critical in any sport programme. However, not much is known about the appropriate strategies to be implemented during these processes, and little scientific inquiry has been conducted in this area. The aim of this study was to identify variables of swimming, ball handling and physical ability, as well as game intelligence, which could assist in the selection process of young water-polo players. Twenty-four players aged 14-15 years underwent a battery of tests three times during a 2-year period, before selection to the junior national team. The tests included: freestyle swim for 50, 100, 200 and 400 m, 100-m breast-stroke, 100-m 'butterfly' (with breast-stroke leg motion), 50-m dribbling, throwing at the goal, throw for distance in the
water, vertical 'jump' from the water, and evaluation of game intelligence by two coaches. A comparison of those players eventually selected to the team and those not selected demonstrated that, 2 years before selection, selected players were already superior on most of the swim tasks (with the exception of breast-stroke and 50-m freestyle), as well as dribbling and game intelligence. This superiority was maintained throughout the 2 years. Two-way tabulation revealed that, based on baseline scores, the prediction for 67% of the players was in agreement with the final selection to the junior national team. We recommend that fewer swim events be used in the process of selecting young water-polo players, and that greater emphasis should be placed on evaluation of game intelligence.

Blazevich AJ, et. al. (2003) examined changes in the muscle size, muscle architecture, strength, and sprint/jump performances of concurrently training athletes during 5 wk of "altered" resistance training (RT). METHODS: Eight female and 15 male athletes performed 4 wk of sprint, jump, and resistance training in addition to their sports training (standardization) before adopting one of three different programs for 5 wk: 1) squat lift training (SQ, N = 8) with sprint/jump training; 2) forward hack squat training (FHS, N = 7) with sprint/jump training; or 3) sprint/jump training only (SJ, N = 8). Muscle size, fascicle angle, and fascicle length of the vastus lateralis (VL) and rectus femoris (RF) muscles (using ultrasound procedures) as well as 20-m sprint run, vertical jump, and strength performance changes were examined. RESULTS: A small increase in VL fascicle angle in SQ and FHS was statistically different to the decrease in SJ subjects (P < 0.05 at distal, P < 0.1 at proximal). VL fascicle length increased for SJ only (P < 0.05 at distal, P < 0.1 at proximal) and increased in RF in SQ subjects (P < 0.05). Muscle thickness of VL and RF increased in all training groups (P < 0.05) but only at proximal sites. There were no between-group differences in squat, forward hack squat, or isokinetic strength
performances, or in sprint or jump performances, despite improvements in some of the tests across the groups. CONCLUSIONS: Significant muscle size and architectural adaptations can occur in concurrently training athletes in response to a 5-wk training program. These adaptations were possibly associated with the force and velocity characteristics of the training exercises but not the movement patterns. Factors other than, or in addition to, muscle architecture must mediate changes in strength, sprint, and jump performance.

Dowson MN, et.al.(1998) studied that muscle strength is thought to be a major factor in athletic success. However, the relationship between muscle strength and sprint performance has received little attention. The aim of this study was to examine the relationship in elite performers of isokinetic muscle strength across three lower limb joints and sprinting performance, including the use of theoretical models. Eight rugby players, eight track sprinters and eight competitive sportsmen, all elite national or regional competitors, performed sprints over 15 m and 35 m with times recorded over 0-15 m and 30-35 m. Isokinetic torque was measured at the knee, hip and ankle joints at low (1.05 rad s(-1)), intermediate (2.09 or 2.62 rad s(-1)) and high (3.14 or 4.19 rad s(-1)) speeds during concentric and eccentric muscle actions. Using linear regression and expressing sprint performance as time, the strongest relationship, for the joint actions and speeds tested, was between concentric knee extension at 4.19 rad s(-1) and sprint performance (0-15 m times: r=-0.518, P< 0.01; 30-35 m times: r=-0.688, P< 0.01). These relationships were improved for 0-15 m, but not for 30-35 m, by expressing torque relative to body mass (0-15 m times: r=-0.581; 30-35 m times: r=0.659). When 0-15 m performance was expressed as acceleration rather than time, the correlation was improved slightly (r=0.590). However, when the data (0-15 m times) were fitted to the allometric force model proposed by Gunther, 77% of the variance in concentric knee extension torque at 4.19 rad s(-1) could be explained by 0-15 m times, limb
length (knee to buttocks) and body mass. The fitted parameters were similar to those from the theoretical model. These findings suggest that the relationship between isokinetic muscle strength and sprint performance over 0-15 m (during the acceleration phase) is improved by taking limb length and body mass into account.

Ross A, and Leveritt M (2001). studied the adaptations of muscle to sprint training can be separated into metabolic and morphological changes. Enzyme adaptations represent a major metabolic adaptation to sprint training, with the enzymes of all three energy systems showing signs of adaptation to training and some evidence of a return to baseline levels with detraining. Myokinase and creatine phosphokininase have shown small increases as a result of short-sprint training in some studies and elite sprinters appear better able to rapidly breakdown phosphocreatine (PCr) than the sub-elite. No changes in these enzyme levels have been reported as a result of detraining. Similarly, glycolytic enzyme activity (notably lactate dehydrogenase, phosphofructokinase and glycogen phosphorylase) has been shown to increase after training consisting of either long (>10-second) or short (<10-second) sprints. Evidence suggests that these enzymes return to pre-training levels after somewhere between 7 weeks and 6 months of detraining. Mitochondrial enzyme activity also increases after sprint training, particularly when long sprints or short recovery between short sprints are used as the training stimulus. Morphological adaptations to sprint training include changes in muscle fibre type, sarcoplasmic reticulum, and fibre cross-sectional area. An appropriate sprint training programme could be expected to induce a shift toward type IIa muscle, increase muscle cross-sectional area and increase the sarcoplasmic reticulum volume to aid release of Ca(2+). Training volume and/or frequency of sprint training in excess of what is optimal for an individual, however, will induce a shift toward slower muscle contractile characteristics. In contrast, detraining appears to shift the
contractile characteristics towards type IIb, although muscle atrophy is also likely to occur. Muscle conduction velocity appears to be a potential non-invasive method of monitoring contractile changes in response to sprint training and detraining. In summary, adaptation to sprint training is clearly dependent on the duration of sprinting, recovery between repetitions, total volume and frequency of training bouts. These variables have profound effects on the metabolic, structural and performance adaptations from a sprint-training programme and these changes take a considerable period of time to return to baseline after a period of detraining. However, the complexity of the interaction between the aforementioned variables and training adaptation combined with individual differences is clearly disruptive to the transfer of knowledge and advice from laboratory to coach to athlete.

Sleivert G, and Taingahue M.(2004) investigated the relationship between sprint start performance (5-m time) and strength and power variables. Thirty male athletes [height: 183.8 (6.8) cm, and mass: 90.6 (9.3) kg; mean (SD)] each completed six 10-m sprints from a standing start. Sprint times were recorded using a tethered running system and the force-time characteristics of the first ground contact were recorded using a recessed force plate. Three to six days later subjects completed three concentric jump squats, using a traditional and split technique, at a range of external loads from 30-70% of one repetition maximum (1RM). Mean (SD) braking impulse during acceleration was negligible [0.009 (0.007) N/s/kg] and showed no relationship with 5 m time; however, propulsive impulse was substantial [0.928 (0.102) N/s/kg] and significantly related to 5-m time ( r=-0.64, P<0.001). Average and peak power were similar during the split squat [7.32 (1.34) and 17.10 (3.15) W/kg] and the traditional squat [7.07 (1.25) and 17.58 (2.85) W/kg], and both were significantly related to 5-m time ( r=-0.64 to -0.68, P<0.001). Average power was maximal at all loads between 30% and 60% of 1RM for both
squats. Split squat peak power was also maximal between 30% and 60% of 1RM; however, traditional squat peak power was maximal between 50% and 70% of 1RM. Concentric force development is critical to sprint start performance and accordingly maximal concentric jump power is related to sprint acceleration.

2.6 SUMMARY OF RELATED LITERATURE

The investigator has reviewed related literature relating physical fitness, physiological and anthropometric variables among volleyball players, net ball players and different other games and groups. Through the review of related literature the investigator found that there was further scope for research in comparing selected anthropometric, physical fitness and physiological variables between netball and volleyball players.

Based on the exper gained the investigator formulated suitable methodology to be adopted, which is presented in chapter III.