Chapter II

REVIEW OF THE RELATED LITERATURE

An exhaustive review has been presented in this chapter. For this purpose every effort was made by the research scholar to have access to maximum literature selected to the study. Some of the studies cited in this chapter do not have direct relevance to the present study but are indirectly related.

Dey\(^1\) analyzed the maturity and physical growth of boys ages seven through twelve years. He found that maturity and physical growth tests showed high levels of inter age consistency, specially between adjacent ages. As the boys advanced in age, their means on all measures but the indexes increased, the measures of three indexes increased and decreased at different ages; the means of sitting height/standing height steadily decreased. Absolute variability also increased with age with the exception of

sitting height/standing height, when it was constant through out the age. He had the opinion that differences between high and low skeletal ages group, gross strength groups, weight groups, formed at age nine years, maintained significant mean difference on the other tests.

Santammria\(^2\) made a longitudinal analysis of maturity and physical growth of boys ages twelve through seventeen years. The subjects were tested for maturity, body linearity, body bulk, and indexes reflecting body proportions. Analysis employed were inter-age correlations among all ages for each variable; means, standard deviations, and coefficient of variation, construction of mean velocity curves, differences in growth patterns, high and low maturity growth strength, relative strength, weight and height groups. Except for lung capacity between .64 and .97, with the heighest correlations between adjacent ages and the lowest when five year intervened. As the boys advanced in age, their mean in all measures but the indexes increased gradually, standard deviation also increased with age.

Difference between high and low maturity groups, gross strength groups, weight groups and height groups formed at twelve years of age maintained significant mean differences on the other tests for the six years of the study.

Jordan conduct the study on 93 boys which were studied longitudinally from age 9 to 12 years and data from 47 subjects were available from age 7 to 12 years. A moderate degree of inter-age consistency was found over the 6 year period for bar push-ups, standing broad jump, 60 yard shuttle run, cable tension strength average, strength index, and physical fitness index; the highest of these were for bar push-ups, .886 between age 11 and 12 years; .876 between age 8 and 9 years, and .826 between age 10 to 11 years. The comparison of the strength and motor ability means for advance and retarded maturity groups revealed continuous significant differences for the two gross strength test batteries, cable tension strength average, and strength index when the growth patterns of high and low PFI groups were compared, continuous significant differences

were obtained for bar push-ups and strength index over the four year period.

Bailey made a longitudinal analysis on 111 boys from ages 12 to 17 years. Data were collected on the individual muscle groups, dynamometric strengths, gross and relative strength batteries, muscular endurance, and motor ability elements. Ten of the fourteen variables studied had a moderate degree of inter age consistency, especially when the correlations were between adjacent ages. As the boys advanced in age, the means of all the measures increased except for the PFI. The longitudinal changes in absolute variability were not consistent. Differences between high and low skeletal age groups and high and low cable tension strength groups formed at age 12 years maintained significance on most other tests through 17 years of age.

Buckellew collected data at each grade level, subjects were evaluated in physical fitness (AAHPER Youth...
Fitness Test), physical growth (Wetzel Grid) educational achievement (Iowa Basic Skill Test), and mental capacity (California Mental Maturity Test). Differences in physical fitness, physical growth, and intelligence of boys classified into high, middle, and low achievement academically at each grade level were analyzed. There was no apparent relationship between physical fitness and academic achievement or intelligence. There was no relationship between developmental level (physical growth) and academic achievement or intelligence. Grade 5, 6, 7 and 8 were progressively (although not necessarily significantly) better in physical performance.

Jordan conducted a study to analysed mental health and tests of body size, physique, strength, motor ability, and maturity, were administered annually to 58 boys aged 15 through 17 years. Inter age correlations of 12 of the 13 mental health scores ranged from .577 to .865 with the highest correlations between adjacent ages. Twenty four correlations between mental health measures and the other

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tests were significant and 17 of the signified correlations occurred at age 15. Average cable-tension strength showed the most significant correlations with mental health, followed by body weight and standing broad jump. None of the 30 comparisons between high and low mental health groups on the test variables over the 3 years period were significant.

Rasmussen\textsuperscript{7} conducted a study to determine the effects of physical activity on structural and functional growth of boys followed longitudinally from age seven through sixteen years. From the boys who were part of the Saskatchewan child growth and development study, a group of 105 boys, tested annually for ten years was used to develop standard growth curve for: standing height, body weight, vital capacity, elbow extension strength, knee extension strength, standing broad jump, absolute maximal oxygen uptake and maximal oxygen uptake expressed per kilogram of body weight. It was conducted that lack of physical activity may have resulted in significant gains in body

\textsuperscript{7}Roy Leonard Rasmussen, "A Longitudinal Investigation of Selected Variables in Physically Active and Inactive Boys Studied during their Circumpubertal Years,"\textit{ Dissertation Abstracts International} 39 (June 1979):7225-A.
weight in the inactive group and that physical activity may have enhanced the active boys' relation maximal oxygen uptake. Being physically active and inactive, within the normal range of activity for boys seven through sixteen years of age, does not appear to affect the decline in relative oxygen uptake which occurs in both group. Standing broad jump appears to improve more than would be expected due to increasing size whether one is physically active or inactive.

Howe\textsuperscript{8} constructed a T scale profile based on 16 maturity, body size, strength, motor ability and mental ability measurements taken at ages 9, 12 and 15. The five who were outstanding out of a total of 20 athletes at both ages 12 and 15 were average or above on all tests at the three ages and were definitely higher in strength, endurance and motor performance at age fifteen. The nine, who were outstanding at age 15 only had above average body size at all three ages had improved their relative strength but not endurance from age 9 to 12, and had improved relative strength and arm shoulder endurance greatly by age fifteen.

\textsuperscript{8}Bruce L. Howe, "Test Profiles of Outstanding Twelve Year Old Elementary School Athletes at Nine, Twelve and Fifteen Years of Age," \textit{Completed Research in Health, Physical Education and Recreation} 9 (1967):95.
The six who were outstanding at age twelve only were generally average or below average in skeletal age and body size but above average on other tests at age nine and twelve and they were relatively lower on most tests at age fifteen.

Mathew⁹ conducted a study on 3000 boys from three distinct ethnic groups found in Uttar Pradesh and Bihar ranging from 12 to 16 years. The subjects were tested to determine growth in standing height, sitting height, weight, upper arm girth, chest girth, thigh girth and calf girth and motor fitness was measured by AAHPER Youth Fitness Test. To determine the differences between the means of different ethnic group the two way analysis of variance was applied and to find out the correlation between the motor fitness and selected growth variables, co-efficient of correlation was employed. The significant difference obtained for upper arm girth, calf girth, chest girth and weight, and not significant in standing height, thigh girth and sitting height, no relationship was found between any growth determine and the motor fitness.

Yadav conducted a study on 270 boys student with all age groups having an equal representation of 45 students each ranging in ages between six to eleven years, the subjects were tested within two months of their birthdays in flexed arm hang, push ups, bent knee sit-ups (one minute), standing broad jump, football throw, 50 meter dash, shuttle run, squat thrust, 600 meter run/walk, sit and reach test and shoulder rotation test. To determine the difference between means of different motor fitness components of various age groups, the level of significance chosen was .05. Since the F ratio obtained for all the tests were significant, to find which of the differences among the paired means on various tests, Scheffe's test was applied. The performance of boys ranging in age between six and eleven years, in motor fitness components increased as the age advanced, except in the case of sit and reach test item.

Berry\textsuperscript{11} studied to determine if selected differences occur in neuro-muscular power development in boys and girls ranging from five through seventeen. The test including a vertical jump test, standing broad jump test, power ratio test, shuttle run test, medicine ball put test, and shot put test. In analysing the test results the boys and girls were found to follow a parallel progression in power performance with the girls only slightly below the boys until the early teenage years. A thirteen years of age the female tended to level of power development while the males continued to advance through age seventeen. A comparison of yearly developmental rates noted significant differences between the majority of adjacent ages. However, boys between ages six and seven, nine and ten, and fifteen and sixteen failed to register significance at the .05 level confidence.

Bobbitt\textsuperscript{12} conducted a study to analyse the static balance performance of boys and girls ages five through seventeen years. The mean growth curves for both boys and girls exhibited a steady increase between the ages of five and nine years. Beyond age nine years, the growth curves became rather erratic, deviating from any consistent pattern. The significant difference in balance performance form one age level to the next occurred primarily from age eleven to twelve years and above that age.

Siddhu and Singh\textsuperscript{13} conducted a study on preadolescent boys with a view to find out the relationship, if any, between body measurements and physical performance tests during growth. Measurements studied included height, extremity lengths, measurement of foot and thigh and calf circumferances and skinfolds. Physical performance was measured through Sargent jump, vertical jump and 200 meter


run. The results indicated that as the child grows, the capacity to perform physical activity also improves. Correlation co-efficient between various anthropometric measurements and physical performance change with age. The highest values of correlation of co-efficient had been obtained at the age twelve, among all the six age groups.

Wolf\textsuperscript{14} investigated growth trends in strength and physical size of a group of boys and girls over a period of three years (grade 1 to grade 4). Eight measures of static dynamometric strength, four applied to the upper and four to the lower extremities were scored annually on all children. The anthropometric measurements obtained annually included standing height, sitting height, weight, biacromial breadth, bi-iliac breadth and calf girth. The finding indicated that both boys and girls tended to hold relative position in the group when composite strength scores were employed, the relations of all composite of all strength measures over the three years being .53 for boys and .69 for the girls. Between year correlation for specific

muscles group varied markedly, being in most instances lower than between year correlations of the composite strength scores. Between year correlations of the anthropometric measures ranged from .532 to .944 for the girls and from .805 to .950 for the boys.

David\textsuperscript{15} conducted a longitudinal analysis of the rate and pattern of growth of selected maturity, structural, strength and motor ability measures of boys ten to sixteen years of age. The yearly velocity rates of skeletal age and most of the functional variables of 100 boys were relatively consistent of the six years; the structural variable shows less consistency. Most of the variables displayed a near linear growth pattern. The highest correlation between velocity rates and the experimental variables were for the structural measures. The correlation between the velocity rates and standing height and leg length increasing from .44 at 11 years to .81 at 16 years of age.

\textsuperscript{15} Docherty David, "Longitudinal Analysis of the Rate and Pattern of Growth of Selected Maturity, Structural, Strength and Motor Ability Measures of Boys Ten to Sixteen Years of Age," \textit{Completed Research in Health, Physical Education and Recreation} 10 (1968):78.
Milne\textsuperscript{16} conducted a longitudinal study of 110 children belonging to 5 through 11 years and data expressed in cross sectional form of performance changes in motor items. The test items are bent arm hang, thirty yard dash, sit and reach, jump and reach, agility shuttle run, standing long jump and the 400 feet shuttle run. Longitudinal performance curves, based upon the mean score for each age group were plotted for each motor performance item semi-annually from 5 through 11 years. Motor performance scores generally indicated an improvement with successive years for both sexes in all items with the exception of sit and reach.

Ward\textsuperscript{17} conducted a study to determine the inter age consistency of skinfold measures for the same boys from twelve through seventeen years of age; and to show the relationship between the amounts of skinfold and tests of maturity, physique type, body size, gross and relative strengths, muscular endurance and motor ability of these


\textsuperscript{17}Barrymore Ward, "Longitudinal Analysis of Skinfold Measures as Related to Selected Physical Tests for Boys Twelve through Seventeen Years of Age," \textit{Abstract Research Papers AAHPER} (1971):62.
ages. 130 boys, twelve years of age were the subjects utilized in this study. Skinfold measures were taken at three sites, triceps, sub-scapular and lateral abdomen. Almost with exception, the highest zero order correlation occurred for adjacent ages, 12 to 13, 13 to 14, 16 to 17 years. The result indicated a significant relationship existed between the total amount of skinfold and performance in physical tests.

Kurimoto 18 conducted a study in which same boys were measured annually from 15 through 18 years of age. Skeletal age and strength increased more than structural measures when mean growth gains were expressed in standard deviation units. Mean mesomorphy increased significantly from 4.05 to 4.65 and mean ectomorphy decreased significantly from 3.71 to 3.18. The standard deviations at a given age often appeared large. Inter age correlations tended to be high: .90 to .96 for skeletal age, above .80 for structural measures and somatotype components, and slightly lower for strength and motor tests. The advance maturity group at age

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15 mentioned their superiority in weight, lung capacity and leg lift strength through age 17.

Sodhi and Saini\textsuperscript{19} conducted a study on the physical growth and performance of Punjabi males aged 13 to 16 years. The purpose of the study was to understand the role of maturity and physical growth in performances. A cross-sectional data of 234 males of Punjab aged 13 to 16 years, was collected. The anthropometric measurements, the tests of performance and jumping ability and the maturity status were recorded for each individual. The horizontal and vertical jumps, with or without approach, constituted the jumping ability tests. On the basis of performance the students were sub-divided into different performance groups. The body mass and height showed a general increase from 13 to 16 years of age. The different anthropometric measurements also showed a general increase. Thus it was concluded that the maturity status of the children plays a dominant role in determining their performance and physical growth. The early maturers have been found to perform better than the late maturers.

Pre and Post NCMFBT test results were analyzed by Fitch\textsuperscript{20} for 414 students, ANOVA was used to compare pre-post scores for each components of NCMFBT. It was found that the overall fitness level of the subjects did not improve. Furthermore, there was no significant difference between the pre and post test times of males and females in the 40 yard dash ($P > .05$). There was a significant difference between the number of sit ups by females from pre to post tests. The data revealed that the girls jumped further than their male counterparts. There was no significant difference found between the other components.

Brar and Shrivastava\textsuperscript{21} conducted a cross-sectional study of motor fitness components of 100 school children of Gwalior whose average age was 10 to 12 years. Studying from VI, VII and VIII classes. The following AAHPER Motor Fitness Tests were administered: (1) 50 meter run for speed, (2) bent knee sit-ups for abdominal strength, (3) pull-ups for arm and shoulder girdle strength, (4) standing broad jump for leg power, (5) shuttle run (4 x 10 mtr) for agility.


and (6) 9 minute run/walk for cardio-respiratory endurance in the procedure described in the AAHPER Test Manual. It was concluded from the study that the students studying in grades VI and VIII vary in their motor fitness, therefore, they should have different physical education programme and different evaluation programme.

Upadhyay\textsuperscript{22} conducted a study on 105 subjects aged between 6 to 12 years. The Kirchmars Motor Fitness Test was applied to collect data from the above mentioned age groups after which seven test was applied to find out the differences in various age groups for the boys above mentioned motor fitness test. A post hoc Scheffe's Test was applied for the significant seven values to find out that which of the paired means was most significant. All the groups indicated significant difference in standing broad jump and 30 meter dash. The higher age groups were found comparatively superior than those of lower age groups. In most of variables, it was found that the difference was significant.

Cisar\textsuperscript{23} conducted a study to investigate the physiological determinants of distance running performance across adolescent age groups. Subjects for this investigation included 106 highly-active males aged 8 to 21 year. Based on logistic growth curves, subjects were divided into subgroups aged 8 to 11, 12 to 14, 15 to 17 and 18 to 21 years. Across adolescent age groups the significant variables in the model predicting 2 mile run time were relative fat and running economy in the age groups 8 to 11 and 12 to 14 years, running economy in the age group 15 to 17 years and body weight, $\text{VO}_2$ max, running economy, fatigue index and anaerobic threshold in the age group 18 to 21 years. The results indicated that different physiological variables were important to distance running performance at various adolescent stages of growth and development.

Mirwald\textsuperscript{24} conducted a study involving the longitudinal investigation of maximal aerobic power in boys aged 8 to 15 year. The data were obtained who participated in the


Saskatchewan Growth and Development Study. Maximal aerobic power (max. \( VO_2 \)) was expressed in absolute terms (l/min) and relative to both body weight (ml/kg) and lean body weight (ml/KGLBW). It was found that absolute max. \( VO_2 \) (l/min) showed an increasing trend with increasing age from aged 8 through 15 years. This trend was steady and linear throughout the age range. Max. \( VO_2 \) (ml/kg) remained steady over the age range 8 to 12 years. However, from 12 to 15 years of age max. \( VO_2 \) (ml/kg) showed a decreasing trend in this longitudinal investigation. The finding of max. \( VO_2 \) (ml/KGLBW) were similar to max. \( VO_2 \) (ml/kg) over the ages 8 to 15 years.

Irving\textsuperscript{25} conducted a study of thirty seven boys at each age from 9 to 15 year were somatotyped and grouped into the following five physique categories: endomorphs, mesomorphs, ectomorphs, endo-mesomorphs, and mid-types. The differences between the means of these groups on 2 maturity, 11 structural, and 10 strength measures were computed and tested for significance by the t ratio. Sketchily, the

following significant results were obtained: greater proportion of endo-mesomorphs were advanced and mid-types were retarded in skeletal age; the endomorphs and endo-mesomorphs had greater body bulk measures; the 10 year old ectomorphs had higher mean standing height and leg length. The mesomorphs had generally higher mean arm strength followed by the ectomorphs and mid-types; very few significant differences were obtained for the gross dynomometric strength measures; the mesomorphs had higher strength indices than the ectomorphs and mid type had higher physical fitness indices than the other categories, and very few significant differences between means were obtained for the cable tension strength tests.

Sodhi and Chopra conducted a study on the menarcheal maturity and physical performance of 12 to 18 year girls of Punjab. Data on 236 girls have been collected from Patiala and its surroundings. Each girl was examined for body weight, stature, standing broad jump, standing vertical jump, dynamic flexibility, flexed arm hang, sit-ups

shuttle run, sitting basketball throw, 50 meter dash and 600 meter run. The menarcheal age was determined on the basis of memory recall method. The date of birth of each child was obtained from the school records. The data have been classified into seven age groups. On the basis of menarcheal maturity in each age group the data has been further subdivided into two. The results indicated that the earlier maturing girls perform better in the most of the performance tests up to 14 years. However, at 17 and 16 years the difference between the performance of early and late maturing girls is considerably reduced.

Haley\textsuperscript{27} investigated the effect of age on physical performance of elementary school boys in grades one through six by administering twelve motor performance tests to measure sprint speed, power, agility, reaction time, static balance, dynamic balance, hip flexibility and elbow flexion strength. He found a significant difference between grade levels on all twelve variables. The Scheffe's test indicated that the largest performance increase were between

grade one and two and between grade five and six within middle grade providing a plateau effect. The performance scores formed a curvilinear relationship for all variables.

Clarke and Wickens\textsuperscript{28} conducted a study in which for each of the 33 maturity, structural, muscular strength, and motor ability measures, the mean, standard deviation and co-efficient of variation were computed for 40 boys at each age 9 to 15 years inclusive. In presenting the mean growth curves for each various measures, an attempt was made to identify the differences in form which occurred. Where only slight differences in curve forms were encountered, they were identified together; where consistent differences were found, separate discription were made.

Odgens\textsuperscript{29} studied the relationship between flexibility measures, skill performances and chronological age of six to


sixteen year old boys. Subjects were tested on 19 flexibility measures and four measures of motor skill. According to his findings means for age groups showed significant differences in the following five measures: arm flexion, extension, trunk lateral flexion, trunk rotation, thigh rotation and wrist flexion-extension. No significant difference was found between boys of different age in the following 14 measures: neck flexion-extension, neck rotation, neck lateral flexion, hand supination, hand pronation, thigh adduction, abduction, knee flexion-extension, trunk extension-flexion, hip extension-flexion, ankle extension-flexion, foot supination - pronation, elbow flexion-extension. While comparing the flexibility measurements of more skilled performers with less skill performers he found that the more skilled were more flexible on the following five instances: neck rotation, trunk flexion and trunk lateral flexion in the soft ball throw. Trunk extension-flexion in the standing broad jump and trunk extension-flexion in the 30 yards run.

High average and low groups in strength were formed by Borms30 at ages 10, 13 and 16 years by combining the

strength index, mean of 11 cable tension strength tests, and the physical fitness index. The higher gross strength groups were larger and more mature, had greater motor ability, and were more mesomorphic. The lower strength group were larger and had greater endomorphy; the higher groups were superior in motor ability.

Pal analysed the relationship between physical fitness to selected anthropometric measurements on 100 men subjects between the age of 16 to 34 years. AAHPER Youth Fitness Test was used and six anthropometric measurement. Such as chest girth, upper arm girth, thigh girth, calf girth, height and weight were obtained. It was concluded that height was the most reliable single anthropometric measurement in prediction of physical fitness of men students, the other measurements were not so reliable. The most valid combination of anthropometric measurements in predicting physical fitness consisted of calf girth, height, weight and chest girth.

Metz\textsuperscript{32} conducted a study on subject which were administered two different treadmill tests (intermittent work and continuous step-up work) designed to elicit maximal work capacity. For 12 and 13 years old all items of the AAHPER Youth Physical Fitness Test, except sit ups, were significant related to maximal oxygen intake, and for 14 and 15 years olds all items but sit ups, soft ball throw and 600 yard run-walk. Pull ups, dips, and right grip strength from the Mecloy strength test, the Harvard step test score, and peak oxygen intake and running time to exhaustion from the continuous step-up treadmill test were significantly related to maximal work capacity.

Paul\textsuperscript{33} conducted a study to examine selected measures of muscular strength and endurance in boys ten, twelve and fourteen years of age. Standardized pull-up and bar push up tests were used to measure muscular strength and endurance relative to body weight. On the initial testing

\textsuperscript{32}Kenneth F Metz, "The Relationship between Maximum Aerobic Work Capacity and Physical Fitness in Twelve to Fifteen Year-Old Boys," Completed Research in Health, Physical Education and Recreation 10 (1968):54.

session, selected structural measures including standing height, body weight and forearm length, were recorded. The exercise task consisted of performing twenty four maximum forearm flexion movements with the right forearm during a two minute exercise bout. All the measurements were recorded in continuous graphic form. The findings were:

i) Muscular strength and endurance parameters increase progressively with age.

ii) There is a significant relationship between selected strength and endurance parameters in the boys ten, twelve and fourteen years of age.

iii) There is no significant relationship between the age and muscular strength and endurance parameters.

Although physiological measurement regarding maturation were not recorded, it is likely that the difference in the rate of physical maturation in the twelve year old group, may have accounted for the obtained difference in muscular strength and endurance relationships.

Smoll\(^{34}\) collected the data from the grade 4 and 11 levels from 24 boys and 24 girls participating in a

longitudinal growth study. Static strength measures of the ankle extensor's, hip flexors and extensors, and knee extensors were measured with a cable tensiometer. Motor performance was represented by standing broad jump and 30 yard dash. The analysis depended primarily on zero order and multiple correlations. Height and weight, separately or in combination, were poor predictors of performance within the age and sex groups. The aggregate lower limb strength had a moderate positive relation with performance. Performance in the broad jump during adolescence can be predicted more accurately than in the dash on the basis of growth strength, and performance taken during middle childhood.

Clarke et al.\textsuperscript{35} conducted the study to relate the somatotypes of boys to their skeletal maturity, structural characteristics, and muscular strength. Five somatotypes categories were formed: endomorphs, mesomorphs, endomesomorphs, ectomorphs and mid - types. The subjects were 37 boys from each age 9 to 15 years inclusive. In general, the endomorphs and endomesomorphs were largest in such body

\textsuperscript{35}H. Harrison Clarke; Robert N. Irving and B.H. Heath, "Relation of Maturity, Structural and Strength Measures to the Somatotypes of Boys 9 through 15 Years of Age," Research Quarterly 32 (December 1961):449-460.
measures as body weight, chest girth, upper arm girth, calf girth, and hip girth. The mesomorphs shows general superiority in both gross and relative muscular strength and muscular endurance measures. The only tests were no difference between means was found were sitting height, leg strength, classification index I, and lung capacity. A significantly greater percentage of endomesomorphs were advanced then were retarded; the reverse was true for the mid-type boys.

Gilliam et al. 36 conducted the study and purpose was to assess differences in peak performance measures between three age groups: 6 to 8 years, 9 to 10 years and 11 to 13 years. Each child underwent a progressive maximal bicycle test. Measures such as oxygen consumption \((\text{VO}_2)\), ventilation, heart rate, respiratory exchange ratio and work rate were continuously monitored. Peak cardiac output, stroke volume and arteriovenous oxygen difference were indirectly determine during the last 15 sec. of exercise using a \(\text{CO}_2\) rebreathing method. Peak measures for oxygen consumption, ventilation and work rate increased with age such that each was statistically different among age groups. No statistical differences

among age groups were found for respiratory exchange rate, cardiac output, stroke volume and arteriovenous oxygen difference. In addition peak ventilation and work rate also differ among children of young age.

Ismail et al. \(^{37}\) conducted a study to investigate the relationship between lean body weight and selected items which authorities claim to measure motor aptitude. The data for 40 variables were obtained from 81 Purdue university faculty sons between 10 and 12 years of age inclusive. Factor analysis was used to identify the factors which could explain the items measuring body composition and motor aptitude. As a result eight factors were isolated and given names growth and maturity factors, body fitness factors, general kinesthetic sense factor, general static balance factor, body balance or object factor, coordination of the lower extremities factor, directionality factor and laterality factor.

Observing the factor loading in growth and maturity factor, it may be concluded that measurement of the lean body weight by the liquid scintillation counting technique

is significant in the assessment of growth and maturity in pre-adolescent boys. In the assessment of body fitness pertaining to pre-adolescent boys, it is revealed that the percent lean body weight is the most important item, as indicated by the value of factor loading presented in body fitness factor.

Nelson\textsuperscript{38} conducted a study to determine the physical fitness is a function of gender. If so, could these gender differences be explained by age and body size characteristics. The sample consisted of 12,362 boys and girls, ages 6 through 17, from throughout the United States. The performance of boys was superior to girls performance by age. The performance of boys was superior to girls on the mile run and sit up tests while girls out performed boys on the sit and reach test. For all three tests, an age by gender performance interaction existed, which demonstrated that the cross-sectional performance curves for boys and girls were not parallel over the ages studied. Boys continue to improve through 17 while girls leveled off and decreased in performance after age 15.

Rad-Cliff\textsuperscript{39} conducted a study on 179 boys for the 60 yard shuttle run and 15 maturity, physique, structural, strength, and motor tests. The highest multiple correlation obtained with the shuttle run as the criterion was .650; the test variables were standing broad jump, PFI, and total body reaction time.

Thirty girls and twenty eight boys, 10 - 14 years of age underwent in Palgi's\textsuperscript{40} multi-stage treadmill test for assessment of VO\textsubscript{2} max (ml/kg/min) and AT ANC (KPM/kg/min) was determined in a 30 second cycling task. A regression equation was used to estimate percent body fat from skinfold measurements. A two kilometer run was selected as the endurance performance test. Results indicated that in 10 - 14 year old children there is a substantial relationship between measures of anaerobic and aerobic function, although to some extent each provides independent information about endurance performance. When girls and boys were compared, no reliable


differences were found for run time and ANC. Boys exhibited reliably higher value for VO$_2$ max and AT (VO$_2$ at AT). In general, the more fit and active children tended to excel in a variety of tests of aerobic and anaerobic capacities.

Four dynamic balance tasks — Cront Pronko Test, spring field beam-walking test; bass stepping stone test and the Johnson stagger jump test were administered by Vance on two successive days to 180 males and females in 3 age group 7 - 8, 11 - 12 and 15 - 16. Comparisons of mean performance levels using the t test indicated no sex difference in balance performance. The generality ratios produced no clear relationship between age and generality of dynamic balance performance. Generality levels were markedly higher for females than the males in 2 of the groups, ages 11 - 12 and 15 - 16, suggesting, that for these tasks, there was some sex differences in generality of dynamic balance performance.

Cooke conducted a study to investigate the relationship between balance and cognitive abilities of children

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in the age range 8 to 13 years. Information of cognitive abilities consisted of scores on the 1963 versions of the California Mental Maturity Scale and Iowa tests of basic skills. Balance performance was measured by means of balance beam and balance board tests which were developed as a result of several pilot studies.

Low positive significant correlations were found between total balance performance and all six cognitive abilities for all subjects. On the basis of these findings a closer examination of the relationship between balance and cognitive abilities in a younger male population is recommended.

Anyanwu conducted a study to establish physical fitness norms for Nigerian boys and girls of ages 11 through 18. Included in the study were the following test items: shuttle run, push up for boys, chair push up for girls, flexed knee sit ups, 45 metre dash, standing broad jump, pull-up for boys, flexed arm hang for girls; 9 - minute run for subject 11 - 12 years and 12 minute run for subjects

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13 - 18 years. Within the scope and limitations of the study, the following conclusions were drawn:

i) In most of the test items the performance of the boys improved from the lower to the upper age levels.

ii) The boys performed better than the girls in all the test items.

iii) The mean scores revealed that the girls of lower age level tend to possess better physical fitness status than the girls of the upper age levels.

Kurowski evaluated the effects of age and leg length on the max. anaerobic power of children, and the possible existence of sex difference with in each age group were evaluated. Male and female children ages 9 - 15 year, each performed 10 trials of the Margaria step-test following 5 initial practice trials. Mean absolute values for maximum anaerobic power ranged from 29.6 (males) and 23.9 (females) K cal/min in nine year old to 63.7 and 48.8 K cal/min respectively, in 15 year old. A statistically significant

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sex difference was noted in absolute max anaerobic power at ages 11, 14 and 15 year. The results also showed that while absolute maximum anaerobic power in males (13 - 15 years) progressed according to age no corresponding improvement was noted among female.

Harrison conducted a study of wrist hand skeletal age assessment were made of 273 Caucasian boys 9, 12 and 15 years of age in the Medford Oregon Public Schools. At each age, the subjects were divided into three mutually exclusive maturity groups retarded, normal and advanced. The differences between the means of these groups on 10 anthropometric, 12 strength and one explosive power measures were computed and tested for significant by the t ratio. The greatest difference was found between the mean body weight of the three maturity groups at all ages. Other test variables which had relatively high significance were hip width, grip strength, sitting height, upper arm girth, and calf girth.

From the literature reviewed in this chapter, it is quite apparent that not much seems to have been done in India either in the form of longitudinal studies or cross-sectional studies to investigate age related changes in physiological variables and motor performance components as well as their relationships across age. Most of the literature cited in this chapter pertains to studies conducted abroad (in other countries) but these studies do not throw ample light either with regard to physiological variables studied across age or the relationship of these variables with motor performance components. The studies reviewed mainly are of longitudinal nature in which the physiological variables have been examined in isolation i.e. by considering one particular variable in a study such as anaerobic power, maximal aerobic power, body composition etc. Some of the studies reviewed aim at the growth related factors such as anthropometric measurements and motor fitness performance. In these studies longitudinal trends in motor performance, skeletal maturity, body size, etc. has been ascertained. A few studies have been reported on the relationship between physical and motor factors but very little and limited literature was available with regard to the relationship of selected physiological variables and motor performance.
components across age. For want of scientific information with regard to the ultimate significance for physical education teachers or the others concerned the present study was undertaken.