Chapter -II
REVIEW OF REALTED LITERATURE
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Sincere efforts have been made by the research scholar to locate literature related to this study. The relevant studies found from various sources, which the investigator has come across, are enumerated below.

Sodhi and Singh\textsuperscript{1} compared the physical growth and motor ability development of 10-14 years boys from India and Nigeria. The physical growth was measured with respect to variable height and weight. Standing broad jump and 50 metres sprint were selected to measure motor development. They found that Nigerian boys had a higher rate of growth as compared to Indian boys during the ages of 12, 13 and 14 years. The growth patterns were, by and large of similar nature. In motor performance, Nigerian boys out performed their Indian counterparts during all the years under study. The patterns of development, however, were mostly of similar nature.

A comparative study on selected anthropometric and motor quality profiles of healthy school going girls (8-14 years, n=700) of Eastern and

North Eastern region of India was conducted by Dey et al. The study revealed that the selected anthropometric and motor quality variables have shown major increment between 10-12 years with advancement of age among both the groups. Eastern region girls were taller than the Northeastern region girls but Northeastern region girls were heavier than their Eastern region counterparts except at the age of 13 years, where Eastern region girls were found to be heavier. All the fitness scores showed positive correlation with age, height and weight but 30 meters run, agility run, and 800 meters run showed significant negative relationships. Height and weight were found to be the strong predictor of strength and anaerobic performance, where adiposity has reflected by sum of skin folds (fat %) is the weakest predictor of running, jumping, and endurance performance. The percentile values of test scores indicated that north eastern region girls were superior to eastern region girls in weight. The 50th percentile values of height of eastern region girls were found to be higher than the 75th percentile value of Northeastern region girls 10-12 years of age. From the study it was concluded that the regional variation for different anthropometric and motor quality variables might be attributed to geographical variations, environmental

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influences, genetic factors, nutritional variation and differences in socio-economic status of Eastern region and Northeastern region girls.

Stefancic and Seljak\(^3\) carried out two years longitudinal study on growth and physical development based on the anthropometrical data of 275 children (132 boys, 143 girls) from Ljubljana, initially aged 10.5, 11.5 and 12.5 years. The measurements took place in the school years from 1991-1992 and 1992-1993. Sixteen anthropometric parameters namely, stature, ilio-spinal height, total arm length, bicromial breadth, chest breadth, bi-iliac breadth, elbow breadth, knee breadth, ankle breadth, chest circumference, upper arm circumference, calf circumference, sub scapular skin folds, triceps skin fold, calf skin folds and body weight were measured. The two-year increases of the measurements were calculated to establish the velocity of growth during adolescence. The study reveals that the growth dynamics during puberty confirms the specific earlier adolescence development of girls in comparison with boys. The girls attain the most intensive spurt of growth already between 10.5 to 12.5 years. The boys do it two years later between 12.5 to 14.5 years. Considering the dimensions of limb only one-year delay was established. The skin fold shows the progressive

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intensity of thickness in girls while some assigned trend of thinning is noticed in boys.

Sidhu and Singh⁴ conducted a study on pre-adolescent boys with a view to find out the relationship between body measurements and physical performance tests during growth. Body measurements studied were height, extremity lengths, foot length, thigh, calf circumferences and skin folds. Physical performance was measured through Sargent jump and 200 metres run. The result indicated that as the child grows, the capacity to perform also improves. The means scores of Sargent jump and 200 metres time for eight-year-old boys were 20.4 cms and 48.8 seconds respectively. The values improved to 27 cms and 33.2 seconds respectively at the age of 13 years. The correlation coefficients between various anthropometric measurements and physical performance tests indicated that the relationship between performance and body measurements also change with age. The highest values of correlation coefficient had been obtained at the age of 12 among all the six age groups studied.

Joon\textsuperscript{5} conducted a study on motor development of Indian male children and youth from nine to 16 years of age (N= 276). Subjects were taken from different states of India and the following tests were conducted to assess the motor development; 40 meters dash, forward bend and reach, standing broad jump, zigzag run, eight Kilograms shot put, 800 meters run and 1500 meters run. Apart from these, the height and weight were also taken. The data was statistically analyzed age wise. The result showed significant improvement in physical growth and motor development in different phases of growth and development of Indian children and youth.

A study on the anthropometric measurements of school going rural adolescent girls aged 11 to 15 years, and it relationship with three motor performance tests namely broad jump, Sargent jump and shot put was conducted by Ahluwalia et al.\textsuperscript{6} for the purpose of this study, cross sectional observations were made on nine anthropometric measurements and three physical performance tests on 150 non-athlete Punjabi rural


girls. A gradual increase in anthropometric dimensions with increasing age was seen. The total increase between 11 to 15 years is found to be 38.6% for weight, 12% for height vertex, 13% sitting height vertex, 11% for bicromial diameter, 13.5% for bi-crystal diameter, 15.15% for total arm length, and 10% for foot length. The total change over the four year period in physical activity events is 20.5% for Sargent jump, 25.5% for standing broad jump and 89% for shot put. Thus, the maximum change over the initial value at 11 years is seen for the shot put event (89%), while the minimum change (20.5%) is seen for the Sargent jump event. In an effort to visualize the association of physical activity performance with growth pattern simple coefficient of correlation (r) between various anthropometric measurements and physical activity events at each age level have been administered. Only at the age of 14 years, anthropometric variables exhibit significant association with standing broad jump and shot put events.

David⁷ conducted a longitudinal analysis of the rate and pattern of growth, strength and motor ability measures of boys 10 to 16 years of age. The yearly velocity rate of skeletal age and most of the functional

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variables of 100 boys were relatively consistent up to 16 years, the structural variables showed 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 strength increasing from .44 at 11 years and .81 at 16 years. The relationship between the skeletal age and structural velocity rates were low but generally significant. Those between the structural and functional measures were mostly insignificant.

Sodhi and Saini\textsuperscript{8} conducted a study on physical growth and performance of Punjabi males aged thirteen to sixteen years. The purpose of the study was to understand the role of maturity of physical growth in performance. A cross sectional data of 234 males of Punjab were tested on anthropometric measurements and jumping ability, both horizontal and vertical with and without approach. On the basis of these tests, the students were divided into different performance groups. They found that the body mass and height increases 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 children plays a

dominant role in determining their performance and physical growth. The earlier maturer have been found better than the late maturer.

Geraldine⁹ conducted a study on the motor performance of primary grade Negro and White six - seven and eight year old children and concluded that static balance, broad jump and vertical jump improved significantly from six to eight years. Flexibility means decreased with age but age differences were not significant. Sex comparisons showed that boys were consistently superior in jumps and girls were superior in static balance and flexibility, but few of the differences were significant. Racial comparisons indicated that Negro children were significantly better in jump and reach and three of the six broad jumping groups.

Drowtzkey and Madary¹⁰ evaluated the physical and motor fitness of 3,400 boys and girls in grade four through twelve, and also the effectiveness of the current physical education programme in the development of fitness. The results showed a marked decline in the girls fitness scores means through the junior and senior high school grades. The results further disclosed that the fitness levels of children who

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participated in physical activities outside the regular physical education classes were found more fit than those who did not participate in such activities. Tenth grade boys and girls demonstrated higher levels of motor fitness than 11th and 12th grades, who were exempted from physical education.

Rajni et al\textsuperscript{11} carried out study on the development of motor abilities of trained (n=75) and untrained (n=75) girls aged 10-14 years. The results revealed that there were significant differences in body height and body weight between trained and untrained girls of 10-14 years. The pattern of development of height and weight indicated an earlier growth spurt in case of untrained girls. Significant differences were also observed in the average performance in motor ability tests, the trained subjects showed higher value than their untrained counter parts. ANOVA and results of post hoc tests showed significant differences in body height, weight, leg strength, sit-ups, arm strength and 40 meter dash among the various age groups of trained subjects. However, in untrained girls significant age group differences were found only in body height, weight and arm strength.

Sohi\textsuperscript{12} conducted a study on development of speed and agility among six to 14 years boys and girls. The improvement in performance was observed with respect to year-by-year increase, inter sex differences in performances, overlapping of performances by age and sex and leveling off the performance. To observe these conditions, two motor task, one each for speed and agility were selected. A cross-sectional population of 499 boys and 470 girls were subjected to test on the motor tasks. The analysis of data revealed that the boys showed linear improvement on the motor tasks. The girls improved interruptedly in sprinting and linearly in agility. The boys were superior to girls in agility.

The boys also outperformed the girls in sprinting except during the age of eight years. The girls leveled off in their performance earlier. The overlapping of performances on these motor tasks was observed by age and sex of the performers.

A longitudinal analysis of maturity and physical growth of boys ages 12 through 17 years was conducted by Santammria.\textsuperscript{13} The subjects


were tested for maturity, body linearity, body bulk and indexes reflecting body proportions. Analysis employed were inter-age correlations among all the ages of each variable; means, standard deviations, and coefficient of variations, construction of mean velocity curves, differences in growth patterns, high and low maturity growth strengths, weight and height groups. Except for lung capacity between 0.64 and 0.94 within the highest 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 deviations also increase with age. Differences between high and low maturity groups, gross strength groups and height groups found at twelve years of age maintained significant mean differences on the other tests for the six years of the study.

Clyde\textsuperscript{14} made a study to determine the selected differences occur in Neuro-muscular power in boys and girls ranging between five through seventeen years. He concluded that boys and girls follow a parallel progression in power performance with girls only slightly below the boys until the early teenage years. At thirteen years of age, the females tends

to level of in power development, while the females continue to advance through age seventeen.

Sodhi and Chopra $^{15}$ conducted a study on the menarcheal maturity and physical performance of 12 to 18 years girls of Punjab ($N = 236$). 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 m. dash, and 600 m. run. The menarcheal age was determined on the basis of memory recall method and accordingly seven age groups were formed. On the basis of the menarcheal maturity in each age group, the data was sub-divided into two. The results indicated that the early maturing girls perform better in most of the performance tests upto fourteen years. However, at 17 and 18 years the difference between the performances of early and late maturing girls was considerably reduced.

Milne $^{16}$ conducted a longitudinal study of 110 children belonging

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to five through eleven years and the data expressed in cross sectional of performance changes in motor items. The test items were 30 yard dash, flexed arm hang, sit and reach, jump and reach, agility shuttle run, standing long jump, and 400 feet shuttle run. Longitudinal performance curves, based upon the mean score for each age group were plotted for each motor performance items semi-annually from five to eleven years. Motor performance scores generally indicated an improvement with successive years for both sexes in all items with the exception of sit and reach.

Ikeda\(^\text{17}\) took the Iowa Motor fitness test in order to compare the physical fitness of children from Iowa and Tokyo. The results indicated that Tokyo children scored better in all motor performance tests except in sit ups. He also stated that Tokyo children had more chances for activity through physical education classes than the Iowa children.

Using the AAHPER Youth Fitness test, Toddonico\(^\text{18}\) studied physical fitness of public school students from economically backward


area with national norms. He compared the physical fitness of public school students from high poverty and low poverty areas. He found that there was no significant difference in the physical fitness of boys or girls from the economically deprived areas and boys and girls represented by the 1975 national norms. No significant difference was found in physical fitness of subjects from high poverty and low poverty areas.

Sharma et al. investigated the growth pattern of adolescence girls belonging to Punjabi population with reference to their socio-economic status. For the purpose of the study 13 anthropometric measurements and three derived measurements in the adolescent Punjabi girls were investigated. The data were based on a sample of 223 girls ranging in age from 10 to 16 years from Government and Public schools of Chandigarh. The study revealed that the Public school girls (high SES) were superior in body size traits than their counterparts from Government school (low SES). The growth pattern remains more or less similar in both the groups but the differences laid in magnitude and age peak velocity was observed between 12 to 13 years in high SES girls and between 13 to 14 in low SES girls for weight, stature and chest circumference. However there was

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no uniform pattern in their circumferential and skin fold traits. As compared to American and British girls the public school girls of the present study were shorter and lighter.

Minucci and Shows\(^{20}\) determined possible age and race differences between black and Caucasian girls aged six, seven and eight years (N=90). Twenty-eight test items measuring speed, muscular power, agility, flexibility, balance, muscular endurance, and cardio-respiratory endurance were administered. Few significant differences were observed between adjacent ages but eight years old females were significantly superior to six-year-old subjects on most of the motor performance variables utilized. The Black subjects were significantly superior in two measures of agility, while Caucasian subjects performed significantly better in the time limit shuttle run and grip strength.

Mathew\(^{21}\) 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 their standing height, sitting


height, weight, upper arm length, chest girth, thigh girth and calf girth, and motor fitness was measured by AAHPER Youth Fitness test. To determine the difference between the means of different ethnic groups, two-way analysis of variance was applied and to find out the correlation between the motor fitness and selected growth variables, coefficient correlation was employed. Significant differences obtained for upper arm girth, calf girth, chest girth and weight. Differences were not significant in standing height, thigh girth, and sitting height. No relationship was found between any growth determine variables and the motor fitness.

Piscopo \(^{22}\) analyzed the skin folds and other anthropometric measurements of preadolescent boys from three ethnic groups. The purpose of the study was to establish percentile norms and to compare skin folds and other anthropometric measurements of 647 Italian, Jewish and Negro preadolescent boys from Boston, Massachusetts’s area. Skin folds were measured at five sites. Other measurements include height, weight, bi-iliac diameter, and selected girths. Correlations were determined between skin folds and selected body build components. Inter skin folds correlations ranged from moderate to high values. The largest

percentile scores were found within the Jewish group. Significant differences were found relative to certain skin folds and weight between ethnic groups at percent one level.

Nemour\textsuperscript{23} did a comparative study of anthropometric measurements of Caucasian and Negro Boys and girls and also their performance in standing broad jump, medicine ball put and zigzag run ($N= 900$). The subjects were of different age groups of six to ten years. The anthropometric measurements were standing height, sitting height, weight, arm length, forearm length, hand length, upper leg length, lower leg length, and total leg length. He found that at the age of six to eight and ten years, boys differed from girls in most of the anthropometric measurements. However, there were no differences in standing height and leg length. Negro girls and boys had longer appendages and were taller than Caucasians. Negro boys and girls were not found superior in power and agility.

Barbanti\textsuperscript{24} carried out a comparative study of selected anthropometric and physical fitness measurements of Brazilian and

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American School children (N=2342). Physical fitness battery consisting of 50 meters dash, nine minutes run, 12 minutes run, standing broad jump, sit and reach test and modified sit ups were administered to the subjects of the both the countries. The results revealed that American boys and girls, in general, were taller and heavier and their scores in 50 meters dash, standing broad jump, sit and reach, and modified sit ups tests were higher than their Brazilian counterparts. On the other hand, Brazilian children scored higher in nine minutes run test.

Lieveld et al\textsuperscript{25} investigated ethnic differences in body structure and physical fitness in Surinamean boys aged 14 years belonging to diverse ethnic/racial groups (n=270) belonging to Negroid, Indonesians and India-Pakistani origin. The subjects were tested on health related and performance related fitness using Euro-fit test battery. Results showed a significant difference between ethnic groups for somatic developments and some factors of performance; and health related fitness. Indonesians were smaller in height and do have a shorter legs and shorter arms as compared to the two other groups. The India-Pakistani boys were fatter than two other groups. India-Pakistani boys were smaller in bone breadth

measurements. The Negroid boys tend to have relatively longer extremities for a given stature and are smaller in bi-illiocristal breadth as compared to the two other groups. Indonesians boys obtained better results on limb eye coordination and flexibility tests than the Negroid boys. The Indonesian were better for explosive power and total body balance as compared to India-Pakistani boys. Racial differences can be explained by somatic developments, maturation level, genetic and environmental factors.

Kurimoto \(^{26}\) conducted a study in which the same boys were measured annually from 15 through 17 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 ectomorph decreased significantly from 3.71 to 3.18. The standard deviation at a give age often appeared large. Inter age correlations tended to be high: 0.90 to 0.96 for skeletal age, above 0.80 for structural measures and somatotype components, and slightly lower for strength and motor tests. The advanced maturity group at age 15 maintained their superiority in weight.

lung capacity and leg lift strength through seventeen.

Smaoll \(^{27}\) collected data from the grades of four to eleven levels from 24 boys and 24 girls participating in a longitudinal growth study. Static strength measures of the ankle extensor, hip flexor and extensor, and knee extensor were measured with a cable tensio-meter. Standing broad jump and 30 yards dash represented motor performance. The analysis primarily depended on zero order and multiple correlations, where 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 standing broad jump during adolescence can be predicted more accurately than in the 30 yards dash on the basis of growth strength and performance taken during middle childhood.

Nelson \(^{28}\) conducted a study to determine the physical fitness as 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, aged six through seventeen from throughout United States. The


The performance of boys were superior to girls by age. The performance of boys were superior to girls in one mile run and sit up tests, while the girls outperformed boys in 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 seventeen, while girls leveled off and decreased in performance after the age of fifteen.

Khanna and Bhatnagar investigated the health and fitness level of the children by monitoring the normal growth and development. The study was conducted on 313 boys of age ranging from 8 to 18 years with an aim to study the growth and developmental aspects of physiological responses during the ergometry in Indian boys. The subjects were given a graded protocol of exercise till maximum exhaustion. Oxygen consumption, carbon dioxide production, ventilation, heart rate, oxygen pulse and breathing equivalent were recorded after every thirty seconds in a computerized ergoneumo test. The O₂ debt was calculated from sum of recovery oxygen consumption. Results revealed that the VO₂ max increases from 0.9 L/min to 2.7 L/min (three fold) within a span of 10 years whereas relative VO₂ max does not change. VE max. increases.

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with an average of 5 L/min per year. Maximum heart rate ranges from 201 bpm at 10 years to 185 bpm at 18 years of age. Mean O\textsubscript{2} pulse in 8 years of age group is 4.5 ml/beat it increases to 14.98 ml/beat of the age of 18 years. However, in relation to the body weight O\textsubscript{2} pulse does not reveal any significant change. Breathing equivalent ranges from 42.5 l/l of O\textsubscript{2} at 11 years to 31.38 l/l of O\textsubscript{2} at 18 years of age. O\textsubscript{2} debt increases at a slower rate till the age of 12 years, thereafter it increases till the age of 16 years. Maximum workload tolerance increases at the rate of 14 Watts/year. The present findings were compared with the international counterparts. It was concluded that Indian children has less functional abilities and rate of development as compared to the International counterparts.

Verma et al\textsuperscript{30} investigated the reliability and reproducibility of maximum O\textsubscript{2} uptake measurements in young Punjabi boys of 10 to 13 years of age. The maximum aerobic capacity of 132 subjects was measured on bicycle ergometer for determining the reliability and reproducibility of maximum O\textsubscript{2} uptake measurements in preadolescent children. The tests were repeated in 48 school children within three to

four weeks of conducting the first test. The mean value of VO₂ max. in these boys were found to be 43.7 ml/kg/min. which is lower than the reported value for contemporary male children in the west. No significant differences were observed when the mean values of VO₂ max. were compared from one age group to another. The results of the repeated measurements of VO₂ max. were grouped on the basis of presence or absence of plateau in O₂ uptake during the last work loads. There were insignificant differences in the mean value of VO₂ max. at test - 1 and test -2, for any of the measurements made. Therefore, the test was considered to be highly reproducible. However the reliability of the tests was found to be depended upon the attainment or non-attainment of plateau at maximum workload.

The relationship between the two VO₂ max. measurements were found to be quite higher (r=0.95) in case of the children who demonstrated plateau in O₂ uptake at the maximum load as compared to the value of r= 0.72 observed in the group of children who failed to attain plateau. The results of this study also indicates that with increase in age the percentage of children who demonstrated plateau in VO₂ max. also increased from 33% at 10 years to 42% at 13 years.
Atomi et al.\(^3\) investigated the physical activity level in nine to 10 year old boys (n=11), with reference to aerobic power or lactate threshold (LT). Daily physical activity levels were evaluated from HR monitoring system for 12 hours on three different days. VO\(_2\) max., VO\(_2\) -HR relationship and LT were determined by progressive treadmill tests. LT was 36.7 ± 3.1 ml. kg\(^{-1}\) . min\(^{-1}\) and 71.0 ± 6.6% VO\(_2\) max. Mean total time of activity with heart rate above the level corresponding to 60% VO\(_2\) max. (T-60%) and that above LT (T-LT) were 34.0± 7 and 18 ± 7 min, respectively. VO\(_2\) max. (ml. kg\(^{-1}\) . min\(^{-1}\)) correlated significantly with T-60% (P<0.01), while no significant relationship was found with LT in ml. kg\(^{-1}\) . min\(^{-1}\). In conclusion, longer daily physical activities at moderate to higher intensity for preadolescence children seem to increase VO\(_2\) max. rather than LT.

In order to understand the level of habitual physical activities and training status among school children, Lakshmeesha\(^2\) carried out an evaluation aerobic fitness. Study was conducted on 1200 school children.


of Karnataka State in the age group of 12 to 16 years. As an objective measurer of aerobic fitness, maximal aerobic capacity (VO₂ max) was found out by using most popular multistage shuttle run test protocol (20 MSR). Both relative and absolute values of maximal aerobic capacity were compared cross-sectionally among 12 to 16 years boys and also with sporting children of our country. Mean Relative maximal aerobic capacity (VO₂ max) of Karnataka schoolboys found decreasing gradually from 12 years to 16 years of age. Statistically speaking there was a significant decrease in relative maximal aerobic capacity between 12 year boys and 13, 14, 15, and 16 years. He also found the boys were very much inferior to the sporting group counterparts. Though there was an increase in mean values of absolute maximal aerobic capacity, linear to the age from 12 year to 16, but improvement was not to the level of sporting children.

Long³³ completed the first study with statistical analysis attempting to compare motor abilities of Df and H individuals. There were 51 boys and 36 girls (for most tests) from an institution for the Df in New York City. The majorities were congenitally deaf and all but one was pre-

lingually deaf. They were matched for age, gender and ethnicity with H children from a Jewish orphanage. Long was concerned about auditory distraction with H subjects and visual distraction with Df subjects during testing. Psychomotor tasks were demonstrated to and practiced by subjects. Results indicated that the only statistically significant difference occurred in the balance test with the H students performing better than the Df students. In conclusion, Long considered Df and H children almost equal in all areas tested except balance.

Morsh\textsuperscript{*4} compared psychomotor performance of 139 Df subjects, 79 girls and 60 boys (including pilot test results), to 163 H subjects, 77 girls and 86 boys. Subjects ranged from five to 26 years of age. The Df subjects were drawn from either the Columbia institution for the Deaf or from Gallaudet College. Their residual hearing ranged from zero to 15\%, and age of onset was from birth to 15 years. A comparison group of H subjects were from public schools. The directions for a tapping test were read and demonstrated to the H group. Directions were simplified and written on a chalk board for the Df groups, however many of them failed to understand at first so the correct and the incorrect method was demonstrated with a pantomime and gestures. Morsh found no

significant difference between the groups. A steadiness test indicated that the performance of the Df students was superior.

For the study of balance the H and Df groups were matched for intelligence. Balance was measured on a balance board (Balanciometer). The Df subjects balanced better only at the 19 degree limit, there was a difference in balance ability between these groups when a blind-fold was applied, with the H groups being superior. Morsh indicated that the test equipment and facility probably had an effect on the result; the counter made an audible sound when the board was off center, and there were variations in voltage at the Gallaudit College testing site. This study was well documented and explained procedures and drawbacks. However, the validity of results are questionable in light of Morsh’s modification of equipment, testing in very different environments, testing at different times, comparing results to previous tests, and using test groups not well matched according to age.

Brace\(^{35}\) compared the balance ability of random sample of 52 boys from the Texas schools for the Deaf, and 59 H boys from the University Junior High, both groups were 11 to 16 years of age. Residual hearing in

the better ear of the Df subjects was from 0 to 70%, with a better ear average of 31%. The Df subjects were given instructions with finger spelling and demonstrations. Subjects were matched on track and field events.

The H and Df groups were equivalent in individual skills such as high jump, baseball throw, broad jump and the 50-yard dash. Both groups performed below the norms; the H groups by 12.1% and Df group by 16.8%. The main emphasis of the study was to compare performance on two static balance abilities. the subjects were matched for general athletic abilities, age, weight, and height. It was found that H boys balanced longer than Df boys and that the H boys tended to improve with trails, especially with eyes closed. Df boys did not show as great and improvement with trails. Brace was the first researcher to review psychomotor performance on the etiology and degree of deafness, congenital–total deafness, congenital-partial deafness, acquired-total deafness, acquired-partial deafness, and unclassified deafness. The congenital total deafness group was superior in the static balance, where as the acquired – total deafness groups was performed least effectively.
Burbank\textsuperscript{36} assessed four static and five dynamic balance beam skills at three month intervals for year. The subjects were 137 Df boys from the New Jersey School for Deaf, ranging from 11 to 21 years in age, and having a greater than 65 dB hearing loss. Burbank calculated a 63\% loss of balance ability between balancing with eyes open as compared to eyes closed. Those Df Students who were athletes were found to balance better when compared to the entire groups, with track athletes being superior. The Congenital etiology group performed better than the disease-caused deafness group in balance. The balance ability of subjects with a meningitis etiology was most affected to compare to nine other deafness etiologies. These results are consistent with Brace who also found superior performance by the congenital group.

Myklebust\textsuperscript{37} competed a series of studies assessing the psychomotor performance of individual with hearing impairments. The manual dexterity of 80 Df males ages 12 to 21 years, from a residential school was evaluated. The results from the Df students fell with in 50\textsuperscript{th} percentile of that of the H for speed, but only the 15\textsuperscript{th} percentile for accuracy. Myklebust also assessed locomotor coordination of 75 Df and


275 H children who ranged from seven to 15 years of age. The Df children were found to be inferior to the H children in this test. That Df students were also divided into the etiological categories of acquired, congenital, undetermined, and meningitis. The meningitis groups fared the poorest in test comparisons. In addition Myklebust assessed balance and manual dexterity in motion, general coordination, manual dexterity, simultaneous motor control, and overflow. 30 Df boys and 20 Df girls from a residential school were tested, they ranged in age from eight to 14 years. Df boys and girls fell 1.5 years below the norms for H children on the average, and they performed poorest on static balance and manual dexterity. However, Df children were well within the norms on overflow and dynamic manual dexterity items. Myklebust noted that these norms may not be appropriate for American children. The method of communication with Df children was not mentioned.

Boyd\textsuperscript{38} studied 90 Df boys from Residential Schools who ranged in age from eight to 10 years. Etiological classification were primarily time based, exogenous-prenatal, exogenous-postnatal, and endogenous (hereditary). The Df subjects had a minimum threshold hearing level of 65dBs or greater for each ear. These subjects were matched across

etiological groups for age, gender, and IQ, with 30 H subjects from elementary schools.

Like Myklebust, Boyd doubted the validity of the norms established by Oseretsky in Russia in the early 1930's and thought the comparison between the experimental and control groups to be most advantageous. Results indicated a significance difference in static balance, with the Df boys being deficient to H boys in all age groups. No significant difference was found between the Df and H eight year olds in locomotor coordination.

However there was a significant difference between Df and H nine and ten year boys, with the Df groups scoring lower. No significant difference was found between the nine and ten year old H and Df boys in manual dexterity speed, but there was significant difference between the eight year olds with the Df seen as superior. This was in contrast to Myklebust's 1964 findings. Both Myklebust and Boyd used subjects from residential schools, however, Myklebust subjects had a higher age range and included some girls. Boyd assessed eight to ten year old boys.

Compared to Myklebust, Boyd found no difference between etiological groups with regard to equilibrium or locomotor coordination.
85% of the exogenous postnatal groups etiology was meningitis, the groups that Myklebust had found to perform least well on balance items. The eight and ten years olds in the endogenous groups were seen as slower in speed then the exogenous prenatal groups.

Vance\textsuperscript{39} compared motor skills of non-institutionalized Df and H children whose ages ranged from five to 13 years. This research is one of the few studies that included Df subjects from different non-residential schools. All of the children were of normal intelligence. Forty-four Df children were drawn from five days school programmes in Iowa. The Df children were matched by age, gender and socio-economic background, with 44 H children from the same school system. The Df children had a 65-dB or greater hearing loss in the better ear. Subjects were given verbal instructions, demonstrations and practice. The results indicated that the H boys had a better mean performance in all ten tasks with a significant difference in balance, tracing speed, grip strength, 50 yards, Dash, squat thrust and ball throw. The H girls performed better in nine of the ten tests, with a significant difference in grip strength and squat thrust. The performance of the Df girls was superior in the ball throw. Hand selection and usage was not clear on the dynamometer. Vance

encountered some difficulty with the 50 yards. Dash administration, two trials were administered in school hallways. Vance conclusion was that Df children are consistently inferior to normal H children on a variety of motor tasks.

Logan\textsuperscript{40} researched difference in balance between H and HI individuals. Four groups were established, two groups of 30 H and 30 HI subjects, ages ten to 12 years, and two groups of 30 H and HI subjects ages 18 to 20. all of the Df subjects were from Gallaudet College, with the younger HI group being from Kendall School. The younger H group was from a local elementary school and there was an equal distribution of black and white subjects in each younger group. The older groups were all from Caucasian and the H group was from University of Maryland. The subjects comprised an equal number of boys and girls in all groups, who are normal intelligence, neurological development and right lateral dominance. The HI subjects had binaural (both ear) audiogram average of 70%. The HI subjects were also delimited to normal prenatal and perinatal development that excluded persons with etiologist, which can

\textsuperscript{40} M.J. Logan, “A comparison of Static and Dynamic Equilibrium among the Hearing and Hearing-impaired at the Elementary and Colleges”, (Unpublished Master’s Thesis, University of Maryland, 1969).
affect balance such as meningitis, German measles and maternal loss of blood.

Six test of balance was used, instructions were given orally to the H subjects and an interpreter signed the instructions for the HI subjects. The four static balance tests were standing on preferred leg with eyes open and with eyes closed, the sharpened Romberg test, standing heel to toe (with arms folded in front and stick balance (standing crosswise on the balls of the feet on a stick). The two dynamic balance tests were stepping stone (leaping circle to circle with alternating feet) and the stabiolometer (Balance Board). Results indicated a significance difference favoring H children in both age groups for the one leg eye closed test, the sharpened Romberg test and the Stabiolometer. The younger HI group was also deficient in three other balancing test. Because of the similarities between the older groups on three of the six tests, Logan suggested that some of the differences of impaired balance were compensated with maturation. It was also thought that the older subjects may have better on the stick balance because of greater leg strength and base of support. Another reason for similarity with older children may have been that children with etiologies that affect balance were excluded from the study.
Although it was stated that the stabiolometer were alter to make the measurement more accurate, it was not indicated whether the difficulty Morsh experienced that of noise influencing test result was resolved.

Bressett\textsuperscript{41} assessed athletic capabilities of youngsters who are either congenitally or pre-lingually Df and H students. There were 25 boys and 25 girls in each category ranging from 12 to 14 years. The 50 Df subjects from a residential boarding school and the H subjects attended a public Junior high school. Bressett noted that physical education programmes of both schools were similar. Subjects were matched for age, weight, height, and gender factors, which were considered important in athletic performance. Etiology and degree of hearing ability were not indicated in this study.

This study used a variety of assessment tools to measure athletic ability potential endurance (maximal breathing capacity and forced expiration of the volume), eye hand reaction time, eye hand coordination, agility, running speed, leg strength and arm strength. Though balance was acknowledge as an integral aspect of athletic capability, Brassett did not measure balance ability because past studies had indicated that Df

children were inferior to H children in this capacity. The Df group perform below the H groups in maximal breathing capacity and forced expiratory volume, which Brassett indicated might to be attributed to the lack of vocalization on the part of the Df. The H boys tested three percent and H girls 12% above the norms in maximal breathing capacity. The H subjects performed significantly better in agility and H girls significantly better in leg strength. There were no significant differences in eye hand reaction time, running speed and arm strength. Differences between the H and the Df students may have been due to opportunities to participate in activities beyond the physical education programme and / or greater participation in athletics.

Lindsey and O’Neal\(^{42}\) compared the performance of 31 physically and mentally normal Df 8 year olds with 77 physically and mentally normal H 8 year olds. The Df subjects were drawn from two residential schools in North Carolina and all had a 65-dB or greater hearing loss. The 77 H subjects were selected from the public schools in the same area and had a 25-dB or better hearing level.

A teacher-interpreter from each school was provided for Df subjects. Demonstrations were given, and the teacher-interpreter signed the explanation, made corrections, and gave praise. Six static and 10 dynamic balance tests were used. The kicking (left and right), squat, balance beam forward, and the jumping-over-rope tests were eliminated from the statistical analysis because of 98% of the subjects passed these tests. Both groups performed better on the dynamic balance skills than on the static balance skills. Static and dynamic balance performance of both groups was impaired with the removal of visual input, with Df children being more affected. There were some scattered equivalences between Df and H individuals, which Boyd in 1967 had also found. The overall results from Lindsey and O’Neal indicated that Df children were deficient in static balance and were more significantly impaired than H children when visual input was removed.

Furthermore, they found that their Df 8-year-olds failed significantly more dynamic balance skills than did the H. These findings are in direct contrast to those of Boyd (1967), who found no significant difference in balance between the 8-year-olds in the Df and H groups. Boyd had a much larger sample size (N=90) than Lindsey and O’Neal (N=31). Also, Boyd’s study included only boys whereas Lindsey and O’Neal’s subjects consisted of 19 boys and 12 girls.
Gayle assessed static and dynamic balance abilities of H and HI children. The subjects were 6 and 12 years of age, and all of the HI children were identified as having a congenital or acquired sensory neural hearing loss of greater than 25 dB. Twenty HI and 20 H students were matched according to age and gender, with 11 boys and 9 girls in each group. Instructions were given verbally and demonstrated to the H students. Total communication and a demonstration were used for HI subjects. This research featured as many as 20 trials for each subject on each balance item. Dynamic balance was measured with a balanciometer. Static balance was tested left and right. The results indicated a significant difference between H and HI groups, with the H subjects being deficient in most tests except for left static balance.

This study included a small number of subjects, yet all were drawn from the same elementary school in Wisconsin. Although the HI students attended special classes, all subjects attended the same physical education programme. In other research studies, subjects were often drawn from different schools than the H subjects.

Geddes evaluated 11 Df and HI subjects, 4 to 6 years of age, with the Geddes Psychomotor Inventory. The 4 boys and 7 girls were from the John Tracy Clinic in Los Angeles. They were given instructions by use of hearing aid and lip readings. The following psychomotor skills were measured: static balance, body awareness, locomotion and dynamic balance, manipulation, climbing, throwing, catching, and kicking. Five of the 5 to 6 year olds performed at age level. Two of the 5 to 6 year olds were a year behind the balance (one had an etiology of meningitis, the other, unknown). The results from the four subjects in 4 to 5 year age range provided no conclusive findings. Subjects performed at age level in 11 of the 18 items. The small number of subjects in this study severely restricts any generalizing of the findings.

Pender and Patterson compared the psychomotor performances of 120 H and HI children, 6 to 11 years of age. Sixty Df children were from the Louisiana state school for the deaf and had hearing losses ranging from 60 to 110 Db. They were matched for age, gender and race with 60 H students from a local elementary school. The method of


communication was not mentioned. A significant difference was found favoring H children in power, kinesthesis, arm and shoulder girdle strength, and static and dynamic balance. A significant difference was found favoring Df children in agility, speed and cardio respiratory endurance. The superior performance of the Df students in cardio respiratory endurance is in contrast to Bressett’s findings in the laboratory. This difference may be due to selection of tests. Bressett used a laboratory test and Pender and Patterson used the step test. There was no significant difference between the groups regarding strength and endurance.

Brunt and Broadhead 46 assessed the motor performance of 154 HI boys and girls ranging from 7 to 14 years of age. The subjects were drawn from the Louisiana state school for the deaf and 98% of them had a greater than 60-dB hearing loss. There were some difficulties with communication in the pilot test. To ensure effective communication, testing include the use of convectional signing, some demonstrations, finger spelling, and /or pointing to objects or body parts. The results indicated that the Df subjects were below the mean in balance, bilateral coordination, and response speed. Brunt and Broadhead indicated this

may have been due to subjects watching the testers. Df subjects were above norms in visual motor control, with the researchers postulating that the cause may have been due to the use of manual communication by the deaf.

Campbell\textsuperscript{47} studied psychomotor differences between H, HI, and Df children 6 to 13 years of age. A hearing impairment was defined as a less than 90-dB hearing loss and Df was defined as a greater than 90-dB hearing loss. The H subjects were randomly selected and matched with the HI and Df subjects for age, height, weight, and gender. There were 94 subjects (47 H, 23 HI, and 24Df) from the Jackson-Mann school, a public school in Massachusetts. The HI and Df subjects had physical education three times a week, 35 minute per session, and the H subjects engaged in physical education once a week. The method of communication was not mentioned. In H to Df comparisons, results indicated that the H group scored significantly higher than the Df group on eight of the nine fitness items. The 9-minute and 30-yard run significantly favored H children over HI children, while the flexed arm hang showed no significant difference between groups.

Butterfield\textsuperscript{48} assessed 132 HI children, ages three to 14 years, from five residential schools for the deaf in four states. Ninety-five percent of the children had a greater than 60-dB hearing loss. Directions were given the school preferred method of either oral or total communication and included demonstration. Butterfield found that those with the greatest dB hearing loss performed at the mature level in kicking while those with less severe hearing loss did not. No relationship was found between the results of the etiological groups, except that the genetic etiology group was significantly superior to the idiopathic group in static balance. There was also a significant relationship between the ability to balance and motor skill development in the performance of stair climbing, running, throwing, catching, kicking, jumping, hopping, skipping, striking, and ladder climbing. In follow-up studies (Butterfield, 1989; Butterfield & Ersing, 1987a, 1987b, 1988) relationships were found between age and jumping (.81), kicking (.82), catching (.96), and throwing (.88). Balance proficiency was also related to these skills and was predictive of mature kicking form. Level of hearing loss was no related to jumping, catching, and throwing but related to kicking.

Winnick and Short 49 in one of the most comprehensive studies of physical fitness, tested 686H subjects, 153 hard-of-hearing (HI) subjects (defined as defective hearing without aid, or a 27-to 90-dB hearing loss), and 898Df (91dB or greater hearing loss in the better ear). The HI and Df subjects were from schools and agencies throughout the United States, with 917 from residential schools and 127 from non-residential schools. All were acknowledged as having a hearing impairment that adversely affected educational performance. Winnick and short measured skin fold; grip strength (right and left), power and strength, flexibility, power and speed, and cardio respiratory endurance. Hand signals were used to start and stop activities, and instructions were given in writing and/or nonverbal communication. The performances of the H, HI, and Df groups were quite similar overall, with a few exceptions. Similar to Campbell (1983), H subjects generally performed better than HI and Df subjects in power and strength (sit-ups). The researchers attributed this difference to visual and vestibular disorientation of the HI and Df groups. The H females had smaller skin fold measures and were more flexible than the HI and Df females.