CHAPTER-II

REVIEW AND LITERATURE

1. ANTHROPOMETRIC STUDIES
2. LUNG FUNCTION STUDIES
3. PHYSICAL FITNESS STUDIES
Anthropometric traits and measurements have been utilized in numerous classification schemes. During the Civil War in America, anatomical measurements were given due emphasis. In 1861, Edward Hitchcock, a medical doctor, went on collecting measurements such as height, weight, age, girths of chest, arm and forearm, lung capacity and strength of the upper arms. He then performed the tests on the students at Amherst College and developed, over the course of 20 years, standard body proportions of college males. These anthropometric measurements initiated the era of scientific measurements in physical education (Phillips and Hornak, 1979).

Classification systems using age, height and weight were developed in the 1930s and were utilized quite extensively to classify students into homogenous groups. The most popular indexes have been those of Cozen (1929), Nelson and Cozen (1934) and McCloy and Young (1954). Delaney (1928) and Adams (1934) both reported very low multiple correlations between performance and 3 factors (age, height and weight). They concluded that age alone provided the most appropriate grouping for junior high school girls.

McCloy (1932) in a study obtained a multiple correlation of 0.63 between performance of boys in Detroit decathlon and age, height and weight. Ages were ranged from 10-16 years. On other samples of U.S. elementary and high school boys, correlations were ranged from 0.58 to 0.64. Thus, age, height and weight were found to account for between 35% and 40% of variance in performance of boys in several combination of events.
The correlation coefficient between the aforementioned formula and the Neilson-Cozen classification index (an outgrowth of Reilly's plan of rational athletics for boys and girls in elementary and junior high schools) was found to be satisfactory for use as a classification device for purpose of competition in physical education activities (Neilson and Cozen, 1934). Also Neilson and Cozen claimed that their classification index of $20 \text{Age} + 5.5 \text{Height} + 1.1 \text{Weight}$ verified McCloy's findings and established the validity of their scheme of classifying elementary school boys and girls (Cozen et al, 1936). This Neilson and Cozen Classification Index was used in the AAHPER Youth Fitness Test Manual in classifying boys and girls of elementary and junior high school age (AAHPER, 1958).

The mean differences in body weight between monozygotic twins and their co-twins is less than between dizygotic twins and their co-twins in children aged between 6 and 12 years. The differences between the birth weights of dizygotic twins are greater than monozygotic twins. Genetic factors are important in the control of body weight in children (Bakwin and Harry, 1973).

Several attempts have been made regarding the assessment of genetic versus environmental influence on some somatological traits. One of these, Hoshi et al (1982) have received much attention. Intrapair similarity of some somatological traits was analyzed using about 59 male and 69 female Japanese monozygotic twin pairs aged between 12.25 and 13.25 years in terms of intra-class correlation coefficient and coefficient similarity. Twins were studied for the measurement of 28 anthropometric parameters, the stature, body weight and illiospinal height were in the highest similarity group, while skinfold
thickness, calf fat thickness (X-ray) and some cephalic measurements belong
to the lowest. Among 20 indices, circumferential sizes, peak height velocity
represented high similarity. In calf tissue composition analysis, bone was
high, fat was low and muscle was intermediate in similarity. The relation of
the similarity with the so-called heritability was discussed.

In 1984, Sharma et al have reported studies regarding anthropometric
traits in a Punjab (India) Community. They performed the tests on the 40
anthropometric measurements for 144 nuclear families in Chandigarh. Most
families contain a pair of MZ or DZ, 1 or more singleton siblings. Twin
correlation seems to indicate a higher level of heritability than correlations
from other family members.

Anthropometric traits and measurements are influenced by different fac-
tors. In 1986, Kramer et al investigated the bivariate path analysis of twin
children of Buffalo NY (USA) for stature and biiliac diameter. They performed
intra-pair correlations of stature x stature, biiliac diameter x biiliac
diameter for MZ, like-sex DZ and unlike-sex DZ as well as intra individual
correlation for all twins of stature x biiliac diameter. Results of the path
analysis revealed heritabilities of 0.54 and 0.51 for stature and biiliac
diameter respectively. The genetic correlation suggested that the two traits
are influenced to some extent by the same genes.

2. LUNG FUNCTION STUDIES:

More than two thousand diseases are postulated to be products of highly
complex interaction of genetic and environmental factors. Chronic obstructive
pulmonary disease (COPD) is not an exception. The role of these two factors
has not been clarified in other two categories of COPD, i.e., pulmonary emphysema and chronic bronchitis. Among previous challenging reports on this problem, that of Jackson (1842) appears to be the first. He states that occurrence of pulmonary emphysema is higher in parents of patients than parents of healthy subjects.

In 1846, John Hutchinson, a British Surgeon, first invented a spirometer to take some accurate experimental measurement of vital capacity. He was one of the scientists in the earliest ages to appreciate individual variations in vital capacity and attempted to explain the scatter on the basis of body height, body position, age, sex etc. and was rather as a pioneer in the field of spirometric measurements with perfect accuracy.

As early as 1919, Dreyer observed a significant relationship between vital capacity with the physical fitness and the difference in vital capacity that he obtained among various socioeconomic classes were attributed to their occupation and mode of life. He also pointed out that vital capacity was related to body weight, body surface area, stem length and chest circumference. West (1920) related the vital capacity to both body surface area and body height and established simple regression equation from these relationships. On an average basis West found 2.50 and 2.00 litres of air per sqm of the body surface area as vital capacity in American men and women. Wilson and Edwards (1921), Stewart (1922), Myers (1923), Moore and Gibson-Williams (1951) and others have showed that the pulmonary function of normal children varies with age and anthropometric build. Foster and Hsiesh (1923) reported such vital capacity of 3.18 litres for Chinese male population. Sotake and Sato (1938) reported 3.8 litres of vital capacity in Japanese younger age group. Hermansen
(1933) introduced the maximum breathing capacity (MBC) test. Ferris et al (1952) and Ferris and Smith (1953) reported normal values of MBC in relation to age, height, weight and body surface area for young children and adolescents of both sexes. Prime (1960) reported significant difference in PEFR between normal subjects and subjects with respiratory abnormalities. He reported a positive correlation of PEFR with PEV. Jain and Ramiah (1969) derived regression equations for healthy Indians (15-40 years) and compared with those of many Indian and Western authors. The mean values of vital capacity and MVV were found to be higher than some of other studies. Singh et al (1971) studied vital capacity and forced expiratory volumes in half, three quarters and one second in 174 healthy school boys. All values had a significantly high correlation with age and physical measurements.

Effects of CO$_2$ and hypoxia on VO$_2$ max, lung volumes and pulmonary ventilation in identical twin athletes were reported by Leitch et al (1975). Twins were trained to similar high degree. They concluded that genetic factors play a major part in the determination of ventilatory responses to CO$_2$ and hypoxia.

Webster et al (1979) measured maximal expiratory flow at 60% of total lung capacity ($\dot{V}_{max \, 60}$) in apparently normal pairs of identical twins (45). Twins were concordant and discordant in smoking habit. The analysis of intra-pair differences of $\dot{V}_{max \, 60}$ values disclose that genetic factors are apparently important in determining the vulnerability of the airways to cigarette smoke.

Respiratory functions were examined in 56 healthy high school twin students (monozygotic twin = 19 pairs and dizygotic twin = 9 pairs) by Kawakami et al (1980). FVC, PEV$_1$, PEV$_{1/2}$, FRC, $\dot{V}_{50}$, $\dot{V}_{25}$, Raw, SGaw, $4N_2m$ CV/VC, $\text{PaO}_2$, $\text{PaCO}_2$, pH
and \([\text{HCO}_3^-]\) were measured to determine the role of genetic factors in determining pulmonary mechanics, lung volumes, gas exchange and ventilatory response to hypoxia and hypercapnia. Analysis of covariance disclosed that FVC, FEV\(_1\), FEV\(_{1}\%\) and ventilatory response to hypoxia and hypercapnia were genetically determined. They reported that apparently genetic factors are responsible at least partially, for the variability of respiratory functions in normal subjects.

Berezovskii et al. (1981) measured respiratory frequency, \(O_2\) consumption and minute lung volumes in monozygotic and dizygotic twins under normal conditions and under conditions of progressive hypoxia and hypercapnia. Respiratory function indices are influenced significantly by hereditary factors. Hypoxia and hypercapnia causes pronounced changes in ventilation and gas exchange. The effect of heredity appears to be greatest in respiratory frequency and \(O_2\) consumption.

Vital capacity, maximal lung ventilation, expiratory frequency, respiratory ventilation, minute ventilation, PCO\(_2\), PO\(_2\), \(O_2\)-uptake, cardiac output and arterial blood pressure were determined in 24 pairs of monozygotic twins and 26 pairs of dizygotic twins by Serebrovskaya and Lipskii (1982). These values equally depend on heredity and environment. Individual variations in forced expired volume, \(CO_2\)-output and pulse rate are entirely due to the environmental effect. Shida (1982) studied FVC, FEV\(_1\), \(V_{50}\), \(V_{25}\) and PRC of 31 twin pairs (20 monozygotic and 11 dizygotic twin pairs) of both sexes, ranging age from 15-18 years. The lung function measurements were corrected for height again, the within-pair variances of MZ were smaller than DZ with
respect to all the measurements except for FRC. These parameters were at least partly determined by genetic factors. Hankins et al (1982) recorded 13 pulmonary function tests on 15 pairs of monozygotic twins and 1 set of monozygotic triplets. Only FEF25-75 and V75 could separate smokers from non-smoking twins when only paired data from twin pair discordant for smoking were used. Intra-twin differences in the discordant group were large and distinctly different from the concordant groups. They concluded that genetic factors are important in determining susceptibility to airway obstruction from cigarette smoke.

A 6 year follow up study was made on genetic and environmental determinants of the cardiorespiratory response to submaximal exercise by Kagamimori et al (1984) in 65 identical and non-identical boy and girl twin pairs. Exercise ventilation at work rates below the anaerobic threshold was independent of genetic and environmental factors. Anaerobic threshold increased with age. The exercise cardiac frequency was subject to genetic and environmental control with the genetic component predominating initially. The influence of environmental component was larger for non-identical than for identical twin pairs and for boys than for girls. The performance during submaximal exercise appears to be interaction between the genetic and environmental components. Zamel et al (1984) studied airway response to inhaled methacholine in 10 MZ and 10 DZ healthy non-smoking twin pairs. The variability of maximum expiratory flows is genetically determined and the airway response to cigarette smoking is also influenced by genetic factors. They further observed that environmental factors are evidently more important than genetic factors in determining the variability of acute airway responsiveness to bronchoactive drugs in healthy non-smoking subjects.
Redline et al. (1987) measured various spirometric measurements in 256 monozygotic and 158 dizygotic twin members of the Greater Boston. Spirometric measurements were adjusted for anthropometric characteristics of twins to estimate the genetic influence and for the effects of a number of environmental factors including respiratory illness, occupational dust exposure and smoking history. Highly significant adjusted intra-pair correlations for all spirometric measurements, ranging from 0.52 to 0.76 were observed for the MZ twins. The intra-pair correlations for the DZ twins were approximately one-half the magnitude of those for the MZ twins. They suggested that a large portion of the measured variability in pulmonary function may be accounted for by genetic influences other than associated with body size.

In order to estimate the genetic component in the determination of resting breathing patterns, inspiratory time (TI), expiratory time (TE), total breath duration (TTOT), VT/TI, TI/TTOT by taking TI, TE and VT all together. Respiratory variables were measured with pneumotachometer and plethysmograph separately by Shea et al. (1989) for 9 pairs of twin. In both studies, there were highly significant similarities with in twin-pairs in the breathing pattern. Redline et al. (1989) studied FEV₁ and FVC in 414 families of adult twins of Greater Boston Twin Registry between 1981-1982. Pulmonary functions were adjusted for age, sex, height and smoking status. The data suggested that phenotypic similarities in pulmonary function related directly to genetic similarities and are consistent with a multifactorial mode of inheritance. In order to estimate the genetic control of pulmonary functions independent of influence of height, Ghio et al. (1989) measured FVC, PEV₁, and PEV_25-75%, Tlcsb, RVsb and D/va of 74 pairs of asymptomatic non-smoking twins. Pulmonary function
indices were adjusted for height using simple linear regression. Following adjustment for height, no measure of pulmonary function which satisfied the requirements of the analysis was found to be significantly heritable. This hypothesis established that when total variances of a function parameters were statistically different between monozygotes and dizygotes, the among component heritability estimate was calculated and used as the best indicator of heritability.

3. PHYSICAL FITNESS STUDIES:

Fitness measurement and evaluation had been continuing from ancient Greek period. But the major effort of testing basic performance traits, especially strength, appeared during 1880 as an extension of the scientific era of measurement. In the Seventeenth Century, French anthropologists developed and used dynamometers for measuring strength. Sargent first emphasized measuring strength when he was a medical student at Yale and developed the Intercollegiate Strength Test in 1873. This test was used extensively in the late Nineteenth Century by Universities.

Athletic motor ability was first tested by the Turners (Normal School of Gymnastics), who, in 1894, developed test items to compare athletic performance of students. In 1921, Dudley Sargent, because of his belief that strength test did not measure endurance and speed developed a battery of simple exercises to be performed for 30 minutes. Those who completed the test battery were considered athletically fit. Shortly thereafter, Dr. George Meylan of Columbia University developed comprehensive tests of running, jumping, vaulting and climbing, these were later used at many universities for grading and classification.
The Physical Fitness Index (PFI), published by Frederick R. Rogers in 1927, was the first modern physical fitness test. Actually Rogers' PFI tests of muscular strength, muscular endurance and lung capacity, which were only three of several components that comprise physical fitness. In 1934, Cozens and Neilson pointed out that the reason behind the use of age, height and weight as classification factor, was that bodily structure basically determines physical capacity. This classification index was used in the AAHPER Youth Fitness Test Manual in classifying boys and girls of elementary and junior high school age (AAHPER, 1958). Gross and Casciani (1962) observed that the functions of age, height and weight had practically no value, singly or in combination, as classification for the 7 test items. Jones (1963) observed the relationship of the age, height and weight with performance of boys and girls on the performance test. Montoye et al (1972) reported the value of age, height and weight in establishing standards of fitness for children of United States aged 9 to 18 years. By employing stepwise multiple regression and partial correlation, it was demonstrated to be sufficient to establish percentile standards by age alone.

Sklad (1975) predicted the genetic determination of the rate of learning of motor skills of 50 pairs of MZ and like sexed DZ twins. He observed that capabilities for acquiring different types of motor skills (ball throwing, tapping and precision movements in the tremometer) apparently are determined by different independently transmitted genetic factors and the concept of general motor capability has a questionable validity.

Engstrom and Fischbein (1977) studied vital capacity, muscular strength and physical work capacity in twins and controls. Intra-pair correlations
showed the MZ twins to be much more similar than the DZ twins in all the capacity measures. The result shows that physical work capacity, therefore, appears to be a more environmentally influenced variable than either vital capacity or muscular strength.

The role of hereditary and environmental factors in the reaction of the human cardiovascular system to physical loading, was reported by Sokolov et al (1980). Under conditions of muscle activity, regulation of the cardiovascular system is primarily under the control of genetic factors. At the end of work period, when signs of fatigue appear, environmental factors play a determining role in the variability of indices of the cardiovascular system. At the 10th minute of rest arterial blood pressure and pulse variability are determined by environmental factors and genetic factors respectively.

Demeersman et al (1984) reported that an individual functional ability in physiological responsiveness may be an interaction between heredity and environment. A set of MZ triplets were allowed for 3 month aerobic physical fitness training programme. The results indicated that environmental factors contribute substantially to the intra-pair variance found among MZ siblings and environmental stimulation of sufficient magnitude may alter the functional adaptability in the individual set by his genotype. Prud'homme et al (1984) reported that sensitivity of maximal aerobic power to 20 week endurance training is largely genotype dependent. A 6 year longitudinal study was made on ventilatory and cardiac frequency response to submaximal exercise by Kagamimori et al (1984) in 65 identical and non-identical boy and girl twin pairs. The performance during submaximal exercise appears to be interaction between genetic and environmental components.
In order to investigate cardiac activity and its relationship to parental blood pressure, Carrol et al (1985) used a simple genetic model that implicated additive genetic effects, along with those stemming from individual environments, best fitted data. The cardiac reactivity of 40 MZ and 40 DZ pairs of young male twin was monitored during psychological challenge, as afforded by a video game. They concluded that individual differences in cardiac reactivity have a heritable component and that high reactivity may be a precursor of elevated blood pressure.

Bouchard et al (1986) studied maximal heart rate, maximal ventilation, maximum \( O_2 \) pulse and \( \dot{V}O_2_{\text{max}} \) in 42 brothers, 66 DZ twins of both sexes and 106 MZ twin of both sexes, 16-34 year of age. Twin data were used to compute the genetic effects. The within-pair estimate of genetic variance revealed that it was significant for all variables except \( \dot{V}O_2_{\text{max}} \). The size of the genetic effect was 40% for \( \dot{V}O_2_{\text{max}} \) kg\(^{-1}\) min\(^{-1}\), 50% for \( HR_{\text{max}} \), 60% for maximal \( O_2 \) pulse and maximal ventilation and 70% for 90 min work output kg\(^{-1}\). A significant genetic effect is present in the population for endurance performance but that a much lower heritability exists for \( \dot{V}O_2_{\text{max}} \).

65 Monozygotic and 55 dizygotic pairs of twins underwent the tests for bodily agility in preschool ages and the sports mark at termination of the 1 class. The concordance quota of the tested characteristics varied in the MZ between 77 and 82%, in the DZ between 41 and 56%. The differences are statistically significant ones (Liebing, 1987). In the same year, Pagard et al studied the contribution of heredity to the interindividual variability of maximum oxygen uptake and of cardiac size and function of 12 MZ and DZ pairs.
of male twins, age 18-31 years. They commented that cardiac factors are not significantly involved in the inheritance of aerobic power. Cardiac hypertrophy in athletes is secondary to training.

Several attempts have been made regarding the assessment of army ability. One of these, Tambs et al (1988) received much attention. The ability scores from all complete twin pairs recruited to compulsory Norwegian military service during the period of 1950-1954, were analysed, using a multivariate design. Three separate scores were obtained from the army test: general ability, technical comprehension and arithmetical skills. The total genetic variances varied from 40% to 66% in three subtests. The environmental within-pair and between-pair variances were about equally large. The intra-correlations between the subtests were generally high and the major part of the genetic variance was common. The genetic effects explained that about 20% of the total variances was specific for general ability. All the environmental between-family variance were common for the three subtests.