ANAEROBIC POWER PERFORMANCE OF UPPER AND LOWER LIMBS OF SELECTED NIGERIAN CHILDREN AND ADOLESCENTS

BY

FARUK RASHID HARUNA
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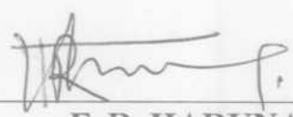
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1998

DECLARATION

I hereby declare that the research work presented in this dissertation, for the award of Doctor of Philosophy has been written and compiled by me. The research, is exclusively, the report of the investigation conducted.

I also declare that this dissertation has not been submitted in any form whether partly or wholly for any other degree. All sources of publications and other related reports cited in this investigation have been identified in the reference section.



F. R. HARUNA

DATE

CERTIFICATION

This dissertation entitled "ANAEROBIC POWER PERFORMANCE OF UPPER AND LOWER LIMBS OF NIGERIAN CHILDREN AND ADOLESCENTS by Faruk Rashid Haruna meets the regulations governing the award of the degree of Doctor of philosophy in Exercise and Sport Sciences of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

Prof. K. Venkateswarlu
Chairman,
Supervisory Committee

2/2/99
Date

Dr. M.A. Chado
Member,
Supervisory Committee

5/2/99
Date

Dr. (Mrs.) F. B. Adeyanju

8-2-99
Date

DEDICATION

This researcher dedicates this work to his Sister Hauwa Haruna for her untiring support, to his wife Habiba Faruk for her love and care and his children Imran, Habib, Zulkarnain and Hauwa Faruk for their patience, and bravely bearing his absence during the course of this research work.

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All honour and glory be to Allah for his abundant mercy and guidance throughout the completion of this course.

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ABSTRACT

The purpose of this investigation was to determine the differences between Nigerian children and adolescents aged 10-16 years in the Anaerobic Power Performance of their upper and lower limbs.

To achieve the purpose of this study, 420 subjects were randomly selected from primary and secondary schools in Zaria to serve as subjects. Out of these subjects were 120 male children, 117 female children, 90 male adolescents and 90 female adolescents. All the subjects were tested for their anaerobic power, anaerobic capacity and fatigue index using Wingate Anaerobic Power Test and Arm Cranking Test. Similarly, 10 male and 11 female subjects were randomly selected from these subjects for serum lactate dehydrogenase activity analysis. Out of these were 9 children and 12 adolescents. The data obtained from these subjects were statistically analyzed to test the hypotheses of the study. The major findings of the study revealed

1) Significant higher values of male subjects over female subjects in all the anaerobic power performance components, and significantly higher anaerobic power performance of adolescents than the children both in upper and lower limbs capacities.

2) Significant difference between male and female adolescents in anaerobic power performance of lower limbs.

3) Insignificant differences between male and female children in anaerobic power performance.

4) Significant effect of the interaction of age and sex on anaerobic power performance exists.

5) Insignificant effect of either age or sex on lactate dehydrogenase activity before or after exercise.

6) Insignificant difference between different categories of subjects both in pre-test and post-test lactatehydrogenase activity.

7) Significant relationship between anaerobic power performance and body height and weight.

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DEFINITION OF TERMS

Anaerobic Power - The exertion of force through a given distance in as short a time as possible.

Anaerobic Threshold - A point in which exercise is almost entirely aerobic (little lactate production).

Anaerobic capacity - The total work performed during the entire 30 second period. It is also referred to as mean power. This presumably reflects the glycolytic (lactic) component plus the alactic component of energy release.

Body Mass Index - This is determined by dividing weight by square of height

$$\frac{(wt)}{Ht^2}$$

Blood lactate concentration - Any given blood lactate concentration to describe the blood lactate in response to exercise.

Peak Power - The highest work performed during any 5 second period. It is also referred to as peak power. This is presumably related to the alactic phosphagen component of anaerobic energy release.

Power decline - referred to as the index of fatigue rate. It can be calculated in two ways: either in absolute power terms or as the difference between peak power and the lowest 5 second power, divided by the time elapsed between the two measurements; or in percentage of peak power. Peak power minus lowest power, divided by peak power and multiplied by 100.

CHAPTER ONE

1.0 INTRODUCTION

The introduction of the Wingate Anaerobic Test (WAnT) as reliable test of anaerobic power combined with a growing interest in performance evaluation in male and female youth sports, have led to a surge of interest in the assessment of anaerobic performance among the sport groups. Sports scientists have since acknowledged the importance of the contribution of anaerobic energy system to successful performance in sports activities, involving short time, and high intensity. However, relatively little work has been reported as regards to the anaerobic capacity and power of children and adolescents especially in Nigeria.

Anaerobic power plays a significant role in successful performance, particularly in events that require short time maximal effort. The ability to jump, sprint, put the shot, throw the javelin or perform fast starts as required of defenders, and attackers in soccer, are a few examples of athletes who depend mostly on anaerobic power (Fox and Mathew, 1981).

If an athletic event or an industrial task can be completed in 5 - 10 seconds, a measure of maximal anaerobic power might prove valuable in the assessment of a candidate's ability to perform such a task (Lamb, 1978). Short sprints and jumps are some of the athletic events that are obviously dependent upon maximal anaerobic power. Similarly, any performance involving all-out exercise of 4 - 6 seconds duration is indicative of a person's immediate anaerobic power (McArdle, et al; 1984). Examples of such tests are sprint running or

cycling, shuttle run or even certain localized movements, such as arm cranking. The measurement of anaerobic power is therefore important since the ability to develop considerable power is a prime factor in athletic success. (Haruna, 1992; Haruna and Chado, 1993).

Until recently, only very few studies have been reported on the ability to perform high intensity, short time anaerobic tasks. Cross-sectional studies on Italian, African, British and American females and males have indicated an age related progression in the performance of the Margaria step-running test. Children, had a distinctly lower mechanical power output than adolescents and young adults in both absolute terms and when divided by body weight or fat free mass (Inbar and Bar-Or, 1986). On the Wingate anaerobic test, leg power in children has been shown to increase with age until the end of the third decade, whereas arm power, similarly measured, reaches its highest value at the end of the second decade (Inbar and Bar-Or, 1986; Sharp, 1991). In Nigeria, no study as to date has been reported on the upper and lower body anaerobic capabilities of Nigerian children and adolescents, despite the important role played by anaerobic power in the attainment of athletic prowess.

Anaerobic power plays a significant role in a number of sports and physical education activities because of the demands made on it by different sport requiring ballistic movements. The ability to thrust the entire body forward, like in sprinting and to propel objects in a fast and forceful manner in sports depends, to some extent, on the individual's anaerobic power. In athletic activities, involving explosive movements, such as jumping, sprinting, throwing,

the speed required in soccer or basketball, and the knock out punch in boxing, require anaerobic power for successful performance.

The understanding of anaerobic power and the role it plays in sports performance and physical activities will assist coaches in designing suitable training programme that will enhance performance in sports, requiring high supply of energy in a short time.

Tests widely used to assess anaerobic power and local muscular endurance of children include Wingate Anaerobic Test, devised by Oded Bar-Or. In this test, the child pedals a cycle ergometer, using legs or arms as hard as possible for thirty seconds against a workload, which is calculated to a proportion of the child's body weight. This test has been found useful for children as young as five years old (Bar-Or, 1985). The Anaerobic performance may also be determined by appropriate laboratory tests before and after periods of training. Such tests may be measures of lactic acid in blood or estimation of anaerobic power by the Wingate test or levels of anaerobic capacity by oxygen debt assessment. Previous results on Anaerobic power tests show that training increases children's peak power output by 14 percent, and the average power sustained over thirty seconds by 10 per cent. (Sharp, 1991).

Available literature on the Anaerobic power of children show that they are much less anaerobic and consequently more aerobic than their older counterparts and adults (Inbar and Bar-Or, 1986; Sharp, 1991; Nindl et al, 1995). This suggests that their ideal activities should be of modestly long as well as short duration, while children are likely to be relatively more successful in activities of longer duration distance. It is also desirable to include exercises of

higher intensity and shorter duration, as they will improve their anaerobic ability for successful performance in sports. This is especially relevant for the child whose main interest is in sprint endurance sports, such as soccer, basketball, badminton, squash, hockey and sprint running that demand higher levels of explosive strength. The sudden large amount of energy demanded in these sports can only be provided by anaerobic energy pathways involving phosphogen break-down and glycolysis (Ayalon, Inbar and Bar-Or, 1974, Bar-Or, 1978; Tharp et al., 1985). It seems therefore advantageous to evaluate the anaerobic power of upper and lower limbs among children and adolescents as it would aid better development and growth of their potentials for successful sports performance in later years.

1.1 STATEMENT OF THE PROBLEM

There has been a growing tendency to accord special attention to children and adolescents, especially in the field of sports. It has also been well documented that children at this age elicit their fullest physical performance characteristics and skills, which would be useful in later years. (Malina and Bouchard, 1991).

In view of scientifically established benefits of regular participation in physical activities, a variety of national, continental and international age group competitions are being organized for children and adolescents. These organized competitions have been recording ever-increasing number of child participant, especially in the age group of 10 to 15 years (Malina and Bouchard, 1991). As performance in these competitions is significantly influenced by anaerobic

capacity, exercise scientists have been attempting to evaluate the anaerobic capacity of children and adolescents.

Unfortunately, there remains a paucity of data worldwide regarding children and adolescents particularly with respect to upper body anaerobic power of both male and female children since most research studies on anaerobic power are on adults. One interesting issue that needs immediate attention is whether sex differences in anaerobic power performance are due to biological differences irrespective of athletic ability and activity levels (Nindl et al., 1995).

At present, developmental aspects of the anaerobic energy system are not fully understood, particularly with regard to sex differences. Moreover, there is a paucity of information concerning sex comparison in anaerobic performance. To date, this investigator has not come across any study in Nigeria on the upper and lower body anaerobic capabilities of children and adolescents. This investigation will attempt to answer the following questions.

1.1.1 Is there any difference between anaerobic power out puts of upper and lower limbs of children and adolescents?

1.1.2 Does anaerobic power change as a function of gender among children and adolescents?

1.1.3 Does anaerobic power performance change with age?

1.1.3 Is anaerobic power performance influenced by body stature, weight and body mass index?

1.2 BASIC ASSUMPTIONS

On the basis of available literature, the following assumptions are made for the purpose of this study:

1.2.1 Anaerobic power performance of children is influenced by increase in muscle mass as the individual grows.

1.2.2 Females have a distinctly lower mechanical power output than their male counterparts.

1.2.3 Anaerobic power performance of upper and lower limbs of children and adolescents can be assessed.

1.2.3 Younger children have a significantly lower ability to work anaerobically compared to adolescents.

1.2.5 Blood lactate concentration in children is not as high after intensive exercise as it is in adolescents.

1.3 HYPOTHESIS

Based on the information currently available, the major hypotheses for this study are:-

1.3.1. There are no significant differences between different categories of subjects in their Anaerobic Power performance.

1.3.2 There are no significant differences between lower and upper limbs of different categories of subjects in Anaerobic power performance.

1.3.3 Anaerobic power performance does not change as a function of age and sex

1.3.4 There is no significant relationship between Anaerobic power performance and anthropometric measures.

1.3.5 There is no significant relationship between Serum lactate dehydrogenase activity and Anaerobic power performance.

1.3.6 There is no significant difference between different categories of subjects in their pre-test and post-test lactate dehydrogenase activity.

1.4 SIGNIFICANCE OF THE STUDY

Several cross-sectional and longitudinal studies have been reported on maximal aerobic power. But, in contrast, only very few studies have been reported on one's ability to generate and sustain high intensity, mostly supramaximal power output, particularly among paediatric population despite the recognition accorded to youth sports in Nigeria.

Some daily activities and many sports routines engaged in by most children and adolescents are largely strenuous and of short duration and thus tax anaerobic energy pathways. Relatively, very few sport events require a sustained continuous effort longer than 30 - 60 seconds during performance and consequently, the vast majority of events depend upon anaerobic capacity, which has been given little attention by researchers. This study therefore is an attempt to evaluate the anaerobic power performance of upper and lower limbs of Nigerian children and adolescents. The results of the study will after analysis indicate:

1.4.1. differences if any between anaerobic power out put of upper and lower limbs of children and adolescents.

1.4.2. differences in anaerobic power and if it has any significant change as a function of sex.

1.4.3. if anaerobic power performance of children will differ with that of adolescents, and if the differences would be attributed to age.

1.4.4. if differences in anaerobic performance will change when adjusted for body stature, weight and body mass index.

1.4.5. If blood lactatedehydrogenase activity of children will differ with that of adolescent before and after exercise.

1.5 DELIMITATION OF THE STUDY

This study would be delimited to measurement of anaerobic power performance of male and female children and adolescents using the Wingate anaerobic test. The subjects were in the age group of 10 - 16 years from primary and secondary schools in Nigeria. The anaerobic power output consisted of anaerobic power, anaerobic capacity and power decline (fatigue index). The results of this study were analyzed separately for these three variables. Similarly, serum lactatedehydrogenase activity was determined using enzymatic method.

1.6 LIMITATION OF THE STUDY

This study considered the following limitations in the interpretation of the results.

1.6.1. The researcher was unable to design or acquire a photoelectric sensor, for counting the number of revolutions. However every care was taken to ensure that all the revolutions were accurately counted including part of a revolution.

1.6.2. Motivation was another limiting factor in measuring anaerobic power performance, as subjects are free to opt out. But every care was taken to ensure that the subjects were highly motivated and encouraged to produce their maximal output.

1.6.3. As norms for Nigerian population in anaerobic power are not available, it was difficult to determine anaerobic power performance qualitatively. However, anaerobic power performance of Nigerians was considered very cautiously when compared with the norms of other countries.

1.6.4. Various sampling techniques may cause large positive errors in the determination of serum lactatedehydrogenase Therefore efforts were made to avoid it.

1.6.5 The researcher was unable to estimate lactic acid. However, lactate concentration was inferred from Serum Lactatedehydrogenase activity.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.1 INTRODUCTION

Many sports such as badminton, basketball, squash, and sprint events demand higher levels of explosive strength. The sudden release of large amount of energy demanded in these sports can only be provided through anaerobic energy metabolism pathways involving phosphogen breakdown and glycolysis (Ayalon, Inbar and Bar-Or, 1974; Bar-Or 1978; Tharp, 1983) within some seconds.

Anaerobic power has often been determined by using field tests, such as the vertical jump, standing long jump, 50 yard dash, Margaria - Kalamen test and the Sargent jump test. (McArdle, Katch & Katch, 1981). In recent years, however, a variety of cycle ergometer tests such as Wingate Anaerobic power test has been developed to measure anaerobic power. As earlier stated, the primary purpose of this study is to determine how children and adolescents, aged 10 - 16 years, differ in their anaerobic power performance. In an attempt to achieve this purpose, the researcher reviewed the available related literature on anaerobic power performance of the selected pediatric subjects. This literature consisted of a very few studies, which are reviewed, in this chapter under the following sub-titles:

2.2: Anaerobic Power

2.3: Tests for Anaerobic Power

2.3.1 Margaria Kalamen Power Test

2.3.2 Sargent Jump Test.

2.3.3 Wingate Anaerobic Test (WAnT)

2.4 Age, Sex and Anaerobic capacity

2.5 Anaerobic metabolism during high - intensity exercise

2.6 Lactate Accumulation Values

2.7 Determination of blood lactate

2.8 Summary

2.2 ANAEROBIC POWER

There are different definitions of the term Anaerobic Power. Anaerobic Power is generally defined as the exertion of force through a given distance in as short a time as possible. In some instances this is termed as explosive power and described as the power developed with rapid, vigorous body movement from a stationary position or with a short running approach. (Beckenholdt and Mayhew, 1983; Lamb, 1978). Power may be defined as the ability to release maximum force in the fastest possible time, as is exemplified in vertical jump, broad jump, shot put, and other movements against resistance in a minimum time (Dharkey, 1984). Power has also been defined as the rate at which work is performed during mechanical work of muscular contraction (Verducci, 1980; Getchel, 1974; Fox, 1979). Fox and Mathew (1981) explained anaerobic power as explosive muscle force, which is commonly demonstrated in activities requiring ballistic explosive movements in mechanical work of muscular contraction. Power can therefore refer to the rate at which work is performed and it is expressed in kilogramme meter per second (kg m S^{-1}) Councilman

(1979) viewed power as one of the most misunderstood of all physical capacities. According to him, it is often considered to be synonymous with strength. Although it is related to strength, it also involves the factor of speed. A more appropriate term for this physical quality might be explosive strength.

Fox (1979) explained that the importance of power in athletics can be readily appreciated as in most sports activities the greatest energy produced in the shortest period of time is a prime factor in a successful performance. This is true, for instance for jumping, running, (particularly sprinting), and throwing. One of the most frequently used screening tests for potential success in football at any position is 40-yard (37 meters) dash (from a standing start), because this test is a test of power, and the ability to generate power is obviously necessary for performance in football.

In athletic activities involving explosive movements, such as jumping, sprinting and throwing, chemical energy is converted into mechanical energy to produce work at the fastest possible rate. Performance of short duration and high intensity, such as the 100- metre dash, 25-yard (23 meters) swim or weight lifting requires an immediate and rapid supply of energy. This energy is provided almost exclusively from high-energy phosphate bonds, adenosine triphosphate (ATP) and creatine phosphate (CP), within the specific muscle activated during exercise. (Saltin, 1973; Lamb, 1979; McArdle et al, (1984). If we assume that 20kg of muscle mass is activated during exercise, there is sufficient stored phosphate energy to walk briskly for one minute, run cross country race for 20 to 30 seconds or perform all out exercise, such as sprint running and swimming for about 6 seconds (McArdle et al, 1984). In the 100

metre dash for example, maximum speed can not be maintained for longer than this time and the runner may actually be slowing down in the last portion of the race. In this situation, the quantity of intramuscular phosphate may significantly influence one's ability to generate great amounts of energy for short duration.

Therefore, activities involving any form of sprinting, shot putting, high jumping, the speed required in football or basketball, the knock-out punch in boxing and most athletic events, demanding a fast burst of speed or maximum effort, require power (McArdle et al, 1984) Anaerobic power is therefore a prime factor in athletic achievement. The measurement of anaerobic power is therefore important since anaerobic power provides the body ability to thrust the entire body forward like in sprinting or to propel objects forcefully. It is measured in three basic forms, namely ability to project one's body, ability to project an object and ability to strike or kick (Nelson and Jensen, 1972).

2.3 TESTS OF ANAEROBIC POWER

Several field tests of anaerobic power, like the vertical jump, standing long jump, and softball throw for distance, have been developed. While these tests were repeatable and reliable, their validity is questionable (Wilmore, 1977). However, a simple and practical method and perhaps the most widely used test of anaerobic power was developed by Margaria in 1966 and subsequently modified by Kalamen (DeVries, 1974; Kalamen, 1968; Wilmore, 1977; Beckenholdt and Mayhew, 1983). This test required the subject to sprint up on ordinary flight of stairs, three at a time. Mechanical power is estimated as the product of the body weight acting through the vertical distance in the recorded time. Similarly, a number of tests have been developed in which the subject

generates high level of muscular power for brief period and peak mechanical power is measured (McCartney et al, 1983; Sargent et al, 1981; Inbar and Bar-Or, 1986). These were in addition to the previously developed step running test of Margaria et al, (1966). The latter assesses the peak mechanical power of the leg's movement in a period of usually less than one second.

Other tests developed to assess anaerobic power include the vertical jump, standing broad jump, and short sprint runs, of which the 40 -yard (37 meters) dash appears to be the most popular test. (Beckenholdt and Mayhew, 1983; McArdle et al, 1981; 1984).

Beckenholdt and Mayhew, (1983) evaluated 50 male athletes for their ability to generate anaerobic power via 4 commonly used tests namely: Margaria Kalamen test, vertical jump, standing broad jump and 40 yard (37 meters) dash. They discovered that soccer players had the lowest score on 6 out of 7 expressions of power while American football players had the highest score on 5 out of 7. This was perhaps, according to Fox (1979), illustrative of the distribution of sports along the aerobic and anaerobic continuum. Their research further revealed that 14 of 56 relationships between anthropometric measurements and power variables were significant. Similarly, 14 of the 21 inter-relationships among the power tests were significant. The absolute magnitudes of the correlation among the 40-yard (37 meters) dash, standing broad jump and vertical jump were all similar.

In recent years, a variety of cycle ergometer tests have been developed to measure anaerobic power. These tests have made the Margaria test less popular for qualitative anaerobic measurements (Bar-Or and Inbar, 1978; Macdougall,

1982) the most popular of these tests is the Wingate Anaerobic Test (WAnT), which was modified from the cycle test of Cumming (1972). One of the tests used to assess anaerobic power of children is the very useful Wingate Anaerobic Test, developed by Oded-Bar-Or by modifying the original Wingate Anaerobic test for adults. In this test, the child works on a cycle ergometer using legs or arms as hard as possible for thirty seconds against a work load, which is calculated as a proportion of the child's body weight. This test can be used for children as young as 5 (Sharp, 1992; Bar-or, 1985). This work performed was calculated as; work (kgm) = kg load x number of pedal revolutions x 6.

2.3.1 Margaria - Kalamen Power Test

The first popular report on peak mechanical power was published in 1966 by Margaria et al (1966) and modified by Kalamen, (1968). The modification resulted in greater power output than in Margaria's original test.

Margaria and Kalamen (1968) recommended their test to measure power. Kalamen (1968) found highly significant relationship (r = 0.974) between this test and the time it took the subject to run all out 50-yard dash after a 15-yard running start (Counsilman, 1977).

Margaria et al (1966) tested 131 healthy subjects whose age ranged from 8 to 73 years. Thirty-five of these subjects were athletes while others were sedentary. They found lower peak power in children than in adolescents and young adults. Among the non-athletes, the peak power per kg in the 9-year old boys and girls was only 60% of the 20-year-old subjects. Di-prampero and Ceretelli (1969) determined the peak power of 156 African subjects with age ranges of 5 to 68 years and found a similar result. Similar findings were

reported by Davis et al, (1972) on 92 6 to 16 years old British boys and girls, and by Kurowsky in 1977 and 294 American 9 - 16 year old girls and boys. (Inbar and Bar-Or, 1986).

Although no data are available for children or adolescents on the relationship between anaerobic performance and the muscle mass of the upper and lower limbs (Inbar and Bar-Or, 1986), it has been shown by Di-prampero and Ceretelli (1969) that even when divided by fat free mass, preadolescent boys and girls have a markedly lower peak power than do adolescents or young adults who performed the Margaria step-running test.

These observations are in agreement with those of Inbar and Bar-Or (1986), that also suggested that age-related difference in anaerobic power performance couldn't be explained merely by differences in body size or in the active muscle mass. If this is so, age related differences in anaerobic performance must be explained by qualitative characteristics of the muscle or by the nature of activation of the motor units.

Using 23 male non-athletes in an in-service class at the Ohio State University, Kalamen (1968) obtained a mean power output of 168.5 □ 31 kgm. S^{-1}. Similarly, he found a mean power output of 200 □ 16 kgm. S^{-1} for seven sprinters of Ohio State University and a mean power output of 240 to 271 kgm. S^{1} for professional footballers (Fox and Matthew, 1981).

Fox and Mathew (1976; 1981) recommended a classification guide for male and female subjects, aged between 20 and 50 years, based on data from studies conducted by Margaria et al (1966) and Kalamen (1968). These guidelines seem to suggest that subjects, aged 15 to 20 years, generally have

higher average power output and those over 50 years have the least values. On the other hand, men seem to have higher mean output than women. It can be concluded therefore that these observations appear to suggest that age and gender affect anaerobic power. These were supported by a number of studies reported by Fox and Mathew (1981), which indicated that maximal anaerobic power decreased after the age of 25 years for both males and females.

2.3.2 **Sargent Jump Test**

In 1921, Dr. Sargent, A Dudley, a medical expert at the Harvard University, became interested in physical fitness and developed a test, which he called "physical test of man" (McCloy, 1946; McCloy and Young, 1954). The test consisted of a vertical jump to test the explosive power of the extensor muscles of the legs and feet, and the toe flexors. Since then the test has become popularly known as the Sargent Jump Test, named after the inventor. Since then jump tests, such as the Sargent jump, have become a common element in many physical fitness test batteries. Previously, the Sargent jump is scored as the difference between a person's standing reach and the maximum jump and touch height (McArdle et al 1984). Fox and Mathew (1981) however observed that measuring the difference between a person's standing reach and height to which he or she can jump and touch (similar to basketball tip off) has erroneously been used as a power test of the legs. If body weight and speed in performing the jumps are not a part of the measurement, one cannot regard this test as a true measure of power.

Since its demonstration in 1921, a lot of studies have reported a fairly high reliability and validity of the Sargent jump test as a measure of explosive

power. Clarke (1967; 1971) reported a reliability coefficient of 0.85 and 0.96 after the subjects practiced its execution. Similarly, Fleishman (1964) reported a reliability coefficient of 0.90 on test-retest using high school girls, Cooper (1945) obtained a reliability coefficient of 0.89 to 0.98 (Gaya, 1987). Also a reliability coefficient of 0.97 and validity coefficient of 0.987 have been reported for college men (Fatile and Venkateswarlu, 1982).

Studies have shown that performance on the Sargent jump test was found to correlate with track and field events requiring explosive movements. Clarke (1967; 1971) reported correlations of 0.65 and 0.81 for men and boys respectively between Sargent Jump Test and track and field events. But Adams (1934) found a slightly lower correlation coefficient with girls between track and field events involving explosive movements.

Using 100-yard dash running, high jump, standing broad jump and 8-pound shot put; McCloy (1932) obtained a correlation coefficient of 0.890 between the Sargent jump test and performance in these events. Similarly, in another study, a reliability coefficient of 0.770 was obtained between the best jump of each of the two series of three attempts each for the jump test (performed without previous practice). When the best two series of three jumps each (performed on different days) was correlated against the best jump of each series (also performed on two different days, a reliability coefficient of 0.854 was obtained. Gaya (1987) compared the anaerobic power of 40 athletes - 20 footballers and 20 basketballers of University of Maiduguri using the Sargent jump and Margaria - Kalamen power tests and found no significant difference between the basketballers and the footballers in their power output as measured

by the Margaria - Kalamen Power test. However, a significant difference was found between their power output scores on Sargent jump test. Similarly, body weight and height correlated significantly with power output scores as measured by the two tests.

2.3.3 Wingate Anaerobic Test

The Wingate Anaerobic Test (WAnT) was developed in 1973 at the Department of Research and Sports Medicine of the Wingate Institute for Sports and Physical Education, Israel. The test was based on the prototype suggested by Cumming (1973). It is a 30 second all out supramaximal task, that can be performed by either cycling or arm cranking to determine maximal anaerobic power (maximal rate of work production at the expense of ATP and creatine phosphate breakdown) and maximal anaerobic capacity (average rate of work production in 30 seconds, presumably at the expense of ATP, creatine phosphate and anaerobic glycolysis (Staff, 1981). The reliability, validity and sensitivity of the Wingate Anaerobic Test (WAnT) have been supported by investigations conducted mainly by researches at the Wingate Institute in Israel. (Ayalon, et al., 1974; Bar-Or, 1978; Inbar and Bar-Or, 1976; Grodjinovsky et al., 1980; Evans and Quinney 1981; Smith et al., 1982).

Currently, the Wingate Anaerobic test, which utilizes a force setting, relative to the individual subject's anthropometric dimensions (load, L = 0.075 kp. kg^{-1}) and body weight, is one of the most widely used tests of anaerobic capacity. This test was designed to evaluate certain metabolic characteristics, namely; the overall mechanical power output in 30 seconds, apparently representing the anaerobic capacity contributed by both glycolysis and

phosphogen; the power output at the highest 5 seconds is assumed to represent the phosphogen phase of the anaerobic pathways. The difference between the highest 5-second value and the lowest 5-second value is assumed to represent the degree of fatigue (Bar-Or, 1978; Staff, 1981). Evans and Quinney (1981) investigated the various resistance settings on a modified monarch cycle ergometer to obtain the true resistance setting necessary to elicit maximal power out put throughout a 30 second all out test. Their findings indicated that resistance significantly greater than the force setting of the weight relative to Wingate protocol is necessary to elicit true maximal power output.

The Evans - Quinney protocol (1981) which considered leg volume as well as body weight in establishing optimal load setting on the cycle ergometer, has been shown to result in significantly higher anaerobic output than the body weight - relative Wingate protocol. Lovoie et al., (1984) compared the anaerobic power output of 50 male physical education and varsity athletes during cycle ergometer work using the Wingate and Evans - Quinney protocols with and without toe stirrups; and found significant differences ($P<0.05$) among the variables of 5 second peak power; 30 second anaerobic capacity and percent fatigue as a function of test protocol. Significantly higher values were obtained for all variables under the Evans - Quinney test procedure using toe stirrups while the Wingate test procedure without toe stirrups showed significantly lower values for all variables.

Akintunde (1992) compared the anaerobic performance attributes of 20 University of Ibadan athletes, comprising of 10 male sprinters and 10 male jumpers using WAnT and found significant differences in maximum anaerobic

power and anaerobic capacity between sprinters and jumpers, whereas no differences were observed in height, weight leg muscle strength and fatigue index. Similarly, Haruna and Chado (1993) compared 40 male athletes from badminton, basketball, long jump and soccer groups. They found significant differences between the sports groups in maximum anaerobic power. Greater mean anaerobic power of basketball and long jump groups were found compared to that of badminton and soccer groups. They also compared WAnT and 200 meters run test and found them to be significantly related ($r = 0.49$).

Bar-Or and Inbar (1978) from their studies concluded that the Wingate anaerobic test is a valid predictor of sprinting ability in non-athletic children. They examined the relationship between the WAnT and run times (40,300 and 600 meters) in 35 non-athletic boys (age 12.0□1.7 years). Corresponding correlations for 5-second power output (anaerobic power) were -0.84, -0.85 and -0.76. These findings are however not in agreement with the results obtained by Tharp et al (1985) on 56 ten to fifteen years old boys. Their results indicated that the Wingate Anaerobic Test is not a strong predictor of sprint and run times. The correlation obtained (-26 to -0.53), is much lower than the correlations reported by Bar-Or and Inbar (1978). Perhaps the larger number of boys in the study of Tharp et al and their wider range of athletic ability may be responsible for the difference in the results of the two studies. The same correlation however is in agreement with an earlier finding of Cumming (1972) who examined the anaerobic power in 12 to 17 years old children at a summer athletic camp. He sampled 103 boys and 168 girls and reported a correlation coefficients between the Wingate anaerobic power and performance in the

following variables in boys: 100 yard (92meters) run (0.55), 440 yard (404 meters) run (0.48), 850 yard (800 meters) run (.69). Similar to the findings of Tharp et al, Cumming found a stronger correlation between anaerobic power and performance in broad jump than between power and run times.

Tharp et al., (1985) explained that the Wingate Test becomes a stronger predictor for dash and run times when it is adjusted for body weight. Similarly, power weight and capacity weight are more strongly correlated with dash and run times than are power and capacity. The partial correlations adjusting for age or weight lend additional support for weight adjustment of the Wingate Anaerobic Test scores. Weight remains highly correlated with power and capacity when the effect of age is removed. But the age loses much of its correlation with power and capacity when adjusted for weight (r decreases from around 0.75 to 0.36). This indicates that body weight is a more critical factor than age and the Wingate Test performance is a better index of relative anaerobic abilities when scores are expressed relative to body weight.

A number of investigations have reported that short-term power output in children, even when standardized for body size, is consistently lower than that in young adults (Davies and Young, 1984); Diprampero and Ceretelli, 1969; Inbar and Bar-Or, 1986; Sargeant 1993). Thirteen year old boys were found to be 17% less powerful than either adult males or adult females when power was standardized for an anthropometric estimate of leg muscle plus bone volume (Sargeant and Doland, 1986) Davies (1985) pointed out that some of the differences in muscle function between children and adults could be accounted for by rather small architectural changes in the muscles. It remains to be

investigated however whether the differences in short term power output could be accounted for by similar factors associated with and determined by, the continuing growth in limb length during childhood.

Inbar and Bar-Or (1986) examined the anaerobic characteristics of 306 8 to 45 year old non-athletic male children and adolescents and found both peak power (pp) and mean power of legs and arms increase alike consistently, from age 10 to young adulthood. They seem to peak at the end of 3rd decade for the legs and at the end of second decade of life for the arms. There is an increase of 35 watts per year in the peak power for the legs and 30 watts increase per year for the respective mean power. The corresponding increases for the arms are 32 and 22 watts yr^{-1} as found in the studies of Di-prampero and Ceretelli (1969) and Margaria et al, (1966) even when correlated for body weight, both peak power and mean power were lowest in the youngest age group, increasing with age through adulthood. Inbar and Bar-or (1986) reported that the relative power output of a 10 year old boy was 80% of that generated by a 13 year old boy and 75% of that generated by a 17 year old boy. Similarly, in all age groups, the anaerobic performance with the arms is 60 to 70% of that achieved by the legs. This percentage is similar to that described for young adults who performed a maximal anaerobic power test with their arms and with their legs. (Asmussen and Hammingsen, 1958).

Even when allowances are made for differences in body weight, the anaerobic energy produced by an 8-year old is only 70 per cent of that of an 11-year-old, which in turn is less than that of a 14-year-old. (Sharp, 1991; Kurouski 1983).

The younger child's muscle has less glycogen, and a much lower rate of utilization of glycogen. It also has less creatine phosphate which is the immediate anaerobic energy store (Bar-Or, 1983) it has also been shown that children have lower maximal concentrations of lactic acid in blood and muscle at various high percentages of maximum effort, compared to adults undergoing similar levels of exercise stress (Inbar and Bar-or, 1986; Simon et al; 1981;) This can be explained by the fewer number of glycolytic enzymes in children, which result in a lower rate of carbohydrate metabolism, and utilization in the muscles.

Another possibility is that young muscle is intrinsically less powerful in short-term exercise due to a restriction in the rate of resynthesis of ATP. However, because there is little evidence to suggest large differences in the resting levels of ATP and CP, instantaneous power could hardly be affected by this (Sargeant, 1989). Mean power also appears to be unaffected for some seconds until the level of high-energy phosphate is depleted. Nevertheless, short-term power output is lower in children when measured in the first few seconds (Sargeant, 1989). It has been suggested that the maximal rate of anaerobic glycolysis may be lower in children than in adult. However, this does not account for the child adult differences observed in exercise of short duration although it could play a progressively important role in mean power output determined in tests lasting for more than 5 seconds.

There are three main observations to suggest the lower age dependent glycolytic rate in anaerobic work. In the first instance, blood lactate concentration in children is not as high after intense exercise as it is in adults

(Astrand; 1952; and Davies et al, 1972). However, the interpretation of blood lactate concentration (Sargeant, 1989) is fraught with difficulties because it is the resultant of not only lactate production via anaerobic glycolysis by the muscle cell, but also its rate of release into the circulation, its distribution in total body water, and its removal and breakdown by other tissues. Furthermore, this observation has recently been challenged by Cumming et al (1980), who suggest that the difference may be illusory and largely a function of the duration of the final level sustained during VO_2 max testing. They reported levels of blood lactate following routine maximal exercise testing in children that are comparable to adult values.

The second observation reveals that the muscle lactate concentrations measured from biopsy of the quadriceps during cycling exercise is lower in boys than in men at comparable levels of aerobic energy demand (Eriksson, 1972). However, taken by itself, this still does not mean that the maximal rate at which anaerobic glycolysis can occur is necessarily lower in boys than in men.

The third observation and a more informative indicator of the maximal potential rate of glycolysis might be the activities of the controlling muscle enzymes-phosphofructokinase (PFK) an important rate-limiting enzyme for glycolysis. Erickson (1972) has reported lower levels of PFK activity in muscle biopsies from boys than those taken from men. Sargeant (1989) cautions that enzyme activity is measured in vitro under optimal conditions, and this is certainly not the same as in vivo. Furthermore, it is worth noting that training increased PFK activity by almost 100% in the boys studied by Erickson. However, no research evidence has been reported to suggest that training

increases anaerobic power independently of muscle size in this proportion (Sargeant et al; 1985; Sargeant, 1989).

At present, research evidence does not confirm an age-dependent difference in the potential maximum rate of anaerobic glycolysis between children and adults. In any case, it is interesting to note that electrical stimulation studies showed that the muscle function of children including an index of fatigue is not different from that of adults if some dimensional corrections are made. (Davies, 1985). Decremental rate of short-term power output after 20-30 years of age is also of similar magnitude but the reverse is its incremental rate seen during growth in children (Sargeant, 1989).

Nindl, et al., (1995) compared lower and upper body anaerobic performance in male and female adolescent athletes. Their findings showed that among adolescent athletes with similar athletic and activity levels, males showed greater peak and mean lower and upper body anaerobic power, both in absolute terms and relative to body mass. In addition, males had greater mean leg power even after sex differences in fat free mass and legs cross-sectional area (CSA) were taken into consideration. The absolute values for lower body peak power (694 Vs 422w) and mean power (548 Vs 308w) for male and female adolescent athletes, respectively reported by Nindi et al (1985) are slightly lower than those in comparable studies on untrained adults and are higher than values reported for children (Bar-or, 1983; Murphy et al., 1986). However, these values are strikingly similar to reported sex differences for trained adults subject both in absolute terms and when normalized body mass and fat-free mass was used by Mand and Shultz (1989) and Murphy et al., (1986). In contrast, Bar-or (1983)

and Van Praagh, (1990) observed less sex difference to anaerobic power of pre-adolescents. These observations suggest that sex difference in anaerobic performance may be related to growth and development and becomes significant by late adolescence (16 - 17 years) (Nindl et al., 1995). Other support for this hypothesis comes from a report showing an age-related increase in anaerobic performance through adolescence for boys but not for girls (Blimkie et al., 1988). In comparison to the upper body, the lower body sex difference was more pronounced for mean power than for peak power. In general, the sex differences in both peak power and means power was more pronounced in the lower than the upper body. One cannot also ignore the possible influence of differences in activity levels between sexes as a causative factor for the differences in anaerobic power output.

2.4 AGE, SEX AND ANAEROBIC CAPACITY

Anaerobic capacity is the ability to persist at the maintenance or repetition of strenuous muscular contractions that rely upon anaerobic mechanisms of energy supply (Lamb, 1984). Anaerobic activities may be dynamic as in the case of sprinting, or static, as exemplified by carrying heavy loads. But all are characterized by intense muscular contractions that demand substantially greater rates of energy (ATP) production than can be provided by aerobic metabolism alone. For most persons, this class of activities includes all those that, by reason of their high intensities, can be sustained for less than one or two minutes (Astrand and Rodahl, 1977). Therefore, anaerobic power and

capacity require a type of physical fitness that is in the center of a continuum of strength fitness and aerobic endurance fitness.

Both Asmussen (1973) and Lamb (1984) reported a direct relationship between strength and anaerobic capacity at submaximal loads. As strength increases with age until about 30, before beginning a gradual decline, both strength and anaerobic capacity are affected in a similar fashion by age. Likewise, because males have greater maximal strength than females, they also have greater anaerobic capacity for submaximal loads. The age range of 12-15 years seems to be optimal for improving anaerobic capacity in simple movements (Asmussen, 1973). Prior to puberty, boys and girls are quite similar in strength and anaerobic capacity. At puberty, however, males begin a much more rapid increase in absolute strength, presumably because of increased levels of testosterone, the male sex hormone. Testosterone promotes muscular hypertrophy. If strength is expressed on a relative basis, that is, per kilogram of body weight, the strength of leg muscles in females after puberty is similar to that in males, but arm and shoulder muscles are about half as Strong (Gregor et al., 1979; Malina, 1974).

There is undoubtedly a cultural effect that also plays some role in determining sex differences in strength and anaerobic capacity. Young girls in general (Lamb, 1984) are taught that forceful physical exertion is unfeminine, and consequently, after puberty they usually shy away from activities that would have a training effect on strength. Therefore, comparison in strength and anaerobic capacity between males and females may be somewhat unfair, since males are likely to be in a more trained state than females. In this light, it is

interesting that leg muscle strength is very similar in girls and boys. Perhaps the explanation for this is that young boy and girls tend to have similar amounts of training for these leg muscles because they do almost similar amounts of walking and running. For muscles of the arms and shoulders, boys usually have more training from rope climbing, wrestling, throwing and other masculine activities.

The changes in strength and anaerobic capacity with age are probably caused not only by changes in muscle mass with growth (increase in youth and atrophy in older persons), but also by changes in the central nervous system (Larsson et al., 1979; Lamb, 1984). This role of the nervous system becomes apparent when one considers that increases in strength with age are greater than the corresponding increases in muscle mass. Therefore, it appears that the maturation of the nervous system in young persons allows the simultaneous recruitment of more motor units; this process may be reversed with advancing age.

Although a definite effect of age and sex on muscular strength can be shown if large numbers of subjects are tested, one must not expect every 10 year old to be stronger than every 8-year old, or every 15 year - old girl to be weaker than every 15 year old boy. There is a wide range of strength at a given age or in a given sex. One of the reasons for strength differences within an age group, especially before age 18, is that children mature at different rates, so that it is possible to find two 12 year olds whose biological or maturation age as determined by x-ray measurements of bones are 10 and 15 years respectively (Asmussen, 1973). The 12 year-old who has not matured as rapidly will

probably have smaller muscles, a less highly developed nervous system, and if males are compared, a lower secretion of male sex hormones. All these factors tend to make the less mature person less strong than his more mature counterpart.

2.5 ANAEROBIC METABOLISM DURING HIGH INTENSITY EXERCISE

Anaerobic energy production is essential for the maintenance of high intensity exercise when the demand for ATP is greater than can be provided aerobically. At the onset of high intensity exercise, anaerobically derived ATP provides up to 80% to 90% of the total ATP required, because oxygen is in short supply, and the cardiovascular system increases 0_2 delivery to the working muscles in an attempt to meet the metabolic demand (Spriet, 1995). Margaria et al (1964; 1969) proposed that phosphocreatine degradation is the only immediate substrate for ATP resynthesis during the early stages i.e. less than 10 seconds of intense exercise. Upon depletion of this substrate, glycogenolysis is activated to provide a continued ATP supply via glycolysis. For many years, this "serial mobilization" theory of anaerobic ATP provision was used to explain how human skeletal muscle responded to the large demand for ATP during high intensity exercise. Therefore, the phosphocreatine store is a powerful energy buffer, as small changes in ATP and ADP concentrations ensure rapid ATP resynthesis. Several investigations have demonstrated that muscle ATP is maintained in the face of intense contractile activity until phosphocreatine is largely depleted (Spriet et al., 1987; Spriet, 1995).

The suggestion that anaerobic glycolysis is activated only when the phosphocreatine store becomes depleted in maximally contracting skeletal muscle is not conclusively supported by experimental evidence. Saltin et al., (1971) measured muscle lactate that was higher than normal resting values following 10 seconds of cycling at 110% $V0_2$ max in two subjects. Consequently, they proposed that anaerobic glycolysis commenced with the onset of muscular contraction. The findings of Jacob et al., (1983) supported this contention, according to which lactate accumulated to 46.1 and 25.2m mol/kg dry muscle (dm) following 10 seconds of maximal cycling in males and females, respectively. However resting lactate and 10 seconds phospho-creatine measurements were not reported. Two additional studies (Spriet, 1995) reported large accumulations of lactate content in muscle (19-61mmol/kg dm), following only 6 and 10 seconds of cycling at high power outputs. These studies (Boobis et al, 1983; Jones et al, 1985) also measured phosphocreatine degradation and demonstrated that it was not depleted following 6 to 10 seconds of high-intensity exercise but had decreased to 25% of the resting level.

The anaerobic ATP provision rate decrease when examined over long periods of time. In the investigations that examined the effects of intense exercise for 30 seconds on these rates, the average ATP provision rates (Mean$\pm$ SD) from phosphocreatine and glycolysis were 1.59 $\pm$ 0.44 and 4.38 $\pm$ 130mmol ATP/kg dm/s respectively. If it is assumed that 25% of the produced lactate escaped from the working muscle during 30 seconds of exercise, then the glycolytic estimate would increase to 5.84 mmol ATP/kg dm/s (Spriet, 1995). The data of Karlsson and Saltin (1970) indicate a total anaerobic ATP provision

of 160mmol/kg dm during intense cycling. Glycolysis provided 60% of the ATP, phosphocreatine breakdown provided 33% and depletion of the ATP store provided only 7%.

It is of great practical importance to be able to measure anaerobic capacity or the maximum amount of ATP that can be supplied by the anaerobic energy pathways. The most commonly used indirect technique of estimating anaerobic capacity is to measure the maximal accumulated 0_2 deficit during short-term intense exercise (Scott et al; 1991; Spriet, 1995).

Some investigations have estimated the contributions of the aerobic and anaerobic (phosphocreatine and glycolytic) energy systems during high-intensity exercise, using measurements of 0_2 uptake, total work output, and made three important assumptions regarding the fuel oxidized, the mechanical efficiency of the exercise, and the time course and capacity of energy derived from phosphocreatine degradation. The anaerobic contribution is that which cannot be accounted for by aerobic metabolism after estimating mechanical efficiency. The assumptions regarding the use of phosphocreatine include -

- Most ATP is derived from the phosphocreatine ATP system in the initial seconds until maximal power output is reached (2-3 seconds).
- The phosphocreatine contribution lasts only 10 seconds at these high power outputs.
- The decrement in the phosphocreatine derived energy is linear from the point of maximal power output to 10 seconds (Spriet, 1995).

The remaining anaerobic contribution is then attributed to the glycolytic system. During the initial 10 seconds of cycling during a 30 seconds Wingate

test, the respective contributions from phosphocreatine glycolysis, and aerobic metabolism were 53%, 44% and 3% (Seresse et al; 1988). The direct measurement of ATP resynthesis from phosphocreatine and glycolysis in the initial 10 seconds of high intensity exercise suggest that the assumptions used in the indirect estimations overestimated the glycolytic contribution. These measurements suggest that by 10 seconds of high-intensity exercise, the glycolytic system has already contributed more anaerobic energy than the phosphocreatine system (Spriet, 1995).

During a Wingate cycling test lasting 30 seconds, indirect estimates of energy provision were 23-28% from phosphocreatine, 49-56% from glycolysis (72-84% anaerobic), and 16-28% from oxidative metabolism (Serresse et al; 1988; Smith and Hill, 1991; Spriet, 1995). In other studies, the energy contribution was 72-82% anaerobic and 18-28% aerobic (Withers et al., 1991). When high intensity cycling was extended to 90 seconds, anaerobic metabolism contributed 36-54% of the required energy, and the aerobic contribution was 44-64% (Serresse et al., 1988; Withers et al., 1991). Direct estimates of the anaerobic/aerobic contributions during 90 seconds of intense exercise were 60%/40% (Spriet, 1995). Therefore, the indirect methods appear to underestimate the anaerobic contribution and overestimate the aerobic contribution to total energy produced when the intense exercise is prolonged.

2.6 LACTATE ACCUMULATION VALUES

A great deal of attention has been directed towards understanding the dynamics of lactate production and removal at the onset of exercise, during exercise, and during the recovery process following exercise. It has been hoped

that an unraveling of these events would provide a key to the understanding of cellular metabolism and its regulation during exercise (Shepard, 1992). It has been suggested that many factors like diet, level of physical fitness, and the type and duration of exercise used, influence the rate and magnitude of the accumulation of lactate in blood and muscles (Gullnick et al., 196l; Skinner and Mclellan, 1979).

The highest lactic acid level is reached during exercise that can be sustained for 60 to 180 seconds (McArdle et al., 1984) Elevated blood lactate concentration has previously been used as an indicator of anaerobic metabolism in working muscle (Huckabee, 1958). The promptness of appearance of lactic acid in muscular exercise as well as its rapid decrease as blood passes through active region of the body showed that lactate diffuse freely between tissue and blood.

The original hypothesis of a sudden transition from aerobic to anaerobic activity was built around a very limited database, obtained during brief bouts of treadmill exercise (Margaria et al., 1963). More precise and more extensive measurements have since established that lactate can begin to accumulate in the arterial blood at efforts ranging from 50% to 70% of maximal oxygen intake, depending on the nature of the exercise performed and the proportion of the skeletal musculature involved (Shepard et al, 1989). The intensity of effort at which blood lactate first begins to increase depends on the ramp function (Hughson and Green, 1982; Campbell et al, 1989) and the type of exercise performed, and is highly individualized. If steady state effort is made at 60-70% of maximal oxygen intake, blood lactate rises at first. But, subsequently, it

returns to resting values if the effort is continued (Kay and Shephard, 1969). At a some what larger fraction of maximal oxygen intake (80 - 90%, the blood lactate concentration rises progressively until the subject is exhausted (Freund et al., 1990). Depending on the intensity of the workload, four patterns of blood lactate concentration are discernable. (Karpovich and Sinning, 1971). Wassermann and Whipp (1975) reported that the first pattern is seen at a very low work rate, where no increase in blood lactate is observed. This work rate may be categorized as of mild intensity. The second appears at slightly higher work rate, in which lactate concentration peaks early in the work and then returns to resting values as VO_2 reaches a steady state. This work rate may be categorized as of moderate intensity. The third develops at higher workload and is maintained at higher than resting values by a balance between sustained production and utilization. These may be categorized as of heavy intensity. The fourth pattern occurs at a work rate at which lactate continues to increase throughout the work. This work rate is of severe intensity.

The increase in blood lactate concentration observed during exercise is a complex process (Brooks, 1985, 1987; Davis, 1985), depending upon the various factors that influence the input and egress of lactic acid from the muscles and circulation (Shepard, 1992). Under well-controlled laboratory conditions, intra-muscular concentrations of lactate are influenced by both the overall rate of pyruvate metabolism, an influence independent of local oxygen partial pressures (Huckabee 1958) and the extent of local hypoxia in the muscle fibres. Because of the varying perfusion of local capillary supply and differences in local intra-muscular enzyme concentrations, one type of fibre within a given muscle may

be functioning aerobicaliy while another is working anaerobically. Lactate can thus diffuse from the anaerobically contracting fibres and be metabolized by fibres that are still operating aerobically. (Shepard, 1992; Mazzeo et al, 1982). The ratio of intramuscular to blood lactate concentration is influenced by the total volume of muscle mass that is functioning anaerobically and by the total circulating blood volume (Shephard et al, 1989). Other influences are the proportion of carbohydrate in the diet and thus the extent of glycogen reserves.

It is clear that the ability to produce lactate is essential for high sensity efforts. However, with such efforts and the associated lactate production, there are adverse effects, which may establish the upper limits of performance by inhibiting both contractile and energy producing mechanisms. Thus, lactate production is a two-edged sword. On the one hand, it produces an amount of energy that can determine the difference between winning and losing a `contest', on the other hand, its production suppresses contractile and metabolic activity (Gollnick et al; 1986).

Measurement of blood lactate concentrations can help to define an optimal level of endurance training that lies just below an intensity at which substantial amounts of lactate accumulate in the blood steam. Lactate data may further contribute to the design of an interval-training plan, and the length of recovery intervals being adjusted to assure no more than a modest accumulation of lactic acid in the working muscles or the circulating blood. According to Sjodin et al, (1982) operating at a blood lactate concentration of 3 - 5 mmol S^{-1} seems optimal in terms of developing a good anaerobic threshold.

2.7 DETERMINATION OF BLOOD LACTATE

The classic method for determination of lactic acid involves its separation and conversion to insoluble zinc lactate by boiling with ZnO or $ZnCo_3$. The zinc lactate is then weighed. This method was applied by wolf in 1914. It is time consuming and requires large samples and therefore has been hardly used in clinical chemical analysis (Drewes, 1974)

Several other techniques employed for the estimation of the acetaldehyde involved Iodometric titration. In the earliest method, that of Boas (1893), the aldehyde was distilled into alkaline iodine solution and the reduced iodine was determined. Von furth and Charnass in 1910 found this direct titration inaccurate, Clausen in 1922 distilled aldehyde into acid bisulfate solution, titrated the free bisulfate with iodine, then split the aldehyde bisulfate addition compound by alkaline PH and continued titration of the released bisulfate directly. The Clausan titration was however modified by others to increase specifically, sensitivity, and yield. For instance, Mns04 was found to increase the rate and yield of acetahdelyde tungstic acid or cuso4-ca (OH) 2 precipitation removing interfering materials (Drewes, 1974).

Lactate has been determined in tissue extracts by fluorescent reaction with α naphthol in the presence of H_2. Simple sensitive methods for blood employ's gas chromatography after oxidation of lactate to acetaldehyde with periodic acid. However, contamination problems with periodic acid and trichoroacetic acid discouraged its use.

Lactic acid was then determined directly by the use of lactic acid dehydrogenase (LDH) and nicotinamide- adenine dinucleotide (NAD+). The amount of NAD+

reduced to NADH + H +, as lactate is enzymatically oxidized to pyruvate, is measured by the increase in absorbance at wavelengths of 334-366nm (Drewes: 1974: Everse, 1975). In these methods, the original pyruvate is either destroyed by H_20_2 or trapped by semicarbonized or hydrazine (Warburg et al., 1960; Drewes: 1974) to drive the reaction to completion. The method of Hohorst (1963) has been shown to be reliable. The availability of this procedure in commercial Kit form has added to its simplicity, which made it the method of choice. Micro determination, fluorometric measurement of the NADH produced and use of 3 acetyl-pyridine- NAD analog are variations of the basic technique. With the NAD independent yeast LDH enzyme, ferric compounds have been used as electron acceptors, leading to visible colour changes at 405-510nm (Tifelt-Hansun and Andersen, 1971; Hohorst, 1963; Drewes, 1974, Everse, 1975). In the determination of lactic acid in blood plasma or serum, the principle is that lactate dehydrogenase (LDH) catalyzes the oxidation of lactate by NAD.

L -Lactate + NAD+ pyruvate LDH + NADH + H+

The equilibrium of the reaction, which would normally lie far to the left, is shifted by removal of the reaction products so that the reaction proceeds completely to the right. Thus hydrazine traps the pyruvate and the hydrogen ion is low because of the high pH. Increase in absorbance due to the formation of NADH + is a measure of enzymatically oxidized lactate. (Drewes 1974; Everse, 1975).

The measurement of lactic acid is directly related mole for mole to the amount of NAD reduced to $NADH^+$, a lactate standard useful in monitoring the

overall system, including the absorbance scale of the spectrophotometer (Drewes, 1974, Everse 1975). De Bruyn-prevost and Sturbois (1980) expressed that maximal lactic acid level is always expressed as the maximal level minus the resting level.

Lactic acid production in the beginning of the exercise may not be measured during the test itself, when the subject reaches the imposed pedaling rate, if the test goes on to exhaustion. It is well known that a delay of a few minutes is necessary to measure correctly the lactic acid production in the venous blood (Karlsson and Saltin, 1968). To evaluate the lactic acid production at a precise moment, the subject has to stop his exercise at that moment and the peak lactic acid level has to be determined during the ten minutes after work (De Bruyn-prevost and Sturbois, 1980). Previous researchers, such as Baker and Summerson (1944), Harrower and Brown (1972), Hermansen and Stenavold (1972), Karlsson and Saltin (1970), and Karlsson (1971) suggested four minutes following maximal exercise as the time required for lactate to diffuse from the muscle into the blood stream.

The normal range for fasting venous blood, withdrawn from the patient at rest, can be taken tentatively as 5-20mg/100ml. There is a general agreement on the lower limit, but the normal upper limit has varied from 10 to 45 mg/100ml. The arterial blood normal range is reported as 3.1-7mg/100ml (Drewes, 1974). That severe muscular work causes an increase in blood lactate is well known, but mild exercise, such as brisk walk, reportedly has no effect. Bed rest results in a mean decrease in the arterial blood level at about

3mg/100ml. While lying down, however, contracting the muscle elevates blood lactate two fold, and exercising the leg three fold (Drewes, 1974).

According to Di-Prampero and Margaria (1971; 1973), alactacid processes that is, the ATP and CP splitting, may be sufficient to provide all the energy necessary in exercise no longer than five to ten seconds. Some observations of Astrand et al., (1960), during intermittent work, suggest that during short exercise of 30 seconds, the oxygen stores fixed on the myoglobin and hemoglobin may play an important role to post pone lactic acid production. Astrand and Rodahl (1970) established that maximal physical performance is attained when the blood lactate concentration is above 70 to 80 mg/100 ml of blood or 8 to 9 mmoles/liter. Karlsson (1971) reported 9.3 mmoles/liter following a brief maximal exercise. The values of 14.6 mmoles/liter, 13.5 mmoles/liter and 14.677 mmoles/liter were reported by Gollnick and Hermansen (1973), Dramant and others (1968) Hermamsen (1971) respectively following strenuous test. Previous studies (Essen and Haggmark, 1975; Wassermann and others, 1965; and Rowell and others, 1966) showed that a rise in lactate concentration could occur during exercise and reach a value as high as 20 mmoles/kg net weight at exhaustion (3-4 minutes). The normal resting value for conditioned individuals has been reported to be about 10mg/100ml (Astrand, et al, 1963). Hermansen (1971), by contrast, measured a maximal lactic acid level as high as 150mg% in an athlete following a 100-meter run performed in 10.6 seconds. De Bruyn prevost and Sturbois (1980) observed that lactic acid values for work duration up to 10 or 12 seconds are situated below the linear regression calculated from all lactic acid levels and exercise durations. According to the

hypothesis of Margaria and Di-Prampero (1971; 1973) and Astrand et al (1966), it may be possible that the differences in values represent the duration of such type of exercise. It may also seem obvious that the production may be some what lower at the start of exercise than after 10 seconds of work.

2.8 SUMMARY

Studies reviewed in this chapter revealed that anaerobic power in children which has been defined as the exertion of force through a given distance in as short a time as possible, has been given little attention by researchers. The importance of anaerobic power in athletics has been recognized by a number of investigators. It is believed that in athletic activities and other forms of physical activities involving explosive movements, such as jumping, sprinting, throwing, soccer or basketball, and boxing that requires fast burst of speed require anaerobic power for successful performance. Therefore, a number of tests such as the vertical jump, standing long jump, 50 yard (46 meters) dash, Margaria - Kalamen test, Sargent test and the most recent Wingate Anaerobic power test, have been developed to assess anaerobic power performance of different populations.

A number of correlation coefficient has been reported between the Wingate anaerobic test and other tests of anaerobic power. The correlation between anaerobic capacity and run times were reported as 0.73; 0.83 and 0.76 respectively, while the corresponding correlations for 5 seconds power out put (anaerobic power) were 0.84; 0.85 and 0.76. Similarly, Wingate anaerobic test was found to correlate with Margaria - Kalamen test 0.46, standing bread jump

.41; and run times such as 100 yard (92 meters) - -0.55; 440 yard (404 meters) run -0.48, 880 yard (800 meters) 0.69, 200 meters run 0.49 and 100 meters run 0.31.

Anaerobic power has been reported to increase with age. Both peak power and mean power of legs and arms for children and adolescents were found to increase consistently from age 10 to young adulthood. Anaerobic power seems to increase at the end of 3rd decade for the legs and at the end of second decade of life for the arms. An increase of 35 watts per year in the peak power for legs and 100 watts per year for the mean power as well as 32 watts per year in the peak power and 22 watts per year in the mean power for the arms were reported.

Conflicting studies have been reported on sex differences in anaerobic power performance. While some studies have shown that among individuals of similar athletic activity, the males have shown greater peak and mean lower and upper body anaerobic power than their female counterparts. Other investigators observed less sex differences in anaerobic power. It was therefore observed that sex differences in anaerobic performance may be related to growth and development or rather an age-related increase, which is more, pronounced in boys than in girls. From the present information, there is a need to further investigate the anaerobic power performance of the upper and lower limbs of Nigerian Children using legs and hands involving cycle ergometer. The most suitable test instrument available for such field test is the Wingate Anaerobic Test.

CHAPTER THREE

METHODOLOGY

3.0 INTRODUCTION

The purpose of this study is to assess the anaerobic power of upper and lower limbs of Nigerian children and adolescents aged 10 - 16 years. The research design used, the population from which the sample of subjects was studied, the characteristics of the sample, the procedure adopted, the tables and the necessary instruments used, the controls maintained and the statistical techniques used in the analysis of the data to achieve the purpose of this study are described in this chapter.

3.1 RESEARCH DESIGN

This study made use of two by two research design (2x2) as shown in figure below. In this design, there was no random assignment of subjects, according to age group and sex. The subjects were not pre-tested. However, one shot treatment was given to all groups and tested for their serum lactate dehydrogenase activity, anaerobic power, anaerobic capacity and fatigue index for both the upper and lower limbs.

Sex	Age	
	Children	Adolescents
Male		
Female		

3.2 POPULATION

The population for this study consisted of selected children and adolescent boys and girls aged 10 - 16 years, from the Ahmadu Bello University Staff School, Amina Primary School Samaru and Army Children Primary School Chindit Barracks, Demonstration Secondary School, Ahmadu Bello University, Government Secondary School, Sabon-Gari, Government Secondary School, Bomo and Government Girls secondary School, Samaru all from Zaria. These Schools were selected because Zaria is a large town with Federal Establishments bringing all Nigerians of different socio-Economic backgrounds, therefore assumed to reflect a typical Nigerian Society.

3.2.1 SAMPLE

The subjects for this study were drawn from the three Primary and four Secondary Schools through stratified random sampling technique.

First, the investigator used stratified sampling technique to select the classes where the actual respondents came from. And from the sample, only those who were between 10 years to 16 years constituted the actual study sample. The advantage of stratified sampling technique according to Borg and Gall (1983) is the assurance that certain sub-groups in the population will be represented in the sample in proportion to their number in the population.

In all, 30 boys and 30 girls were drawn from each of the following age groups: 10, 11, 12, 13, 14, 15 and 16 years to make a total of 420 subjects. Similarly 21 male and female subjects consisting of 9 children from the age groups of 10-13 years and 12 adolescents from the age group of 14-16 years

were randomly selected from the subjects for the evaluation of lactate dehydrogenase activity before and after exercise.

3.3 SEQUENCE OF TESTS

During the period of this investigation, the following tests and sequence were used:

a) Anthropometric measurements

b) Anaerobic power performance test for the lower limbs

c) Anaerobic power performance test for the upper limbs

d) Lactate dehydrogenase activity

3.3.1 Anthropometric Measurement - The Following anthropometric measurements were taken: Height, Weight, body mass index, and upper and lower limb measurements.

Height and weight: - The standard anthropometric protocol of international working group on Kinanthropometry (IWGK) as described by Ross and Marfell Jones (1983) were used in measuring height and weight. The height was taken in meters and the weight in Kilograms, using the laboratory weighing scale (Shemond) with subjects dressed in minimum sport wear and without shoes. The body mass index was determined by dividing weight by the square of height

$$\frac{wt}{Ht^2}$$

Length measurements:- This was taken using Broad blade anthropometer using the Behnke and Wilmore's (1974) procedure.

i. Upper arm length- from the acromion process to the tip of of olecranon process at the elbow joint

ii. Lower arm length - From the olecranon process at the elbow joint to the tip of the third finger.

iii. Upper leg length:- From the end of the spinal column to the Knee joint.

iv. Lower leg length:- From the Knee joint to the floor

v. Total leg length: - From the end of the spinal column to the floor or taken from the greater tronchater to the floor. All measurements were taken in centimeters (cm).

3.3.2 **Wingate Anaerobic Power Test (Lower Limb)-Monarch cycles ergometer**

i. Warm-up- A 10 minutes intermittent warm up alternating 30 seconds exercise with 30 seconds rest was used. This was done on the cycle ergometer (Monarch Swedish made) in order to promote more specific Physiological and motor adaptation - A 3 - 5 minutes rest interval to separate the warm up from the test was used.

ii. The Test: - Wingate Anaerobic Power Test (Bar-Or 1978,1987; staff 1981)

The height of the cycle ergometer seat was adjusted for each subject to allow for near total extension of the leg (Knee bent at 15^0) and the pedal and toe clip with straps was used to prevent the feet from slipping off the pedal. At the command, the subject pedals the unloaded ergometer as fast as he can (initial) frictional resistance only. Then within 3 - 4 seconds gently but quickly the resistance was applied and simultaneously a stopwatch was pressed. The quick

application of the load was expected to cause an immediate deceleration in pedaling rate. The load used was adjusted relative to body weight. 0.75kg per body weight (Bar- or, 1978, staff, 1981) The work loads was set to the nearest observed ½ kilo pound kp) setting. Revolutions were monitored by six counters who kept eyes on a reflective reddish material attached lightly on the hauls of the wheel. When the reddish materials returns to its original position during pedaling, it was counted as one revolution. The number of revolutions pedaled for exactly 30 seconds or at a point of failure as well as the highest and lowest number of revolutions were recorded. Considerable verbal encouragement as motivation to work harder was provided and the test was terminated immediately when a subject can no longer maintain the given work load even before 30 second expires.

iii. Cool down - since the subjects are regarded as potentially susceptible to dizziness (staff, 1981; Tharp et al, 1985), subjects were encouraged to continue to pedal at "zero" load for 2 - 3 minutes immediately following the completion of the test. As a safety measure, a medical

A personnel was stationed to check the cases of nausea, dizziness and vomiting if any but there was no such incidence throughout.

3.3.3 Anaerobic Power Test (Upper Limbs)- Arm Cranking cycle

This test was conducted 30 minutes after the lower limb test (Bar-or et al, 1977, Bar-or-1987)

i. Warm-up A 10 minutes intermittent warm-up alternating 30-second exercise with 30 seconds rest was used. This was done on the arm cycle

ergometer. A 3 to 5 minute interval was used to separate the warm-up from the test.

ii. The test- The pedals were stripped off their frames to retain only their rotating center. This was wrapped with cloth tape or the like to facilitate a suitable grip.

To a command, the subject pedaled the unloaded ergometer as fast as possible against a low resistance, which was increased to a predetermined level within 3 - 4 seconds. The load used was adjusted relative to body weight 0.50 kg per kg body weight for females and 0.58kg per kg body weight for males (Bar- or, 1978, staff, 1981) work loads was set to the nearest observed ½ kilo pound (kp) setting. When this load was reached, a stopwatch was pressed and pedal revolutions recorded for 30 seconds.

The revolutions were monitored by six counters who kept eyes on a reflective reddish material attached lightly on the wheel and counted each time as it appears. It included an exact total 30 seconds count or at a point of failure as well as the determination of the highest and lowest number of revolutions in any 5 seconds.

The work performed on the monarch cycle was calculated using the following formula. Work (kgm)= Kgload x number of pedal revolutions x 6 (Tharp et al., 1985).

iii. Cool-down: - Subjects continued light pedaling for 2 -minutes immediately after the test so as to prevent muscle soreness and dizziness.

3.4 DETERMINATION OF PERFORMANCE INDICES

Three main performance indices of mean power, peak power and power decline (fatigue index) were calculated.

a) Mean power: - This is the mean mechanical power over the entire 30-second period. It is also called anaerobic capacity. This presumably affects anaerobic capacity both glycolytic and alactic (Inbar et al, 1976, staff; 1981)

b) Peak Power: - This is the highest power at any 5-second period, presumably representing the alactic phosphogen component of anaerobic power production

c) Power decline: - This is the index of fatigue rate. It can be calculated in two ways, either in absolute power terms as the difference between the peak power and the lowest 5 seconds power divided by the time elapsed between the two measurement; or in percentage of peak power minus lowest power divided by peak power multiplied by 100. (Staff, 1981, Lamb, 1984; Bar-Or, 1987)

3.5 LACTATE DEHYDROGENASE ACTIVITY IN SERUM

Each subject performed the Wingate anaerobic power test. All the subjects were encouraged to complete as many revolutions as possible within the given 30 seconds.

Two blood samples of 5mls each were drawn from each subject from a catheter inserted in an anticubital vein of the forearm before the commencement of the test and 4 minutes following the test (Karlsson and Saltin, 1970, Karlsson, 1971; De Bruyn-prevost and Sturbois 1980).

Serum Lactate dehydrogenase was determined by spectrophotometric method (Hohorst, 1962; Drewes, 1974). Using the principle according to which lactate dehydrogenase (LDH) catalyze the oxidation of Lactic acid by the following equation:

$$\text{L- Lactate+NAD+} \xrightarrow{\text{LDH}} \text{Pyruvate + NADH+H+}$$

A Bausch and Lamb spectronic spectrophotometer was employed to determine lactate DH activity by taking the absorbance value after the reaction at 340 nm (Drewes, 1974; Everse, 1975). The blood samples were-analyzed in the laboratory of the department of biochemistry, Ahmadu Bello University Zaria.

3.6 INSTRUMENTS

The following instruments were used:

i. Broad blade anthropometer - for measuring the upper and lower limb length (Behnke and Wilmore, 1974).

ii. Shermond weighing machine - For measuring weight and height (Rose and Marfell Jones, 1983)

iii. Monarch cycle ergometer (Swedish made) was used for determining the maximal leg anaerobic power, anaerobic capacity and fatigue index (Bar-or-1978; Inbar and Bar-or, 1986). This instrument was calibrated in power unit kpkg-1

iv. Arm cycle ergometer (British made) was used to determine maximal arm (upper Limbs) anaerobic power anaerobic capacity and fatigue index (Bar-or; 1978; Inbar and Bar-or, 1986).

v. 6 stop watches- These were used to determine the entire 30 second period for the test as well as the highest and lowest power output in any 5 seconds.

vi. Catheter- These were inserted into the anticubital vein for drawing blood samples of subjects

vii. Syringes- These were used to collect the blood samples drawn from the catheter.

3.7 TESTERS:

A total of 6 Assistants, four laboratory technologists and two medical personnel were involved in this study. All the Assistants were trained in calibrating the desired work load on the ergometer and the determination of power in a given time. All the Assistants were trained in the administration of the tests till they obtain 0.96 or more inter-tester test- retest reliability and intra-tester test re-test reliability coefficients. All the tests were conducted in the human performance laboratory of the Department of Physical and Health Education. However, the blood samples were analyzed for lactate dehydrogenase activity in the - department of biochemistry laboratory all of Ahmadu Bello University, Zaria.

3.8 EXPERIMENTAL CONTROL

Before the commencement of the test, informed consents were obtained from the subject's parents and guardians, which were filled and dully signed to ensure that all subjects were in healthy condition. Similarly, the researcher made it clear that the test is optional and an individual was free to quit whenever he or she wishes.

3.8.1 Rotation of Testers

In order to avoid any bias of any tester for any test, the testers were rotated at random so that no tester conducts the same test in two consecutive testing sessions.

Orientation of Subjects

Both tests (leg and arm) were explained to the subjects with the emphasis on the need to start "all out" from the beginning and then attempt to maintain maximal speed throughout the entire 30 second period in order to achieve a reliable measure of mean power. Peak power and power decline (Fatigue Index) "Tactics" such as starting slowly in order to finish faster were strongly discouraged. Verbal encouragement was given throughout the test.

Subjects were cautioned against eating and smoking or engaging in vigorous exercise at least 2 hours proceeding the time of the test.

Each subject completed his or her task in one day. The cycle ergometer test (arm and leg) were conducted in the human performance laboratory of the Department of Physical and Health Education, Ahmadu Bello University, Zaria, at approximately the same time of the day (9- 11 am) and at the same room temperature.

Because of the potential fatigue factor induced by cycle ergometer test, the leg test was conducted first. A 30 minutes rest interval was allowed before the commencement of the arm cycle ergometer test. Subjects were encouraged to perform a cool down exercise after each of the tests to eliminate the chances of experiencing dizziness or nausea following the tests.

3.9 STATTISTICAL TECHNIQUES

The data collected were analyzed through the use of SPSS Package at the Institute of Agricultural Research (IAR) computer center, using descriptive statistic of mean, standard deviation and standard error for the purpose of interpretation.

Multiple correlation was computed for establishing relationship between the independent variables of age, weight, height and the dependent variables of anaerobic power, Anaerobic capacity and fatigue index for both legs and arms of children and adolescents.

Analysis of variance (2 WAY ANOVA) was used to see if there will be any significant variation (interaction) in anaerobic power performance between children and adolescents. Scheffe post hoc test was used to locate the place of significance.

The t-test statistics was computed to determine if there were significant differences in anaerobic power performance of males and females of the same age.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 INTRODUCTION

The purpose of this study was to determine differences between children and adolescents in their anaerobic power performance. To achieve this purpose, the data collected in this study was statistically analysed, the results of which are presented and discussed according to hypotheses in this chapter.

4.1 RESULTS

Before the statistical analysis of the data is presented according to hypotheses, descriptive information about the subjects is presented. Information regarding the anthropometric characteristics is shown in table one.

Table 1: Mean and Standard Deviations of Anthropometric characteristics of Subjects

Category subjects	Height (cm)	Weight (Kg)	Body Mass Index	UAL (cm)	LAL (cm)	TAL (cm)	ULL (cm)	LLL (cm)	TLL (cm)
All subjects	149.07 ± 11.63	41.31 ± 10.09	18.29 ± 2.48	29.31 ± 3.25	40.73 ± 3.88	69.80 ± 7.09	44.68 ± 6.23	44.89 ± 4.26	89.25 ± 10.75
All male subjects	148.71 ± 12.83	39.63 ± 9.71	17.67 ± 2.00	29.27 ± 3046	40.37 ± 4.24	69.34 ± 7.84	43.70 ± 5.77	44.76 ± 5.04	88.29 ± 11.00
All female subjects	149.43 ± 10.29	43.02 ± 10.20	18.91 ± 2.75	29.36 ± 3.04	41.10 ± 3.44	70.27 ± 6.22	45.67 ± 6.53	45.01 ± 3.30	90.23 ± 10.42
All children subjects	142.34 ± 8.14	35.68 ± 7.14	17.43 ± 1.95	28.00 ± 2.49	38.81 ± 3.32	66.61 ± 6.01	41.80 ± 5.24	42.86 ± 3.76	84.48 ± 8.84
All Adolescent subjects	157.88 ± 9.45	48.73 ± 8.50	19.41 ± 2.66	31.04 ± 3.34	43.26 ± 3.02	74.01 ± 6.15	48.47 ± 5.35	47.54 ± 3.33	95.54 ± 9.77
All male children	140.41 ± 7.59	34.02 ± 5.94	17.16 ± 1.62	27.43 ± 2.33	38.04 ± 3.35	62.25 ± 6.34	40.73 ± 4.97	41.88 ± 3.94	82.27 ± 9.47

Table 1 contd.									
All Female children	144.38 ± 8.23	37.39 ± 7.86	17.71 ± 2.20	28.59 ± 2.54	39.60 ± 5.33	68.01 ± 5.33	42.90 ± 5.30	43.87 ± 3.27	86.75 ± 7.52
All male adolescent	159.79 ± 9.61	47.11 ± 8.67	18.34 ± 2.26	31.72 ± 3.20	43.47 ± 3.18	74.80 ± 6.15	47.67 ± 4.15	48.60 ± 3.57	96.32 ± 7.06
All female adolescents	155.98 ± 8.94	50.34 ± 8.04	20.49 ± 2.61	30.36 ± 2.61	43.04 ± 2.85	73.21 ± 6.08	49.27 ± 6.25	46.49 ± 2.72	94.76 ± 11.88

KEY
- VAL - Upper Arm Length
- LAS - Lower Arm Length
- TAL - Total Arm Length
- ULL - Upper Leg Length
- LLL - Lower Leg Length
- TLL - Total Leg Length

A general observation of Table 1 indicates that on the average female subjects are slightly taller (149.43cm) and much heavier (43.02) than the male subjects, which are, reflected in Longer segmental lengths (70.27cm) and higher body mass index of females (19.91). Similarly, adolescents were taller and heavier with longer segmental lengths than children, reflecting the influence of growth and development on the anthropometric characteristics of the adolescents. However, Female children were taller and heavier with longer segmental lengths than male children, a trend that has reversed in adolescents, except in weight and body mass index. The heavier weight and higher body mass index of female adolescents may be attributed to the accumulation of fats in females during adolescence in preparation for womanhood.

Information regarding anaerobic power, anaerobic capacity and fatigue index of different categories of subjects is presented in Table 2.

Table 2: ANAEROBIC POWER, ANAEROBIC CAPACITY AND FATIQUE INDEX OF SUBJECTS

Category of subjects	Body segment	Anaerobic power		Anaerobic capacity		Fatigue index	
		Mean (kp)	SD (kp)	Mean (kp)	SD (kp)	Mean (kp)	SD (kp)
All subjects	Legs	286.77	148.49	1361.65	615.17	39.64	16.46
	Arms	202.24	68.46	976.65	385.05	32.05	13.99
All male subjects	Legs	300.94	127.01	1484.80	647.14	33.02	20.11
	Arms	212.52		1051.19	425.27	30.64	13.23
All female subjects	Legs	272.39	166.57	1236.71	555.15	46.36	16.73
	Arms	191.80	61.98	901.25	323.32	34.40	14.51
All children subjects	Legs	228.84	94.29	1029.01	443.82	45.65	14.85
	Arms	162.22	43.57	760.79	240.08	35.03	14.02

Table 2 contd.							
All adolescents subjects	Legs	362.90	171.06	1799.63	529.52	31.73	18.07
	Arms	254.92	58.97	1261.11	354.27	29.18	13.27
All male children	Legs	242.96	114.42	1096.08	470.61	38.44	21.16
	Arms	168.20	45.32	791.91	252.80	33.81	13.38
All female children	Legs	214.56	65.15	960.22	405.11	53.05	19.36
	Arms	156.09	41.00	728.87	222.87	36.29	14.59
All male adolescents	Legs	378.25	98.98	2003.10	460.36	25.78	16.07
	Arms	271.62	59.89	1396.89	357.43	26.42	11.83
All female adolescents	Legs	347.56	220.41	1596.16	517.95	37.68	18.08
	Arms	238.22	53.33	1125.34	295.60	31.94	14.11

Table 2 reveals higher anaerobic power and anaerobic capacity and lower fatigue index of male subjects compared to those of female subjects, suggesting that the male subjects had higher anaerobic power performance capacity than the female subjects both in upper and lower limbs. Similarly, adolescents had higher performance capacity than children reflecting the influence of growth and development on anaerobic power performance capacity. Similar trend was found when female children and adolescents were compared with their male counterparts in anaerobic power performance.

Results of the analysis of information on differences between different variables are presented on Table 3.

Hypothesis 1.3.1: There are no significant differences between different categories of subjects in their anaerobic power performance.

To test hypothesis one, mean values for anaerobic power, anaerobic capacity and fatigue index were computed from the values obtained for lower and upper limbs of different categories of subjects. t values were then computed for differences between the different categories of subjects in the three components of anaerobic power performance, the results of which are shown in Table 3.

Table 3: t - test for differences between categories of subjects in Anaerobic Power, anaerobic Capacity and Fatigue Index

Variable	Category of Subjects	Mean	SE	t Value
A P	Male	253.58	5.03	2.20
	Female	234.93	6.85	
A C	Male	1258.13	28.80	4.85
	Female	1076.86	23.80	
FI	Male	32.73	087	
	Female	39.51	1.71	
AP	Children	181.20	411	-1424
	Adolescents	291.10	5.91	
AC	Children	812.59	17.65	-19.47
	Adolescents	1431.19	24.04	
FI	Children	43.03	1.96	6.34
	Adolescents	30.98	0.75	
AP	Male children	182.20	431	-15.35
	Male Adolescents	307.11	6.27	
AC	Male children	826.46	25.16	-16.77
	Male adolescents	1581.89	34.14	
FI	Male children	40.88	1.44	-8.77
	Male adolescents	26.63	0.91	

AP	Female children Female adolescents	180.17 275.09	7.05 993	-7.26
AC	Female children Female adolescents	789.40 1281.09	24.78 31.02	-11.50
FI	Female children Female adolescents	45.21 35.33	3.69 1.13	2.89
AP	Male children Female children	182.20 180.17	431 7.05	0.25* N.S
AC	Male children Female children	826.46 798.40	25.16 24.78	0.79* N.S
FI	Male children Female children	40.58 45.21	1.44 3.69	1.10 N.S
AP	Male adolescents Female children	307.11 295.09	6.26 9.90	2.75
AC	Male adolescents Female children	1581.89 1281.09	34.14 31.02	6.52
FI	Male adolescents Female children	26.62 35.33	091 1.13	-6.02

*Not significant t (above 120) = 1.960 < .05

Table 3 reveals two trends in the distribution of anaerobic power performance components. One is across sex and the other one is across age. Table 3 shows significantly higher anaerobic power performance scores and lower fatigue index for males compared to those in females in general. These significantly higher scores of anaerobic power performance and fatigue index of male subjects were evident particularly among adolescents. Such differences were insignificant in children. Table 3 further reveals significantly higher scores of anaerobic power performance and significantly lower fatigue index of adolescent males and females compared to those of male and female children, thus the results presented in Table 3 does not support null hypothesis 1.3.1 except for anaerobic power performance of male and female children, in which the differences were insignificant. These differences are shown in figures 4.1 to 4.3.

Hypothesis 1.3.2: There are no significant differences between lower and upper limbs of different categories of subjects in anaerobic power performance.

To test this hypothesis, t-ratios were computed for differences between lower and upper limbs in anaerobic power performance of different categories of subjects, the results of which are shown in Table 4.

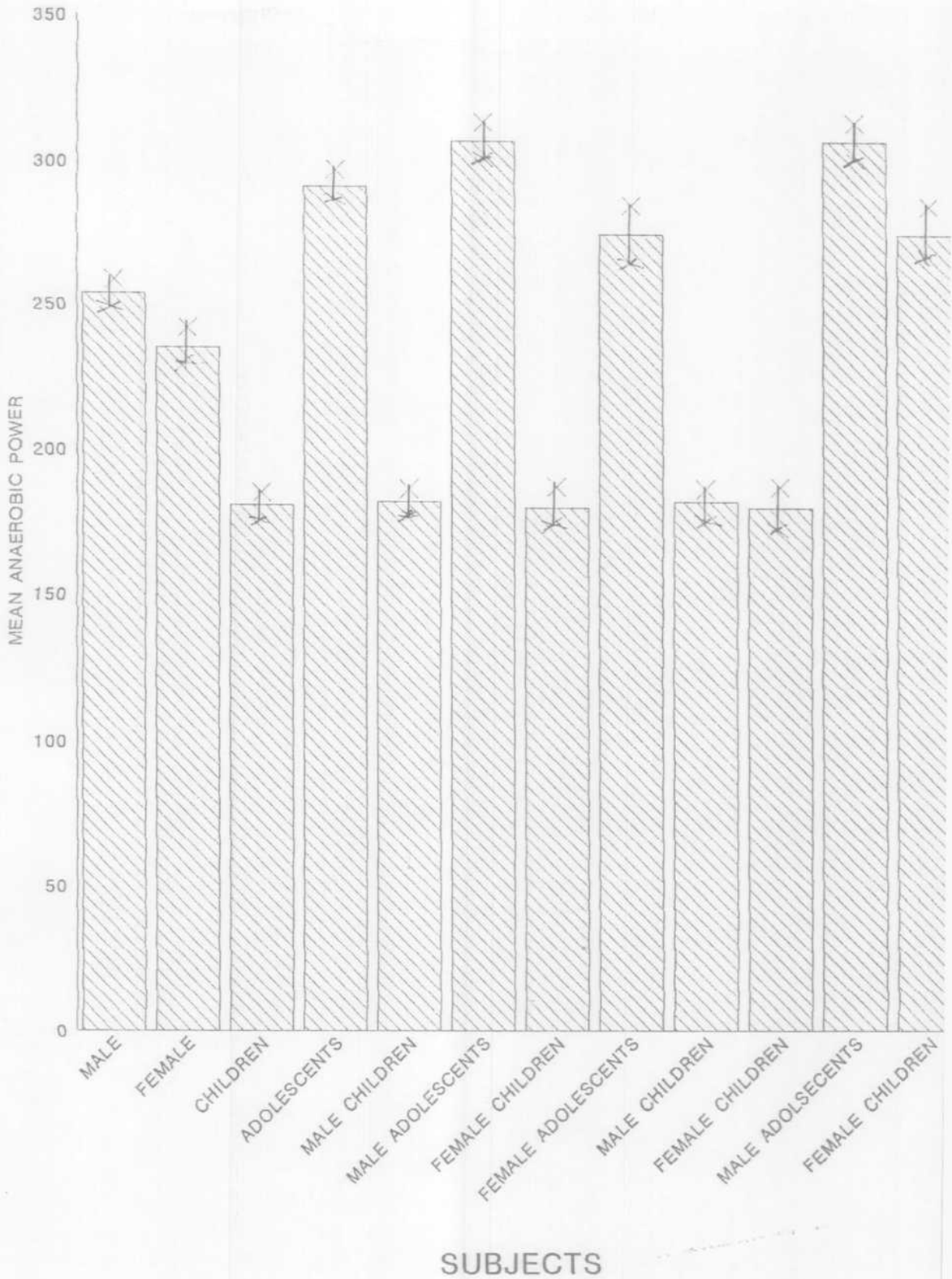


Fig.4.1: MEAN DIFFERENCES BETWEEN CATEGORIES OF SUBJECTS IN ANAEROBIC POWER

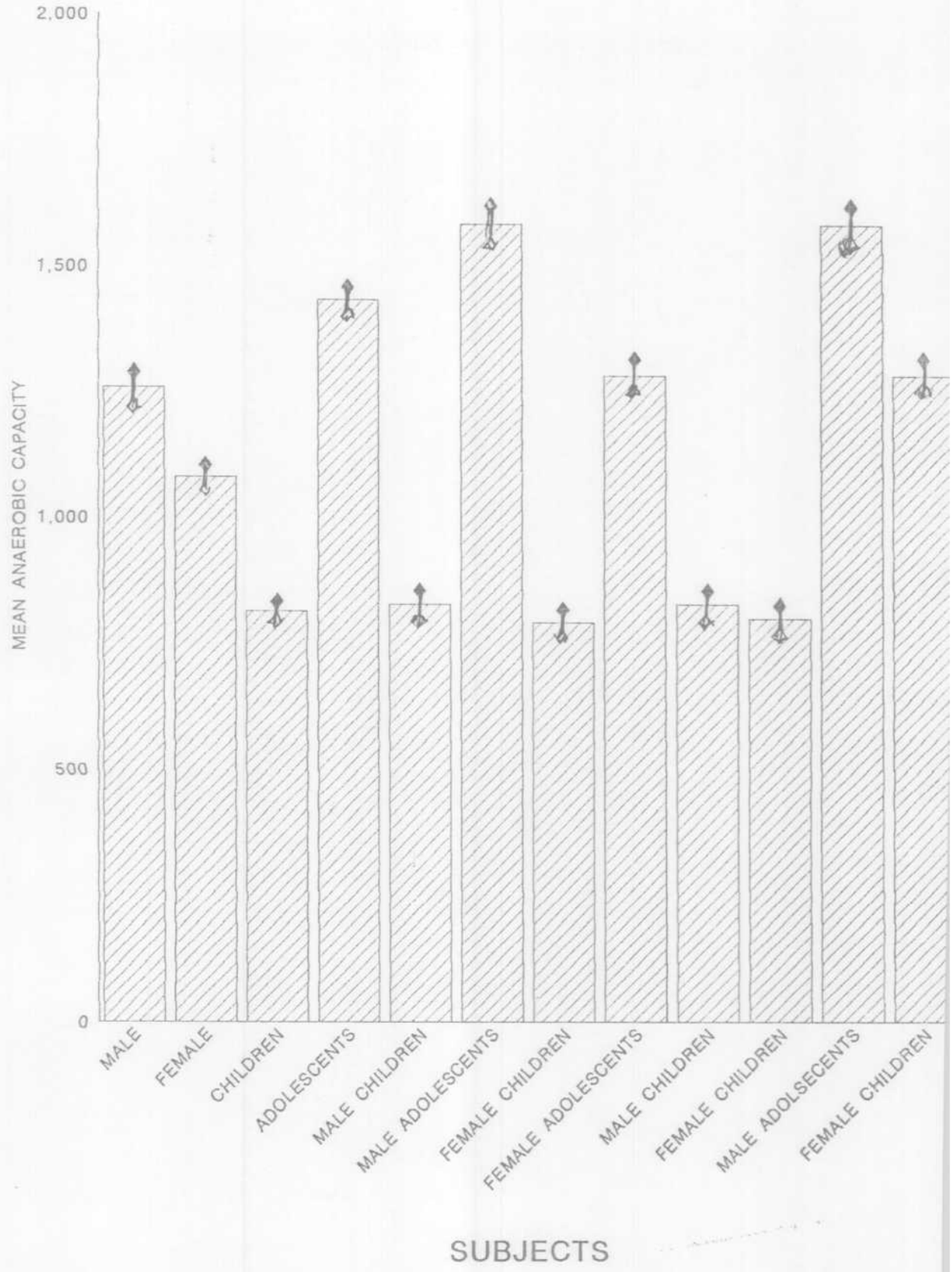


Fig.4.2: MEAN DIFFERENCES BETWEEN CATEGORIES OF SUBJECTS IN ANAEROBIC CAPACITY

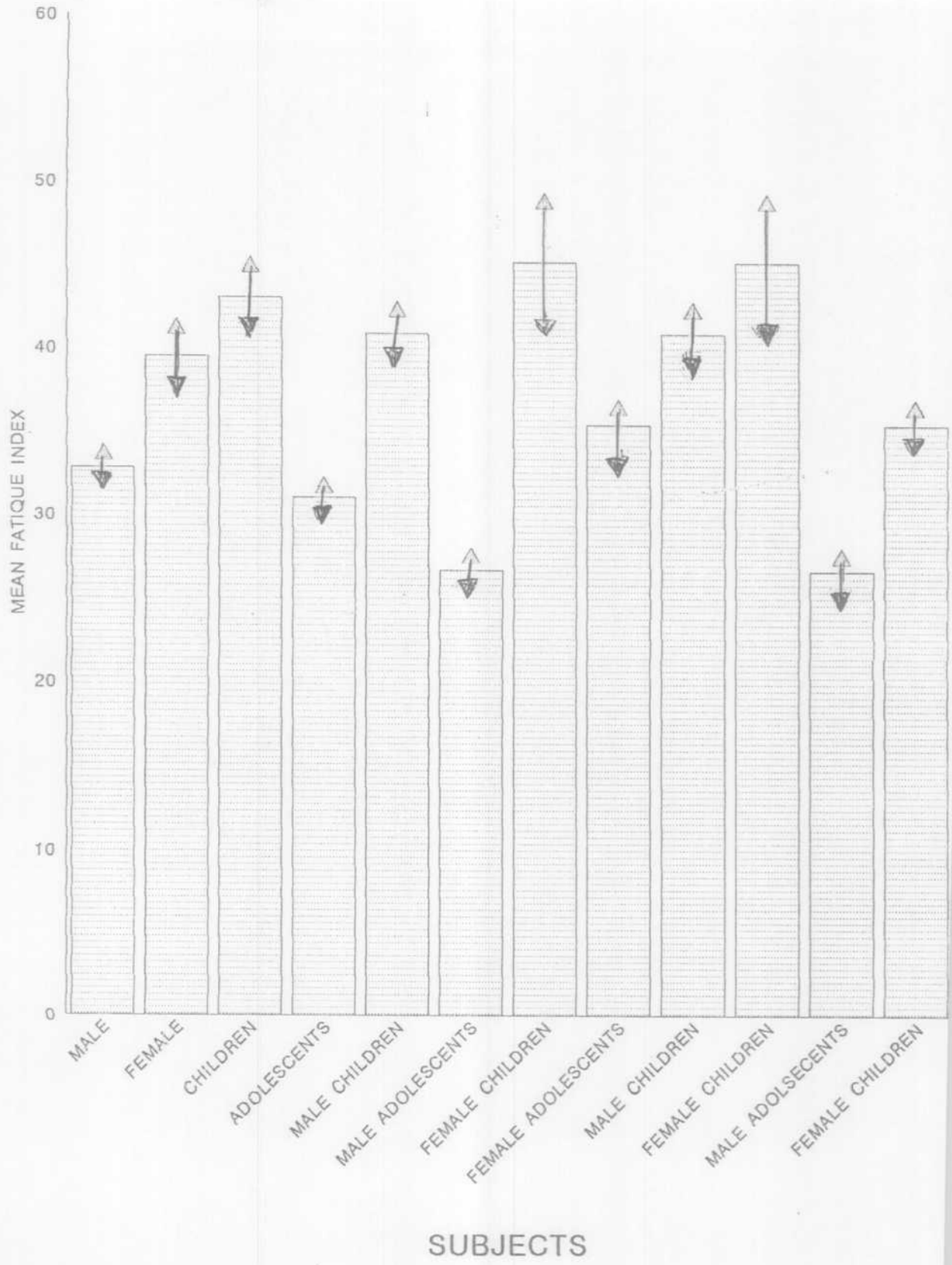


Fig.4.3: MEAN DIFFERENCES BETWEEN CATEGORIES OF SUBJECTS IN FATIQUE INDEX

Table 4: t-test for differences in lower and upper limb Anaerobic Power, Anaerobic Capacity and Fatigue Index of different groups of subjects

Variables	Extremity	Category of Subject	Mean (KP)	S.E (KP)	t
AP	Lower Limbs Upper Limbs	All Subjects (N=834) " "	286.48 202.11	7.26 3.35	10.55
AC	Lower Limbs Upper Limbs	All Subjects (N=834) " "	1359.93 955.95	30.10 18.83	10.81
FI	Lower Limbs Upper Limbs	All Subjects (N=834) " "	39.71 32.51	1.78 0.68	3.77
AP	Lower Limbs Upper Limbs	All Male Subjects (N=418) " "	295.35 211.80	7.63 5.15	9.08
AC	Lower Limbs Upper Limbs	All Male Subjects (N=418) " "	1466.86 1049.41	45.01 29.69	7.74
FI	Lower Limbs Upper Limbs	All Male Subjects (N=418) " "	34.71 30.76	1.48 0.92	2.27
AP	Lower Limbs Upper Limbs	All Female Subjects (N=414) " " "	277.53 192.33	12.38 4.17	6.52
AC	Lower Limbs Upper Limbs	All Female Subjects (N=414) " " "	1251.97 901.78	38.61 21.99	7.88
FI	Lower Limbs Upper Limbs	All Female Subjects (N=414) " " "	44.76 34.27	3.23 1.00	3.11
AP	Lower Limbs Upper Limbs	All Children (N=354) " "	210.94 151.45	7.13 2.59	7.84
AC	Lower Limbs Upper Limbs	All Children (N=354) " "	930.25 694.93	29.75 14.43	7.12
FI	Lower Limbs Upper Limbs	All Children (N=354) " "	49.24 36.82	3.73 1.05	3.20
AP	Lower Limbs Upper Limbs	All Adolescents (N=478) " "	342.51 239.69	10.07 4.06	9.47
AC	Lower Limbs Upper Limbs	All Adolescents (N=478) " "	1678.61 1184.37	35.63 23.15	11.63

FI	Lower Limbs Upper Limbs	All Adolescents (N=478) " "	32.65 29.31	1.23 0.85	2.23
AP	Lower Limbs Upper Limbs	Male Children (N=178) " "	211.77 152.63	6.22 4.03	7.98
AC	Lower Limbs Upper Limbs	Male Children (N=178) " "	948.09 704.82	41.44 22.26	5.17
FI	Lower Limbs Upper Limbs	Male Children (N=178) " "	45.63 36.14	2.39 1.44	3.40
AP	Lower Limbs Upper Limbs	Adolescent Males (N=238) " "	358.03 256.18	8.95 5.82	9.54
AC	Lower Limbs Upper Limbs	Adolescent Males (N=238) " "	1855.93 1307.85	47.92 33.50	9.37
FI	Lower Limbs Upper Limbs	Adolescent Males (N=238) " "	26.52 26.73	1.47 1.07	-.11
AP	Lower Limbs Upper Limbs	Female Children (N=174) " "	210.09 150.24	13.00 3.26	4.47
AC	Lower Limbs Upper Limbs	Female Children (N=174) " "	912.00 684.81	42.87 18.33	4.87
FI	Lower Limbs Upper Limbs	Female Children (N=174)" "	52.92 37.51	7.14 1.53	2.11
AP	Lower Limbs Upper Limbs	Female Adolescents (N=238) " "	326.99 223.20	17.97 5.27	5.54
AC	Lower Limbs Upper Limbs	Female Adolescents (N=238) " "	1501.29 1060.89	47.70 27.84	7.97
FI	Lower Limbs Upper Limbs	Female Adolescents (N=238) " "	38.77 31.89	1.82 1.27	3.10

t (above 120) = 1.960 ($p < .05$) *Not significant

A critical examination of Table 4 shows significant differences between Lower and Upper limbs in the three components of anaerobic power performance on the different categories of subjects. However, table four shows three clear cut trends in these differences. The differences are minimal in children compared to adolescents. The difference becomes much more striking and significant in adolescents. These differences are strikingly higher in male adolescents than in female adolescents. Therefore, these results have failed to support hypothesis 1.3.2. These differences are shown in Figures 4.4. to 4.6

Hypothesis 1.3.3: Anaerobic power performance does not change as a function of age and sex.

This hypothesis was generated because of the fact that the t-ratios presented in tables 3 and 4 revealed two dominant trends in variations of anaerobic power performance of the subjects. These included the significant effects of age and sex on anaerobic power performance. However, they failed to answer the question of the contribution of the interaction of sex and age to the variation in anaerobic power performance. In an attempt to answer this question, two way ANOVA was applied to the differences in anaerobic power performance, the results of which is presented in Table five.

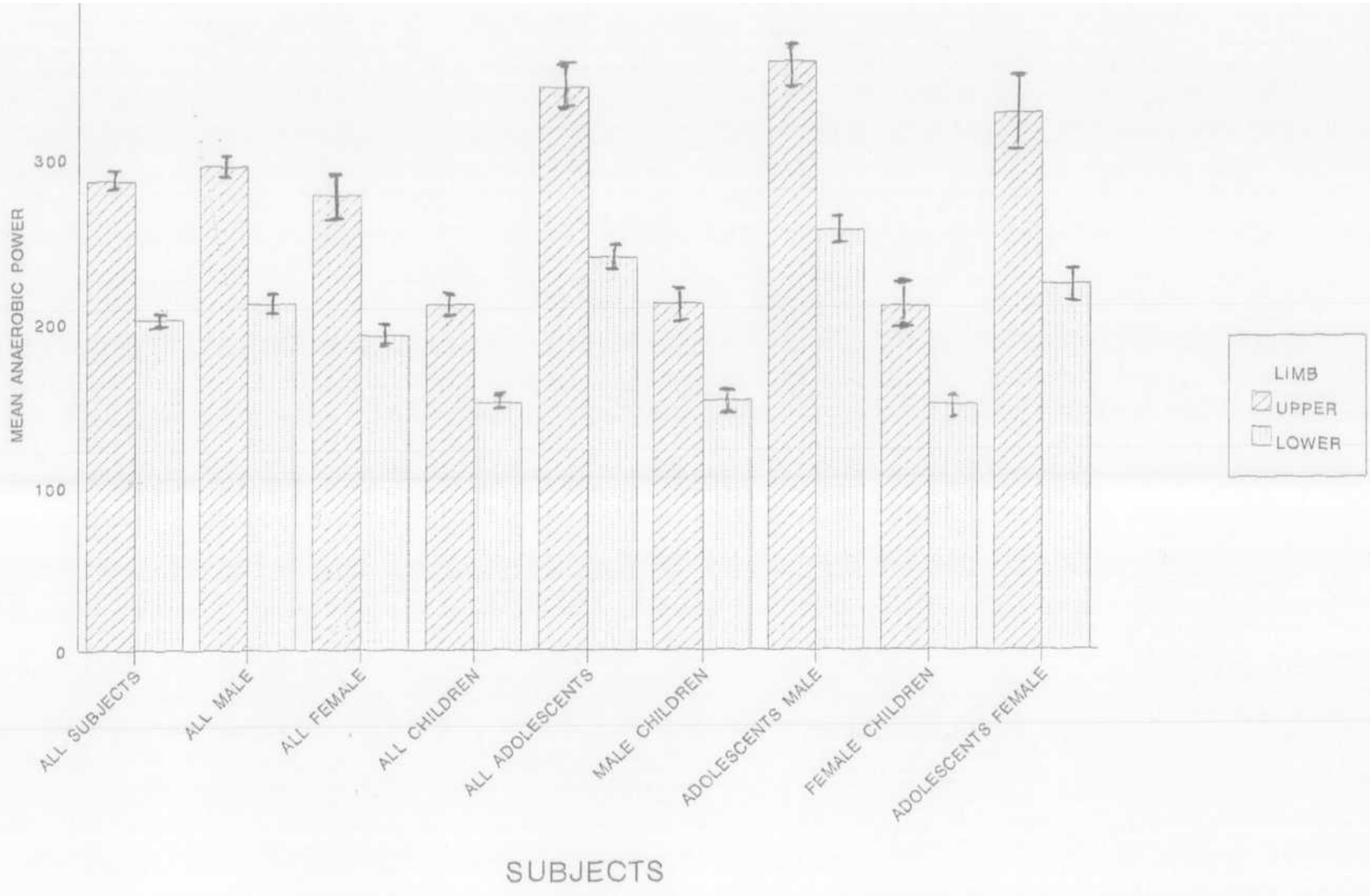


Fig.4.4: MEAN DIFFERENCES OF UPPER AND LOWER ANAEROBIC POWER OF DIFFERENT GROUP OF SUBJECTS

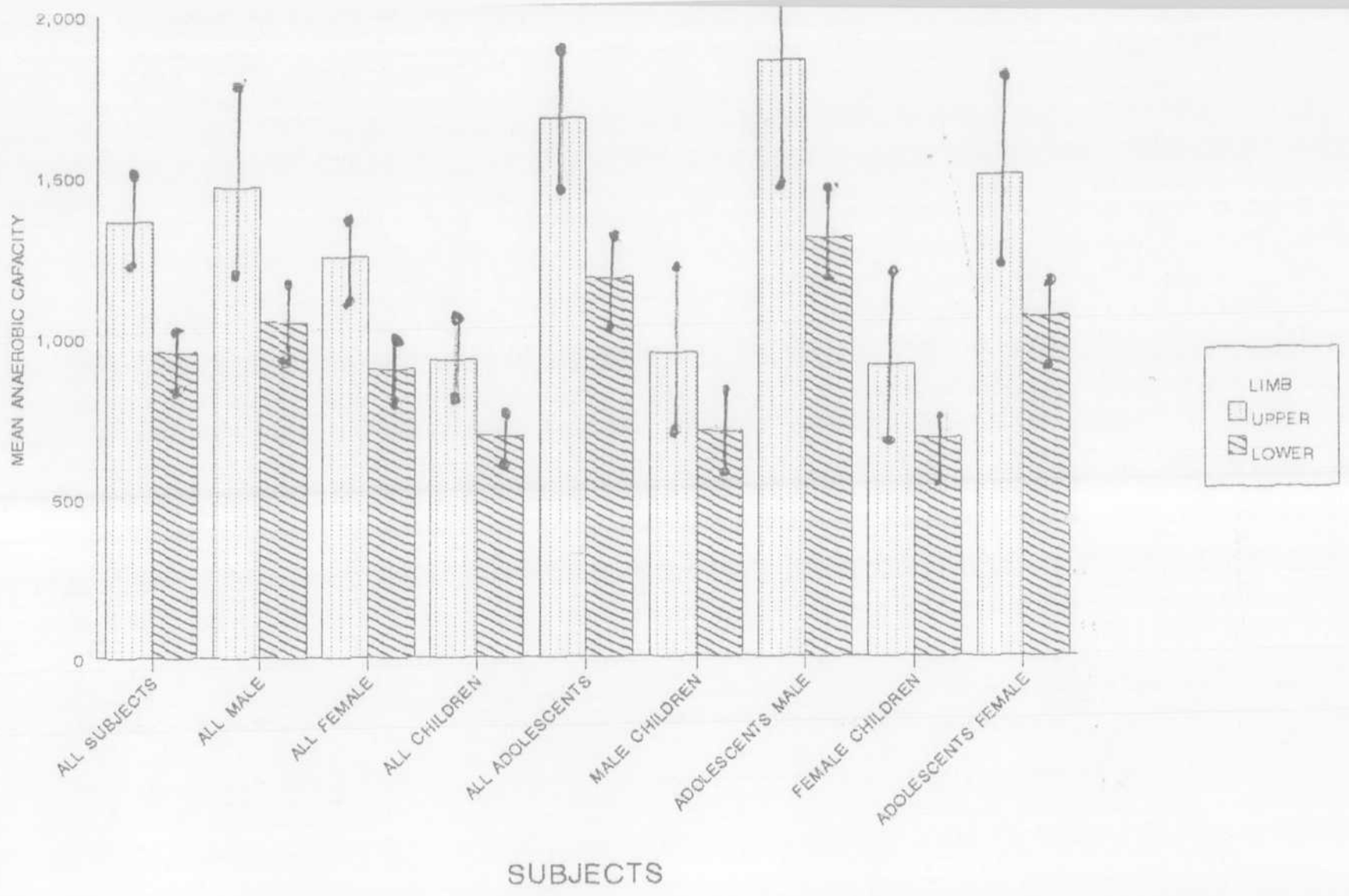


Fig.4.5: MEAN DIFFERENCES OF UPPER AND LOWER ANAEROBIC CAPACITY OF DIFFERENT GROUP OF SUBJECTS

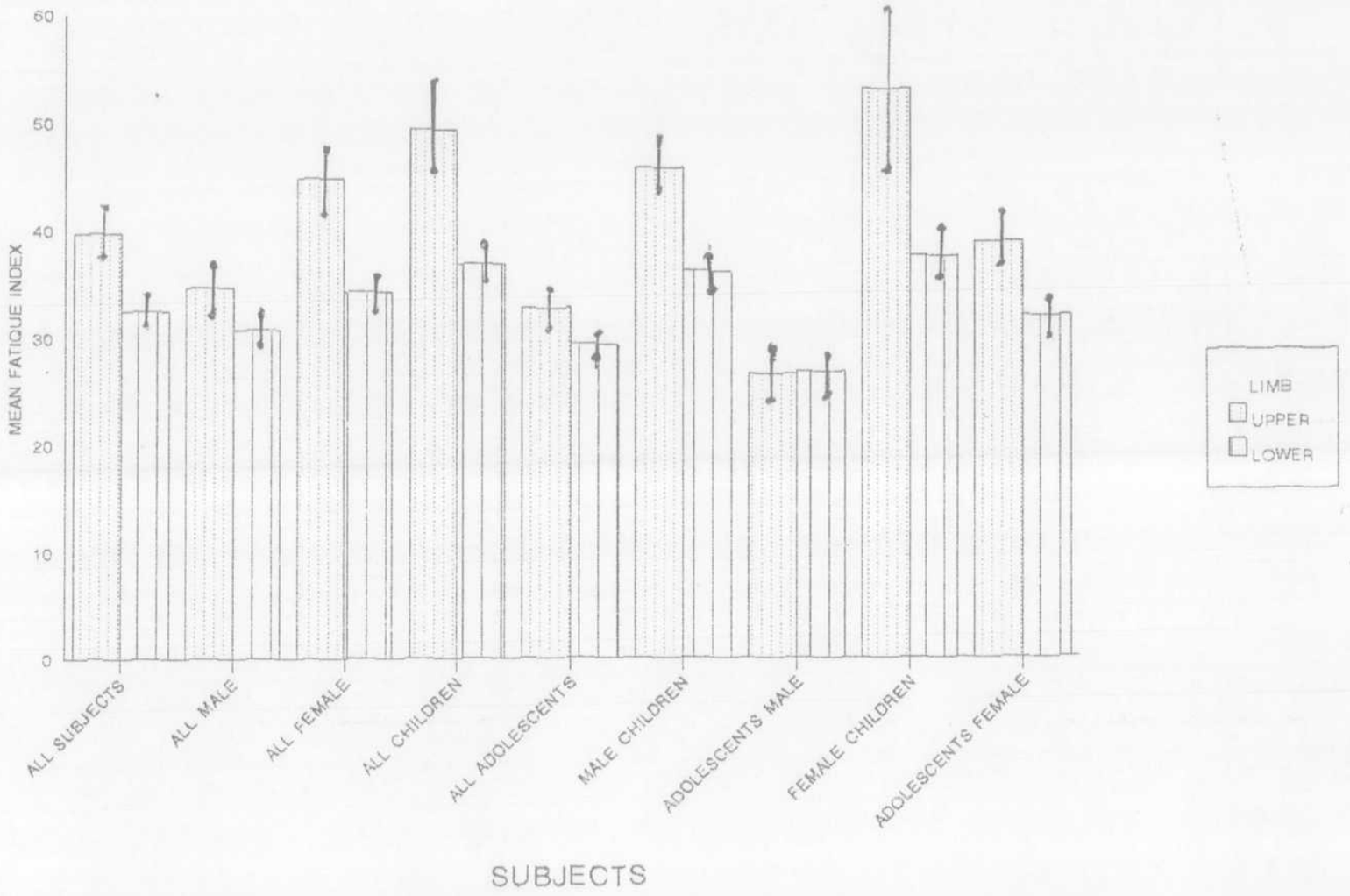


Fig.4.6: MEAN DIFFERENCES OF UPPER AND LOWER LIMB FATIQUE INDEX OF DIFFERENT GROUP OF SUBJECTS

Table 5: Two ways ANOVA for differences in Anaerobic Power, Anaerobic capacity and Fatigue Index by Age and Sex

{PRIVATE } Variable	Source of Variation	Sum of Squares	D.F	Means of Squares	F. Value
Anaerobic Power	Main Effect	2546282.91	2	1273141.45	105.57
	Effect **V3**	77419.26	1	77419.26	6.42
	2 way interaction V1	2473647.75	1	2473647.75	205.11
	V3 Explained	45918.53	1	45918.53	3.81
	Residual	45918.53	1	45918.53	3.81
		259220.43	3	864067.15	71.65
		10033986.18	832	12060.08	
	Total	12626187.62	835	15121.18	
{PRIVATE }Anaerobic Capacity	Main Effect	85420457.80	2	42710228.90	220.26
	V3	7126746.05	1	712646.05	36.75
	2 way interaction	78553989.20	1	78553989.20	405.11
	V1 V3	3801043.30	1	3801043.30	19.60
	Explained	3801043.30	1	3801043.30	19.60
	Residual	89221501.10	3	29740500.37	153.37
		161331250.18	832	193907.75	
	Total	250552751.27	835	300063.18	
{PRIVATE }Fatigue Index	Main Effect	39462.12	2	19731.06	27.11
	V3	9792.46	1	9792.46	13.46
	2 way interaction	29858.45	1	29858.45	41.03
	V1 V3	980.05	1	980.05	1.35
	Explained	980.05	1	980.05	1.35
	Residual	40442.17	3	13480.72	18.52
		605483.23	832	727.74	
	Total	645925.40	835	773.56	

$F(2,832) = 3.00$

Table 5 indicates significant differences between children and adolescents (age) and between male and female subjects (sex) in anaerobic power performance. Further, table five reveals significant contribution of the interaction of sex and age to the total variance of anaerobic power performance, thus contribution of age, sex and interaction of age and sex to the total variance of anaerobic power performance is shown graphically in Figure 4.7. Application of Schefee's posthoc test to these significant

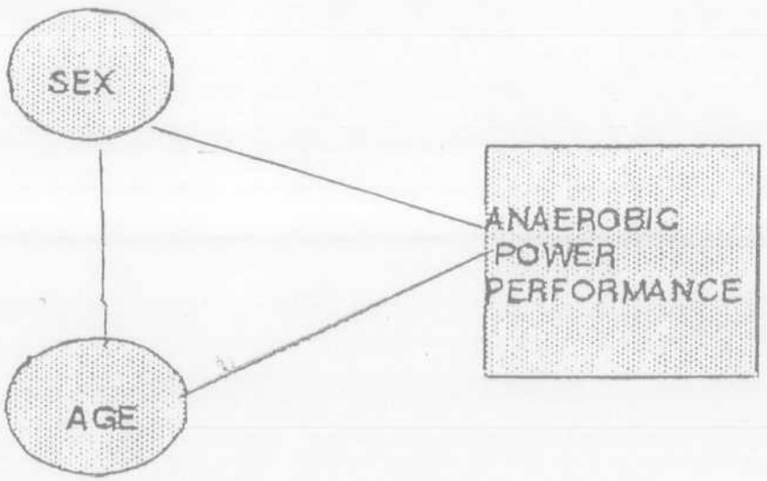


Fig : Determinants of Anaerobic Power performance

differences revealed that the significant differences were mainly due to mean differences between children and adolescents and males and females in anaerobic power, anaerobic capacity and fatigue index. It also further revealed that 2 way interaction of sex and age significantly affected the differences only in anaerobic power and anaerobic capacity and not in fatigue index. Thus, hypothesis 1.3.3 is not supported by the results of this study.

Hypothesis 1.3.4: There is no significant relationship between anaerobic power performance and anthropometric measures.

To test this hypothesis, anaerobic power performance was decomposed into three components, which included anaerobic power, anaerobic capacity and fatigue index. Coefficients of correlation between these components and the different anthropometric measures were then computed, the results of which are shown on Table 6.

Table 6: Intercorrelations between Anthropometric and Anaerobic Variables

No.	Variables	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14	V15	V16	V17	V18	V19
1	Height (V3)	1,000	.7881*	.3319*	.6562*	.7774*	.6829*	.6647*	.7969*	.7001*	.3909*	.558*	.5902*	-.1049* NS	.7313*	.4006*	.6914*	-.1464* NS
2	Weight (V4)	.7881*	1000	.7835*	.5922*	.7536*	.6350*	.6740*	.6712*	.6657*	.4547*	.3479*	.6182*	-.1270* NS	.7593*	.4032*	.7047*	-.1154* NS
3	Body mass index (V4)	.3319*	.7835*	.1000*	.3067*	.4390*	.3388*	.4018*	.2853*	.3458*	.3459*	.2003*	.3956*	-.6978* NS	.5141*	.2672*	.4634*	-.6447* NS
4	Val (V6)	.6562*	.5922*	.3067*	.1000	.6171*	.7604*	.5743*	.6218*	.5481*	.2474*	.2355*	.3971*	-.0483* NS	.5936*	.3809*	.5146*	-.0808* NS
5	LAL (V7)	.774*	.7536*	.4390*	.6171*	1000	.7682*	.6717*	.7680*	.7132*	.4067*	.3328*	.5520*	-.0561* NS	.6542*	.355	.6138*	-.0835* NS
6	TAL (V8)	.6829*	.6350*	.3388*	.7604*	.7682*	1000	.6080*	.6285*	.6011*	.3188*	.2866*	.4645*	-.0508* NS	.5993*	.3530*	.5454*	-.0729* NS
7	ULL (V9)	.6647*	.6740*	.4018*	.5743*	.6717*	.6080*	.1000	6718*	.8259*	.3243*	.26662*	.4612*	-.1101* NS	.5459*	.300*	.5083*	-.0042* NS
8.	LLL (V10)	.7969*	.6712*	.2853*	.6218*	.7680*	.6285*	.6718*	1000	.7738*	.3967*	.3606*	.5349*	-.0641* NS	.6407*	.3551*	.5876*	-.0897* NS
9	TLL (V11)	.7001*	.6557*	.3458*	.5481*	.7132*	.6011*	.8249*	.7738*	1000	.3584*	.3039*	.4904*	-.0786* NS	.5797*	.3237*	.5387*	-.0467* NS

10	HNRV (AP) leg (V12)	.3909*	.4547*	.3459*	.2474*	.4067*	.3188*	.3243*	.3967*	.3584*	1000	.3643*	.1000*	.1300* NS	.5170*	.2357*	.5217*	-.0178* NS
11	LNRV (AP) leg (V13)	.3558*	.3479*	.2003*	.2355*	.3328*	.2866*	.2662*	.3606*	.3039*	.3643*	1000	.5959*	.3062* NS	.4519*	.2466*	.4748*	-.1680* NS
12	TRV CAC leg (V14)	.5902*	.6182*	.3956*	.3971*	.5520*	.4645*	.4612*	.5349*	.4902*	.5916*	.5959*	.3062* NS	-.3457* NS	.7398*	.3976*	.7754*	-.2330* NS
13	F. I. Leg (V15)	-.1049* NS	-.1270* NS	-.0978* NS	-.0483* NS	-.0561* NS	-.0508* NS	-.1101* NS	-.0641* NS	-.0784* NS	-.1300* NS	-.3062* NS	-.3457* NS	1000	-.2101* NS	-.1341* NS	-.2250* NS	-.0893* NS
14	HNRV (AP) Arm (V16(	.7313*	.7593*	.5141*	.5936*	.6541*	.5993*	.5459*	.6407*	.5797*	.5170*	.4519*	.7398*	.2101*	1000*	.5070*	.8938*	-.1414* NS
15.	LNRV Arm (V17)	.4006*	.4032*	.2672*	.3809*	.355*	.3530*	.300*	.3551*	.3237*	.2357*	.2466*	.3976*	.1341* NS	.5070*	1000*	.4764*	-.2931* NS
16	TRV (AP) Arm (V18)	.6914*	.7047*	.4634*	.5146*	.6138*	.5454*	.5083*	.5876*	.5387*	.5217*	.4748*	.7754*	-.2250* NS	.8938* NS	.4764*	1000	-.2977* NS
17	F. I. Arm (V19)	.1464* NS	.1154* NS	.0647* NS	.0808* NS	.0835* NS	.0729* NS	.0042*	.0897* NS	.0467* NS	.0178* NS	.1680* NS	.2330* NS	.0893* NS	.1414* NS	.2931* NS	.2977* NS	1000

Perusal of Table 6 above reveals significant relationships between the three different components of anaerobic power performance and the different anthropometric measures. However, anaerobic power was most highly related to height, ($r = .7312 < .05$) weight ($r = .7593 < .05$), explaining more than 53% of its variance, but on the other hand the highest relationship of anaerobic capacity with anthropometric measures was ($r = .4032 < .05$), explaining only 16% of its variance. However, the relationship of fatigue index with any of the anthropometric measures was not significant, suggesting that height, weight, body mass index and segmental length do not significantly affect fatigue index. These relationships for upper limbs are very similar to those of lower limbs except for the fact that the relationships of the upper limbs are higher than those of lower limbs anthropometric measures.

Table 6 further shows significant intercorrelations between different anthropometric measures, which are only of academic interest without implications for the testing of hypothesis 4. Thus, the results presented in Table 5 do not support hypothesis 1.3.4.

Hypothesis 1.3.5: There is no significant relationship between Serum lactate dehydrogenase activity and anaerobic power performance.

This hypothesis was generated on the assumption that higher anaerobic power performance depends on the ability to tolerate higher concentration of lactic acid. In this study, higher concentrations of lactic acid were inferred from higher concentration of serum lactate dehydrogenase. Therefore, coefficients of correlation were computed between concentrations of serum lactate

dehydrogenase and the different components of anaerobic power performance. The results of which are presented in Table 7.

Table 7: Coefficients of Correlation between anaerobic power performance and lactate dehydrogenase of lower and upper extremities

Variables	Lower Limbs			Upper Limbs		
	V_1(AP)	V_2(AC)	V_3(FI)	V($_4$AP)	V_5(AC)	V_6(FI)
Pre-test LDH	-1780	-0559	-2484	-.0467	-0949	-1094
	NS	NS	NS	NS	NS	NS
Post-test LDH	-2781	-1434	-1945	-0156	-0915	-1298
	NS	NS	NS	NS	NS	NS

r (19) = .433 < 0.05 NS - Not significant.

Examination of Table 7 clearly indicates insignificant relation of serum lactatedehydrogenase to the different components of anaerobic power performance of lower and upper limbs of subjects, suggesting that anaerobic power performance is influenced by a variety of factors, in which lactatedehydrogenase activity may have very insignificant influence. This statement appears to be true irrespective of the body segments used and before or after exercise. This trend suggested by the results of this study is contrary to the assumption that anaerobic power performance is very closely related to lactate and thus to lactatedehydrogenase. As the results presented in Table 7 supports hypothesis 1.3.5. The acceptance of this hypothesis is reasonable.

The results presented in Table 7 were obtained from all the subjects. It therefore became necessary to verify whether the trend of these results can be generalized to different categories of subjects. Thus correlations between anaerobic power performance and different serum lactate dehydrogenase were computed for different categories of subjects separately, the results of which are shown in Table 8.

Table 8: **Correlations between anaerobic power performance components and lactate dehydrogenase of different categories of subjects.**

Category of subjects	Variable	Lower limbs			Upper limbs		
		AP	AC	FI	AP	AC	FI
Children (N=9)	Pre-test LDH	-.51	-.46	.33	-.48	-.65	-.41
	Post-test LDH	-.42	-.32	.19	-.70*	-.29	-.61
Adolescents (N = 12)	Pre-test LDH	-.26	-.17	.17	-.63*	-.63	-.94*
	Post-test LDH	-.40	-.23	.19	-.04	-.44	-.10
Male subjects (N = 10)	Pre-test LDH	-.70*	-.44	.51	-.47	-003	-.62
	Post-test LDH	-.02	-.39	.42	-.52	-.1.0	-.61

Table 8 contd.							
Female subjects (N = 11)	Pre-test LDH	-.32	-.34	.71*	-.21	.17	-.03
	Post-test LDH	-.45	-.44	.60	-.35	.26	-.03
Male adolescents (N = 6)	Pre-test LDH	-.13	-.54	.45	-.68	-.51	-.74
	Post-test LDH	-.28	-.40	.59	-.51	.31	-.62
Male children (N = 4)	Pre-test LDH	-.52	-.37	-.21	-.81	-.46	-.35
	Post-test LDH	-.41	-.27	.24	-.85	.53	-.23
Female children (N = 5)	Pre-test LDH	-.37	-.57	-.13	-.28	-.32	-.14
	Post-test LDH	-.53	-.65	.23	-.44	.46	-.23

r (7) = 681; r (10) = .576; r (8) = .632; r (9) = .602; r (4) = .811; r (2) = .95; r (3) = 88 < 0.05.

A critical analysis of Table 8 shows insignificant relationships between anaerobic power performance and lactate dehydrogenase activity of both lower and upper limbs of all categories of subjects. However, there are exceptions to this general statement which include the significant negative relationship between anaerobic power of upper limb after exercise of children and lower limbs of all male subjects, anaerobic power, anaerobic capacity, fatigue index of lower limbs of adolescents and fatigue index of lower limbs of female subjects with lactate dehydrogenase activity before exercise. Thus these results generally indicates insignificant relationships between anaerobic performance and LDH concentration of lower limbs as well as upper limbs for all categories of subjects, except for the upper limbs of adolescents.

In an attempt to find out the variance of LDH activity before exercise and after exercise with age and sex, coefficients of correlation between LDH activity age and sex were computed, the results of which are presented in Table 9.

Table 9: Correlation of LDH Concentration with Age and Sex

Variable	Age	Sex
Pre-test	.0687	.0812
Post-Test	.1026	.0302

$r(19) = .433 < 0.05$
NS = Not Significant

Table 9 shows insignificant relationship of both pre-test and post-test LDH activity with age and sex. This suggests that neither age nor sex have any significant influence on LDH activity either before or after exercise. Thus the results supports hypothesis 1.3.5.

Hypothesis 1.3.6: There is no significant difference between different categories of subjects in their pre-test and post-test lactate dehydrogenase activity.

To test this hypothesis, t-ratios were computed for differences between different categories of subjects in their pre-test and post-test lactate dehydrogenase activity, the results of which is shown in Table 4.

One issue that has come up from the results presented so far is the variability of LDH activity with exercise in different categories of subjects. To solve this issue, t-ratios were computed for differences between pre-test and post-test LDH activity in all categories of subjects, the results of which are shown in Table 10.

Table 10: T-test for differences in pre and post test lactate dehydrogenase (LDH) activity of subjects.

Type of test	Category of Subjects	Mean (umol)	Standard error (umol)	t-value
Pre – test	All subjects (21)	99.43	12.68	-7.41*
Post –test	All subject (21)	146.43	15.72	
Pre-test	Male subjects (10)	94.60	14.02	-0.36
	Females subjects (11)	103.82	21.19	NS
Post test	Male subjects (10)	144.20	16.59	-0.13
	Females subjects (11)	148.46	26.77	
Pre-test	Children (9)	83.78	13.74	-1.07
	Adolescents (12)	111.17	19.48	NS
Post-test	Children (9)	127.44	13.50	-1.05
	Adolescents (12)	160.67	25.37	NS
Pre-test	Male adolescents (6)	95.67	18.29	-0.78
	Female adolescents (6)	126.67	35.20	NS
Post-test	Male Adolescents (6)	139.00	26.57	-0.84
	Female adolescents (6)	182.33	44.02	NS
Pre-test	Male children (4)	93.00	25.22	-0.57
	Female children (5)	76.40	16.35	NS
Post –test	Male children (4)	152.00	16.34	-1.86
	Female children (5)	107.80	16.69	

$t(20) = 2.086 < .05$; $t(19) = 2.093 < .05$; $t(10) = 2.228 < .05$; $t(7) = 2.365 < .05$

NS - Not significant
* - Significant

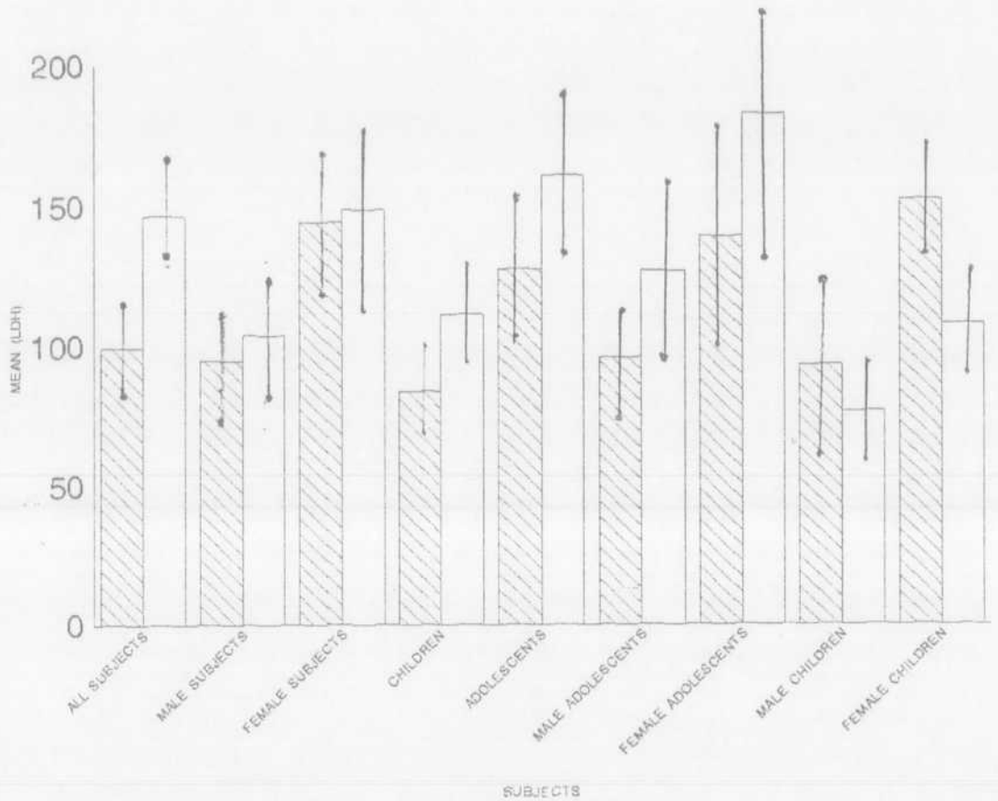


Fig. 4.8: MEAN DIFFERENCES OF PRE-TEST LACTATE DEHYDROGENESE (LDH) CONCENTRATION, ALL SUBJECTS

Observation of Table 10 indicates insignificant differences between male and female subjects, children and adolescents, male adolescents and female adolescents and male and female children in both pre-test and post-test LDH activity. But when all categories of subjects were combined and the t-ratios was computed for differences between pre-test and post-test LDH activity a significant increase in LDH activity was found after exercise. This trend of increased post-test LDH activity was found in all categories of subjects, and in females compared to males, although the observed increase in LDH activity was statistically insignificant. These differences are shown graphically on Figure 4.8

4.2 DISCUSSION

The results of this study showed significant differences between male and female subjects and children and adolescents in the three components of anaerobic power performance, which included anaerobic power, anaerobic capacity and fatigue index. Similar age differences have been reported earlier by Margaria et al., (1966); Diprampero and Ceretelli (1969) Bar-or (1983; 1984); Korouski (1983), Sargeant et al (1985), Inbar and Bar-Or (1986), Sharp (1992), and Sargeant (1989). Infact, some of them (Korouski, 1983; Inbar and Bar-Or, 1986; Sharp, 1992) even went to the extent of reporting that the relative power output of a ten year old boy was 80% of that generated by a thirteen years old boy and 75% of that generated by a seventeen year old boy. The general explanation for the lesser relative power of children has been that immature muscle has less glycogen and a much lower rate of glycogen

utilisation, in addition to lower level of creatine phosphate which is the immediate anaerobic energy store (bar-or, 1983). For example, Bar-Or (1983) and Erikson and Saltin (1974) reported distinctly lower muscle glycogen levels in prepubertal children compared to adolescents and adults, which appears to be the main biochemical differences between children and adults (Inbar and Bar-Or, 1986). The resting glycogen levels of pre adolescent children range from 50-70m Mol/L compared with about 65m mols/L in adults (Astrand and Rodahl, 1986), which is responsible for the utilisation of a lower proportion of anaerobic pathways by children compared to adolescents and adults. Although there are insignificant differences between children and adolescents in the three major substrate for anaerobic energy production, which include adenosine-triphosphate, creatine-phosphate and glycogen, their rate of utilisation during exercise is less in children than in adults (In bar-Or, 1973; Erikson and Saltin, 1974).

Another possible explanation for this age difference is that young muscle is intrinsically less powerful in short term exercise because of relatively low rate of resynthesis of ATP. However, as there has been no research evidence to support this explanation, it could be assumed that instantaneous power could hardly be affected by the limited rate of resynthesis of ATP (Sargeant, 1989) although it could play a progressively significant role in mean power output determined by test lasting for more than 5 seconds.

The lower anaerobic power of children can be partially attributed to their lower level of acidosis at maximum exercise (Inbar and Bar-Or, 1986). This explanation is based on the fact that Matejkova et al., (1980) reported a

decline of 0.01 to 0.02 pH units per year in the children between 8-18 years. It also appears that the child-adult difference in anaerobic power depends on the ratio of muscle length to cross section area (Sargeant and Doland, 1986). For example, after the cessation of longitudinal growth, adults continue to increase the cross sectional area of their muscle fibers thus changing the angle of pinnation and affecting force production, which gives them a greater mechanical advantage. In addition, other factors like dimensional changes in muscles, the density of myofibrils, development of neuro-muscular transmission, and changes in the contractile speed of muscle with growth contribute to the increase in the anaerobic power output of children (Sargeant, 1989).

An alternative and more acceptable explanation for the child-adolescent differences in anaerobic power is that the rate of glycolysis is dependent on the activity of the controlling muscle enzyme, phosphofructokinase (PFK), which is a rate limiting enzyme for glycolysis. This explanation appears to be acceptable because of the fact that PFK activity is lower in children than in adolescents (Erikson, 1972; Erikson and Saltin, 1974; Fournier et al., 1982). A similar situation can be observed when succinic dehydrogenase (SDH) activity is considered. SDH is the rate-controlling enzyme of oxidative phosphorylation in the mitochondria of the active muscle fibers. It appears that there is an inverse relationship between SDH and PFK activity, such that a decrease in PFK activity and therefore anaerobic glycolysis is counter balanced by a proportional increase in SDH activity, which is higher in children than in adults. (Erikson, 1972) and therefore oxidative phosphorylation. However, it is not clear whether anaerobic power output is

age dependent irrespective of the muscle size of the subjects (Sargeant et al., 1985; Sargeant, 1989).

Although available research evidence does not confirm an age dependent difference between children and adults, the potential maximum rate of short term power output during growth in children has been generally observed by all the investigators in this area (Sargeant, 1989).

The significant differences found between adolescent males and females support the findings of Armstrong and Davies (1984), Bale et al., (1989) Bale (1992), Pirnay and Crielaard (1980) and Vanpraagh et al., (1990). These differences are attributable primarily to greater testosterone levels in male adolescents compared to adolescent females who have higher oestrogen levels. Testosterone plays a critical anabolic role in the growth and development of muscle mass during adolescence (Florini, 1987), whereas oestrogen increased adipose tissue levels which has a retarding effect on lean mass and reduces glycogenolysis. The greater body fat % and body mass index level of female subjects support this explanation. The absence of such sex difference in children is attributable to the insignificant difference between male and female children in testosterone and oestrogen levels. It may be further stated that, in addition to its qualitative effects on muscle mass, testosterone may also transform type II fibers to a more glycolytic profile and impact neural factors to favour anaerobic exercise (Bleisch et al., 1984, Kelly et al., 1985; Nindl et al., 1995). In addition, available evidence suggests positive correlation of testosterone with the rate of lactate production and increases lactate dehydrogenase (Krotkiewski et al; 1980). The possible role of testosterone in

anaerobic exercise may explain the sex differences in anaerobic performance. An alternative explanation for this sex differences in anaerobic power performance is that females in general have lower ability to recruit and activate muscle during the Wingate Anaerobic Test (WAnT), and short term power output is greatly dependent upon the degree of muscle fiber activation (Saavedra et al., 1991; Vanpraagh et al., 1990). It is possible that the observed sex differences in the rate of force development could be due to the ability to recruit available motor units, or the number of fast twitch units available to recruit. In addition, fundamental cellular differences between males and females have been reported by some investigators. Qualitative sex differences in muscles including key enzymes in the glycolytic pathway, like phosphorylase, Hexokinase, Phosphofructokinase and lactate dehydrogenase have been reported to be significantly higher in males than in females (Komi and Karlsson, 1978; Simoneau and Bouchard, 1989; Sumoneau et al., 1985). These findings are supported by the fact that males have a larger percentage of fast twitch fibers and larger mean fast twitch fiber area than females (Simoneau and Bouchard, 1989; Simoneau et al., 1985).

The results of this study show significant differences between lower and upper body anaerobic power performance. These results thus support the findings of Asmussen and Hammengsen (1958) Bar-Or and Ziweren (1975), and Inbar and Bar-Or (1986), which showed significant differences between upper and lower body anaerobic power in all categories of subjects. These significant differences may be attributed to the greater muscle mass involved in leg pedalling than in arm cranking. Asmussen and Hammingsen, 1958; Inbar

and Bar-Or, 1986; Nindl et al., 1995). This explanation is also applicable to the greater anaerobic power of males than females both in upper and lower body extremities. This is because of the fact that males have greater muscle mass than females in both upper and lower extremities (Bar-Or, 1983; Murphy et al., 1986; Nindl et al., 1995). This sex difference in lean muscle mass is attributable to greater activity level and testosterone concentration of males than females (Canada fitness survey, 1983; Johnson and Hedberg, 1991; Nindl et al., 1995). Another explanation could be that the greater Q angle of females may reduce the proportion of quadriceps muscle force that is transmitted through the patella tendon-keeping females at a disadvantage in power generation. However, this is applicable to lower body and not to upper body.

The greater difference between males and females in lower body anaerobic power found in this study, is attributable to a higher glycolytic enzyme activity and larger muscle mass in males than in females. However, no significant sex differences exists concerning glycolytic enzymes of the upper extremities (Haralambie, 1979). This fact explains why there was a lack of a more pronounced sex difference for upper body anaerobic power performance in this study. As most strenuous involvement in physical activities exerts a stronger training stimulus on the lower body than on the upper body, the underlying physiology and biochemistry on anaerobic metabolism might be expected to be more significantly different between male and female adolescents for lower body anaerobic power performance.

The results of this study shows insignificant correlation between anaerobic power performance components and pre-test and post-test lactate

dehydrogenase activity for both upper and lower limbs of all the subjects of this study. This findings may be explained on the basis that increased blood lactate levels do not necessarily indicate anaerobic capacity Green et al., 1983; Washington, 1989). This explanation is justified by the fact that blood lactate concentration is the net result of muscle lactate production countered by lactate clearance and therefore may not indicate the onset of blood lactate (OBLA). An alternative explanation is that serum lactate concentration is inferred in this study from the estimation of serum lactate dehydrogenase. This inference may not be as accurate as the direct assay of blood lactate, moreover, increased anaerobic work by the muscles in exercise precedes the onset of blood lactate. Therefore significant relationship between anaerobic power and blood lactate levels may not be expected. This explanation justifies the insignificant correlations found in this study between anaerobic power performance component and pre-test and post-test lactate dehydrogenase activity of different categories of subjects in this study except for adolescents.

This study revealed significant differences between pre-test and post-test lactatedehydrogenase activity in all subjects which may be justified by the fact that the lactate dehydrogenase activity increases immediately after anaerobic exercise as a result of anaerobic glycolysis the rate of release of lactate dehydrogenase into the circulation, its distribution in the total body water and it's breakdown in different tissues. However, it should be pointed out that there has been considerable controversy regarding factors responsible for increased lactate production during exercise. For example Katz and Sahlin (1990) support the views that lactate production during exercise is due to

mitochondrial hypoxia. According to them, part of the controversy regarding lactate production during exercise is due to alternative definitions of cellular hypoxia. Cellular respiration and metabolism are affected by the partial pressure of oxygen (Po_2), they suggests that many investigators state that if cellular respiration is not impaired, cellular metabolism, including the formation of lactate, is not dependent on oxygen, to support which they produced evidence to show that impaired cellular metabolism is affected by oxygen availability before respiration is compromised.

Katz and Sahlin (1990) proposed that mitochondrial respiration is stimulated by the increase in Adenosine diphosphate (ADP), inorganic phosphate (P1) and NADH under conditions of restricted oxygen availability which favour the stimulation of glycolysis. This in turn increases cytosolic NADH formation. This increase combined with the increased mitochondrial NADH causes an increase in cytosolic NADH, which then shifts LDH equilibrium toward increased lactate production. They do acknowledge the fact that availability of oxygen is only one of the many determinants of lactate during exercise, relative kinetics of glycolysis, LDH, and mitochondrial respiration. However, they suggests that availability of oxygen has its major importance in the regulation of lactate production during exercise.

Contrary to this view, Stainsby and Brooks (1990) suggests that even though restricted oxygen availability to metabolism increases muscle lactate production, hypoxia is only one cause of increased lactate production, which is very unusual. They therefore suggest that a major effector of blood lactate is the ß-adrenagic receptor system. They produced evidence to support the view

that oxygen lack in the mitochondria does not occur and is not related to lactic acid net output during exercise, in free flow normoxic conditions They very strongly believed that the ß adrenagic stimulation muscles accelerates the rate of glycogenolysis and that lactic acid production is determined by contraction pattern, duration of contraction, substrate availability, hypoxia and ß adrenagic stimulation.

In light of these views and on the basis of the findings of this study, the researcher feels that lactic acid addition to the blood during anaerobic exercise rises in direct proportion to the number of muscle fibers recruited and the intensity of activation. The blood lactate concentration will thus increase curvilinearly as exercise and oxygen consumption increase. At the same time, lactic acid removal from the blood should rise. As a result of this simultaneous increase in the rise and removal of blood lactic acid and the rise of exercise level, the rise in blood lactate will be slow during the early stages of exercise. As blood epinephrine level rises with the increase in intensity of exercise, glycolysis is stimulated, resulting in an increase in the muscle lactate production with the decrease removal of lactate from other tissues, thus causing a net increase in blood lactate. Moreover, during the early stages of exercise, it is slow twitch muscle fibers that are primarily recruited with little epinephrine released into the blood and little effect on circulating levels of serum lactate. As the intensity of exercise increases, there is an increase in the recruitment of fast twitch muscle fibers, glycolysis and plasma epinephrine and thus increased muscle lactate production, decreased blood lactate clearance and increased blood lactate accumulation.

When the blood LDH concentrations were treated according to different categories of subjects differences between pre-test and post-test serum LDH concentration were found to be insignificant, this finding that is inconsistent with the above finding may be attributed to the fact that when the subjects were categorised into different categories, the sizes of the samples became too small to show very delicate differences between pre and post exercise serum LDH concentrations. Alternately, this finding may be attributed to the fact that lactate concentration was only inferred from lactatedehydrogenase activity and not directly determined, which is the limitation of the study. However, the trend of the results of this study indicates increased levels of lactatedehydrogenase immediately after anaerobic exercise in all categories of subjects however insignificant it is. This trend also suggests sex difference in post exercise serum lactate- dehydrogenase activity, which may be attributed to sex differences in metabolic factors, like enzyme actions, muscle mass and lactic acid kinetics. For example, significant relationships have been reported between lactic acid production and testosterone levels (Falgairette et al., 1989; Fellmann et al., 1988; Mero, 1988; Bass et al., 1971; Dux et al., 1982). In return, the rate of lactate production depends on the circulating testosterone, which is higher in male adolescents.

The above explanations justify age and sex related differences in post anaerobic exercise serum lactatedehydrogenase activity. However, they do not explain the exact mechanisms responsible for such differences. Studies at cellular level are needed to find whether there are any age-related differences

in the muscle fiber types that are recruited during supramaximal exercise. However, as this approach requires invasive techniques which are not ethically justified in many countries, the progress of our understanding of the low anaerobic ability of children and female adolescents may be limited till feasible, appropriate, valid and reliable technologies are developed in this area.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

In recent years, several cross-sectional and longitudinal studies have been reported on maximal aerobic power. But in contrast, only very few studies have been reported on capacity to generate and sustain high intensity, mostly superamaximal power output, particularly among paediatric population, despite the recognition accorded to youth sports in Nigeria. Recently, with the development of a variety of cycle ergometer tests, such as Wingate Anaerobic power test (WAnT) and Arm cranking Test, several studies have been reported on the anaerobic power output of different groups of subjects. Unfortunately, there remains a paucity of data worldwide regarding sex differences in children and adolescents, particularly with respect to upper body anaerobic power of both male and female children since most research studies on anaerobic power are on adults. To date, this investigator has not come across any study in Nigeria on sex comparison of the upper and lower body anaerobic capabilities of children and adolescents. This investigation was therefore conducted to determine the differences if any between Nigerian children and adolescents aged 10-16 years in the anaerobic power output of their upper and lower limbs, and also to find out if differences in anaerobic power performance change as a

function of sex and age. In addition, changes in LDH due to sex and age in pre and post exercise conditions were investigated.

To achieve this purpose, 420 Nigerian children and adolescents aged 10-16 years were randomly selected from primary and secondary schools in Zaria to serve as subjects in this study. Out of these were 180 adolescents and 237 children. They were tested in their anaerobic power, anaerobic capacity and fatigue index constituting anaerobic power performance using Wingate anaerobic Test and Arm Cranking Test. Initially, the subject's height and weight, body-mass index and limbs measurements were taken. Subsequently, the work load in the Wingate anaerobic Test and Arm Cranking Test were calibrated relative to individual's body weight from which anaerobic power performance was determined. Similarly, 21 subjects were randomly selected from the total sample of male and female adolescents and children to determine pre and post exercise serum lactate dehydrogenase activity levels. LDH activity levels were determined to find out their relationships with anaerobic power performance components, and differences between children and adolescents, and between male and females. The data thus collected were statistically analysed to test the hypotheses of the study.

5.2 CONCLUSIONS

From the findings of this study, and in view of its limitations, the following conclusions are drawn:

5.2.1 Males had significantly greater anaerobic power, and anaerobic capacity and lower fatigue index than females.

5.2.2 Adolescent males and females had higher anaerobic power performance capacity and significantly lower fatigue index than male and female children.

5.2.3 Male children did not significantly differ from their female counterparts in anaerobic power performance.

5.2.4 Children had distinctly lower anaerobic power performance of upper and lower limbs than their adolescent counterparts.

5.2.5 Male adolescents had significantly higher anaerobic power performance than their female counterparts.

5.2.6 Significant sex differences were found in anaerobic power performance of the lower than the upper extremities.

5.2.7 Sex and age significantly affected the differences in anaerobic power and anaerobic capacity and not in fatigue Index.

5.2.8 Significant positive relationships were found between the three components of anaerobic power performance and body height and weight.

5.2.9 Serum lactate dehydrogenase was insignificantly related to the different components of anaerobic power performance. However, a significant negative relationship was found between anaerobic power of upper limbs of children after exercise, lower limbs of all male subjects, anaerobic capacity, fatigue index of lower limbs of adolescents before exercise and serum lactate-dehydrogenase.

5.2.10 Neither age nor sex had any significant influence on LDH activity before or after exercise.

5.2.11 Insignificant differences were found between male and female subjects, children and adolescents, and male and female adolescents in both pre and post-test LDH activity.

5.2.12 A significant increase in LDH activity was found after exercise in all categories of subjects.

5.3. RECOMMENDATIONS

SUGGESTIONS FOR PHYSICAL EDUCATION AND SPORTS TRAINING PROGRAMMES

On the basis of the findings of the study, the following recommendations are made:

5.3.1 As most of the research on children shows that they have relatively limited anaerobic capacity, it is recommended that their ideal activities should be predominantly anaerobic.

5.3.2 As energy for anaerobic activities are provided mostly by anaerobic energy pathways, training programme for the improvement of their anaerobic capacity should be designed in both primary and secondary schools to increase their enzymatic hormonal levels required for anaerobic metabolism.

5.3.3 Physical Education Programme for children should include exercises involving faster and shorter bursts of activities with longer intervals of rests to improve their anaerobic capacity.

5.3.4 Since successful performance in sports such as sprints running and swimming, short put and discus depends on high level of anaerobic power, Wingate anaerobic power test is recommended for use by physical educators

and exercise scientists, particularly those whose sports require supramaximal, explosive effort.

RECOMMENDATIONS FOR FUTURE RESEARCH

In the course of this research, the investigator, experienced inadequacy in understanding the relations between different factors affecting anaerobic performance, from these experiences, he identified a few problems for future research, which are given below.

5.3.5 As there is inconclusive evidence about the relationships between body fat %, lean muscle mass, oestrogen and testosterone levels and anaerobic power performance, studies are needed to findout:

a) Relationship between fat content and sex hormones

b) Relationship between lean muscle mass and sex hormones

c) Relationship between lean muscle mass and anaerobic power performance.

5.3.6 Available evidence suggests that the number and type of motor units recruited during exercise influence muscle and blood lactate concentrations. If this is so, there should be decreased lactate concentrations in the upper limbs because of the lower lean muscle mass compared to lower limbs. Studies are therefore needed to find out differences between upper and lower limbs of different body types of different age groups of males and females in blood lactate concentration before, during and after exercise.

5.3.7. Although, anaerobic power performance has been found to be very closely related to sprint performance, is not clear whether it contributes to other

related components of fitness like sprint endurance and spring endurance. Studies are therefore needed to findout the relation of anaerobic power performance to different components of endurance and strength, like explosive strength, dynamic strength, sprint endurance and spring endurance.

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APPENDIX I

Department of Physical & Health Education,
Faculty of Education,
Ahmadu Bello University,
Zaria.

16th May, 1998.

The Zonal Education Officer,
Zonal Education Office
Zaria.

Dear Sir,

RE: MR. F.R. HARUNA

The above named staff is a Ph.D. candidate who is undertaking a research project in the area of Exercise and Sport Sciences.

He has chosen some Primary and Secondary schools in your zone as his area where to select his population for the study.

I shall be very grateful if he could be allowed to use those schools selected for his study.

Thanks for your co-operation.

Yours faithfully
(Sgd.)

Dr. B.A. Ladani
for PG Co-ordinator

APPENDIX II

Department of Physical & Health Education,
Faculty of Education,
Ahmadu Bello University,
Zaria.

Dear Parent/Guardian,

PERMISSION FOR YOUR CHILD/WARD TO PARTICIPATE IN RESEARCH WORK AS SUBJECT.

I write to request you to permit your child/ward to participate in a doctoral research work, titled "Anaerobic power of upper and lower limbs of Nigerian children and adolescents".

Your child will be required to ride a stationary cycle ergometer using legs for a period of 30 seconds following which his/her blood sample will be taken for lactic acid assessment. The blood sample will be collected in our laboratory by qualified medical personnel.

All information obtained will be treated strictly confidential and will be used for educational purpose only.

Thank you for your anticipated Co-operation.

Yours Sincerely,

F.R. Haruna.

APPENDIX III

Department of Physical & Health Education,
Faculty of Education,
Ahmadu Bello University,
Zaria.

Dear Parent/Guardian,

PERMISSION FOR YOUR CHILD/WARD TO PARTICIPATE IN RESEARCH WORK AS SUBJECT.

I write to request you to permit your child/ward to participate in a doctoral research work, titled "Anaerobic power of upper and lower limbs of Nigerian children and adolescents".

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All information obtained will be treated strictly confidential and will be used for educational purpose only.

Thank you for your anticipated Co-operation.

Yours Sincerely,

F.R. Haruna.

APPENDIX IV

DEPARTMENT OF PHYSICAL AND HEALTH EDUCATION,
AHMADU BELLO UNIVERSITY,
ZARIA.

CONSENT FORM

1 ...the undersigned subject voluntarily agrees to take part in the study. As part of the said study, I understand and agree that during participation, complications may arise, if I am not tolerating work well, it usually becomes necessary that exercise can be stopped by my decision or that of the investigator or his representative. Other risk, in addition to dizziness, nausea, vomiting or even fainting may occur during participation but rare.

Student's Signature: _____

Date : _____

Witness name: _____

Signature_____

Date: _____

DETERMINATION OF LACTATEDEHYDROENASE ACTIVITY IN HUMAN SERUM

{PRIVATE}S/NO	Sample Number	Activity (U/L)	Sample Number	Activity (U/L)	Age (Yr.)