DEDICATED TO

My wife and children

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DECLARATION

This is to certify that the contents of this project are my original work. It has not previously been submitted to any institution towards a higher degree.

Dr. M.A.R. Jagot

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ABSTRACT

Due to the lack of morphological data on prepubertal Indian male soccer players in South Africa, this study was undertaken on ninety male prepubertal subjects. The subjects were divided into three groups of thirty subjects each: Experienced "E" (*those playing organized soccer for more than two years*), beginners "B" (*those playing organized soccer for less than two years*) and sedentary "S" (*those not participating in organized soccer)*. All subjects were measured according to Heath - Carter anthropometric somatotype methods. Fitness tests comprising power and strength tests (vertical jump height and standing broad jump) and muscle endurance tests (push - ups and sit - ups) were also done. The three groups were first compared to each other and then to available international data.

There were no statistical differences among the three groups for: height, weight, age, triceps, subscapular, suprailiac, calf and total skinfolds, humerus and biceps girth, ectomorphy, mesomorphy and endomorphy, suggesting a general homogenicity between groups. For fitness tests the "E" group performed significantly better than the others for standing broad jump and sit - ups ($p = 0.005$ and $p = 0.036$ respectively). For push - ups the "B" and "E" were significantly better than the "S" group, ($p = 0.013$, for "B" versus "S" group), indicating that in soccer muscle strength and explosive strength are important.

The lack of difference between the groups for anthropometric criteria in this study may be explained by the experienced players' inadequate training. Other factors may include the lack of parental involvement, inadequate knowledge on fitness aspects and poor training methods. Furthermore, the sedentary group may be participating in unorganized activities which renders them at a level similar to the experienced group.

Data on non - Indian South African junior players is required to help us understand the lack of significant Indian talent in the National team. Other factors such as diet, cultural differences, training methods, level of coaching, environmental factors and sport facilities need investigation and be addressed if we want to see an improvement in the South African Indian soccer players.

CHAPTER 1 INTRODUCTION

MacDougal JD *et al* (1991), reaffirm that the major factor determining the athlete's potential to excel in his sport is genetic endowment. This includes not only anthropometric characteristics, inherited cardiovascular traits and muscle fibre - type proportions but also the capacity to improve with training. Although the genetic component cannot be altered, the sport scientist, coach or trainer can suggest optimal training strategies, based on scientific data, which will optimize performance. The scientific data used to monitor progress include anthropometry, physiological characteristics, physical performance and sport - specific skills.

Soccer is a sport of movement and contact, where the basic aim is to gain possession of the ball, with which the principle act of the game, that of scoring a goal must be accomplished. The young soccer player must acquire several qualities to perform well. Among them being dexterity, strength, speed, mobility and skilfulness. During the game, the athlete does different technical actions such as running, jumping, gaining possession of the ball, receiving, conducting, passing and shooting the ball. These are carried out in a series of accelerations and decelerations with or without the ball. The composition of the actions is complex, both as far as the neuro - muscular content is concerned, and relative to the metabolic demands. In metabolic terms, anaerobic - aerobic energy processes are stimulated alternately. The aerobic aspect is represented mainly in the recovery stages, which are frequent and alternate with the anaerobic stages of the specific motion activity.

Children and adolescents cannot be considered as adults on a small scale. They therefore cannot automatically be taught all forms of movement practised by adults, using only the simple device of reducing the magnitude of the exercise. Norms for adults therefore cannot be used in training and competition of children and adolescents. They require a constant adjustment of sporting and locomotor activity and its motivation in response to the continuous changes in physiological, anthropometrical and psychological characteristics that occur during the course of their growth and development.

The fact that the South African national soccer team lacks adult Indian soccer players needs further investigation. It is crucial to explain if this is because of problems beginning at junior level, so that appropriate interventions can be carried out. The data will also help in assessing to what extent growth, training and other factors influence the anthropometric characteristics.

Although there are many studies completed internationally on soccer players, there are no published data for the South African adult or junior soccer players. Therefore the purpose of this study was to establish a set of norms for Indian prepubertal male soccer players in South Africa, and to establish differences between sedentary, beginners and experienced soccer players for anthropometry and fitness levels. Baseline data will be accumulated, against which future studies can be compared. The aim included comparison of the present data to available data in the literature. Coaches can use the information to assess the strengths and weaknesses of a player. Baseline data for individual program prescription is also provided. Repeated testing will provide information about the effectiveness of a training program. The information will ultimately help the coaches upgrade the level of soccer.

CHAPTER 2 REVIEW OF LITERATURE

2.1 ANTHROPOMETRY IN GENERAL AND TECHNIQUES

Anthropometry is concerned with the systematised measurement and quantification of the dimensions of the human body. The word anthropometry means the measurement of man and is of Greek origin. It is clear that anthropometry provides information about the morphology or structure of the human body. In recent years there has been an ever increasing need to establish a link between human structure and function. Kinanthropometry utilizes amongst others, anthropometric data to appraise human size, shape, proportion, composition and gross function with a view to solving problems related to growth, exercise, performance and nutrition. Anthropometric measurements must be performed in reference to a standard anatomical position, which is, standing in the erect position with the head and eyes directed forward, upper limbs hanging by the side with palms facing forward and fingers fully extended pointing downwards and feet together pointing forward. The anatomical planes that one follows, as shown in Figure 1 include the following:

Median: This is a midline plane dividing the body into right and left halves.

Sagittal: This is a plane dividing the body into unequal right and left parts and is parallel to the median plane.

Coronal and frontal planes: These divide the body into equal / unequal front and back parts. For anthropometric measurements it is important to know the principle anatomical landmarks (Figure 2). The sites, techniques and problems associated with these measurements will be discussed in Chapter 3 (section 3.3).

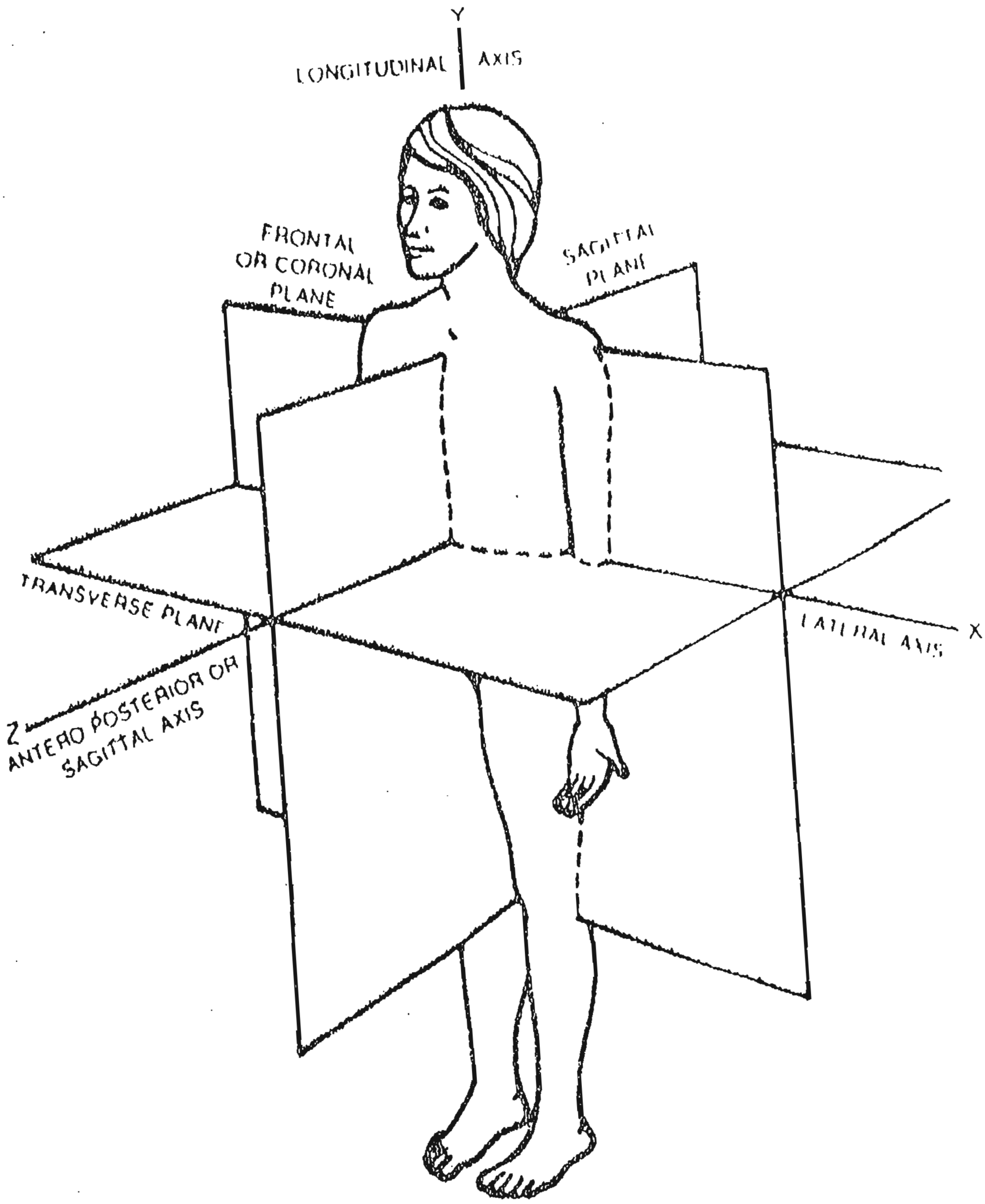

Figure 1: Anatomical planes. (MacDougal J.D. *et al, 1991)*

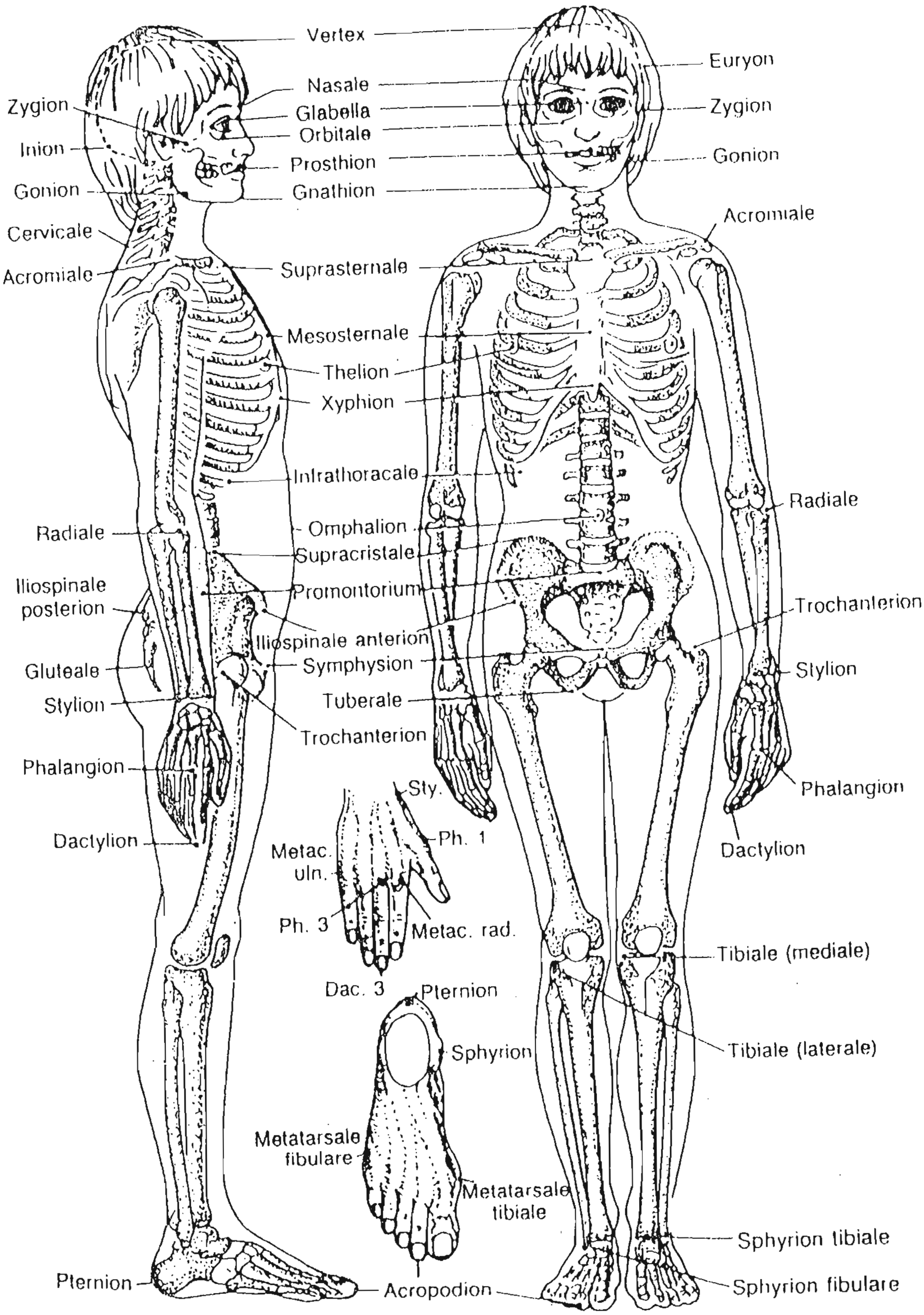

Figure 2: Principle anatomical landmarks (MacDougal J.D. *et al, 1991)*

Table 1: Heath - Carter Somatotype rating form (Carter J.E.L., 1980)

HEATH-CARTER SOMATOTYPE RATING FORM

NAME: ______________________________ AGE: ____________ SEX: M F NO: ____________

OCCUPATION: ______________________________ ETHNIC GROUP: ____________ DATE: ____________

PROJECT: ______________________________ MEASURED BY: ______________________________

Skinfolds mm

- Triceps =
- Subscapular =
- Supraliac =
- TOTAL SKINFOLDS = [ ]
- Calf =

TOTAL SKINFOLDS (mm)

Upper Limit	10.9	14.9	18.9	22.9	26.9	31.2	35.8	40.7	46.2	52.2	58.7	65.7	73.2	81.2	89.7	98.9	108.9	119.7	131.2	143.7	157.2	171.9	187.9	204.0
Mid-point	9.0	13.0	17.0	21.0	25.0	29.0	33.5	38.0	43.5	49.0	55.5	62.0	69.5	77.0	85.5	94.0	104.0	114.0	125.5	137.0	150.5	164.0	180.0	196.0
Lower Limit	7.0	11.0	15.0	19.0	23.0	27.0	31.3	35.9	40.8	46.3	52.3	58.8	65.8	73.3	81.3	89.8	99.0	109.0	119.8	131.3	143.8	157.3	172.0	188.0
FIRST COMPONENT	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12

- Height cm [ ]
- Humerus width cm [ ]
- Femur width cm [ ]
- Biceps girth [ ] – T [ ]
- Calf girth [ ] – C [ ]

Height cm	139.7	143.5	147.3	151.1	154.9	158.8	162.6	166.4	170.2	174.0	177.8	181.5	185.4	189.2	193.0	196.9	200.7	204.5	208.3	212.1	215.9	219.7	223.5	227.3
Humerus width cm	5.19	5.34	5.49	5.64	5.78	5.93	6.07	6.22	6.37	6.51	6.65	6.80	6.95	7.09	7.24	7.38	7.53	7.67	7.82	7.97	8.11	8.25	8.40	8.55
Femur width cm	7.41	7.62	7.83	8.04	8.24	8.45	8.66	8.87	9.08	9.28	9.49	9.70	9.91	10.12	10.33	10.53	10.74	10.95	11.16	11.36	11.57	11.78	11.99	12.21
Biceps girth	23.7	24.4	25.0	25.7	26.3	27.0	27.7	28.3	29.0	29.7	30.3	31.0	31.6	32.2	33.0	33.6	34.3	35.0	35.6	36.3	37.0	37.6	38.3	39.0
Calf girth	27.7	28.5	29.3	30.1	30.8	31.6	32.4	33.2	33.9	34.7	35.5	36.3	37.1	37.8	38.6	39.4	40.2	41.0	41.7	42.5	43.3	44.1	44.9	45.6

SECOND COMPONENT	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9

- Weight kg =
- Ht./∛Wt. = [ ]

Upper Limit	39.65	40.74	41.43	42.13	42.82	43.48	44.18	44.84	45.53	46.23	46.92	47.58	48.25	48.94	49.63	50.33	50.99	51.68
Mid-point	and	40.20	41.09	41.79	42.48	43.14	43.84	44.50	45.19	45.89	46.32	47.24	47.94	48.60	49.29	49.99	50.68	51.34
Lower Limit	below	39.66	40.75	41.44	42.14	42.83	43.49	44.19	44.85	45.54	46.24	46.93	47.59	48.26	48.95	49.64	50.34	51.00
THIRD COMPONENT	½	1	1½	2	2½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9

	FIRST COMPONENT	SECOND COMPONENT	THIRD COMPONENT	
Anthropometric Somatotype				BY: ______________________
Anthropometric Somatotype				RATER: ______________________

According to Jones *et al* (1994), the significance of information about the size, shape, and body composition of athletes is that it correlates with performance and may also indicate "condition" and "potential ". He further explains that anthropometric and body composition information can contribute to decisions concerning the sport or event in which an individual is most likely to succeed. It also helps in the development of appropriate training schedules and in the management and rehabilitation of those with sports injuries. Furthermore, body composition may contribute to the assessment of the state of training of an athlete and is a means to describe subtle changes in energy balance which are not readily apparent when measuring body mass alone. Anthropometry is useful in the measurement of joint angles (eg. hypermobility) and the mechanics of limb levers.

Somatotype is a classification of physique and is based on the concept of shape or the outer conformation of body composition, disregarding size. Jones *et al* (1994), further stated that the early anatomists noted four different body types: the fat abdominal type, the strong muscular type, the tall slender chested thoracic form and the rounded, larger headed cephalic type. In the 1940's Sheldon, a pioneer in this field, introduced three discrete and continuous variables, *endomorphy, mesomorphy and ectomorphy* to describe the varieties of human physique. Due to Sheldon's rigid adherence to his concept of unchanging genetically determined somatotype, this method was virtually abandoned. Heath and Carter modified it and used it as a phenotypic rating. They provided a rating that allows for changes over time, with the three components being open - ended and applying to both sexes. The components were still termed *endomorphy, mesomorphy and ectomorphy* (Table 1).

According to Jones *et al* (1994), the endomorphy is characterized by roundness of the body parts with concentration in the centre. This is a pear shaped individual with a large abdomen, round head, short neck, narrow shoulders, fatty breasts, short arms, wide hips, heavy buttocks and short, heavy legs. The mesomorph is muscular has large bones, prominent facial bones, long but muscular neck, wide sloping shoulders, muscular arms and forearms, broad chest, muscular abdomen, low waist, narrow hips, muscular buttocks and powerful legs. The ectomorph is characterized by small bones with linearity and fragility predominating. The ectomorph has a large forehead, small facial bones, long skinny neck, narrow chest, round shoulders with winged scapula, long slender arms, flat abdomen, inconspicuous buttocks and long thin legs. In determining the body build classification the individual is scaled from 1 to 7 in each component. The somatotype is thus given a three number sequence, in which the first number represents the endomorphic component, the second, mesomorphy and the third ectomorphy. An extreme endomorph is classified as 7-1-1, an extreme mesomorph is a 1-7-1, and an extreme ectomorph is 1-1-7. Most people are dominated by two components. The lesser of the two is usually employed as the adjective in describing the somatotype eg. 2-6-4 is an ectomorphic mesomorph.

Anthropometric techniques may initially appear to be very simple but mastery of accurate and reliable measurements necessitates a knowledge of the use of the instruments, rigorous methodological training, strict adherence to specified techniques and an appreciation of the possible errors and limitations of measurements.

The most widely used laboratory method for determining somatotype without the use of photography is the Heath - Carter system. It involves the measurement of height, weight, skinfolds, circumferences and diameters. The rating form (Table 1) comprises three sections, one for each somatotype component. Endomorphy is determined by skinfolds, mesomorphy by diameters and girths and ectomorphy by a height to weight ratio, the ponderal index. In the first section the sum of the triceps, subscapular and suprailiac skinfolds (in millimetres) is entered on the chart by circling the closest value. (The sites and methods of taking these skinfolds will be discussed later). The first component (endomorphy) is determined by circling the number directly under the column of the number with the total skinfold entry.

In the second section, the height, humerus and femur width is recorded in the appropriate boxes. Before recording the biceps and calf girths they must be corrected for skinfolds. Triceps skinfold is subtracted from the biceps girth and calf skinfold is subtracted from calf girth. The subjects height is entered. For each bone diameter and girth, the figure in the proper row nearest the measurement is circled, choosing the lower value if the measurement falls exactly midway. Working from the columns only, the average of the column deviations for the diameters and girths is found. The left most column containing a circled figure is considered as the zero column. The total number of columns counted to reach the other circled numbers is counted and divided by four. The figure derived is counted from the zero column and is marked with an asterisk. In the row marked second component you move from the number four, that number of columns to the right or left of the height marker depending upon the direction of the asterisk from the height marker. The second component is thus circled. The regression towards four is a conservative approach and is less likely to produce extreme results. The third component is derived by calculating height divided by the cube root of weight. The closest value is circled and the third component is located in the column below.

Proportionality is the relationship of body parts to each another or to the body. Thus, two individuals with similar somatotypes may have significantly different proportionality profiles. This aspect is not within the scope of this study.

2.2 BODY COMPOSITION

The main methods of assessing body composition include body mass index, whole body densitometry, skinfold calliper prediction of percent fat formulas, and the O - scale. The body mass index (BMI) is derived by the body mass divided by height squared. This is often used as an indicator of obesity. The assumption is that the higher the BMI the greater the level of adiposity. The inappropriateness of this assumption is obvious in a lean athlete who would be classified as obese because his BMI exceeds 27. Densitometry, an assessment of total body density, is a means of estimating fat and fat - free masses. Two methods of assessing body density include underwater weighing and volume of water displaced. By using a special formula the density is calculated and body fat predicted. Ross *et al* (1991), advised that densitometry not be used to predict percent body fat because the two - compartment model is patently untenable.

The skinfold calliper prediction of percent fat relies on 5 assumptions:
- constant compressibility of skin folds.
- skin thickness being negligible or a constant fraction of skinfold.
- fixed adipose tissue patterning.
- constant fat fractionation of adipose tissue.
- fixed proportion of internal to external fat.

These assumptions have been refuted by Martin *et al* (1986) and therefore this prediction of percent fat is unreliable.

The O - scale is a computer program for obesity scaling and not predict percent fat. It is useful in the monitoring of training and nutrition. It thus seems that no method is without fault. In the future imaging techniques such as CAT or MRI scans will help measure precisely the distribution of body fat. Other body composition techniques include bioelectrical impedance analysis, near infra - red interactance and ultrasound.

2.3 ANTHROPOMETRY IN SOCCER

Anthropometry is useful in forming part of talent selection criteria. Vecchiet *et al* (1992), in their book showed that anthropometry in soccer varied according to ethnic origin, position played on the field and level of play. Information from the Nigerian national team, the North American professional soccer league, the Danish, English and professional Italian soccer players were correlated. An oscillation of height measurements from 169cm of the Nigerians to 176cm of the North Americans and 178cm of the Italians to 180cm of the English was observed. The weight showed variation from 64.8kg (Nigerian) to 75.7kg (North Americans). But when the subjects were examined on the basis of lean mass the Nigerians and North Americans showed the lowest values whereas the Danes had the highest. Di Prampero *et al* (1970), (as reported by Vecchiet *et al*, 1992) compared the percentage body fat of soccer players with other sports and concluded that soccer players had rather high values.(Mean equals 15% body fat). Raven *et al* (1974), (as reported by Vecchiet *et al,* 1992), compared anthropometric characteristics on forwards, midfielders, defenders and goalkeepers. The results indicated that goalkeepers were the tallest and lightest, forwards had the highest lean body mass and goalkeepers had the highest sum of plicas.

Viviani *et al* (1993), compared anthropometric criteria on senior soccer players. The studies involved various countries and players playing at different levels. English players were among the tallest and heaviest but all countries showed a mesomorphic somatotype. The overall average somatotype of soccer players is that of ecto - mesomorphy with a predominance of mesomorphy. Martirosov *et al* (1987), confirmed these somatotypes when examining 254 leading young footballers of the world at the 1982 international tournament in Moscow and Tashkent. On determining main total body dimension, fat mass, and somatotype according to Heath - Carter, it was concluded that the soccer players are of more than middle height and tall, the body mass is proportional to length and fat mass values are not great. The specific somatotype was well balanced mesomorphic and ecto - mesomorphic types. The average somatotype can be presented as 1.7-5.6-2.6.

2.4 ANTHROPOMETRY IN PREPUBERTAL SOCCER

No data is currently available on anthropometry of prepubertal soccer players in South Africa. Of significance to this study is one done by Viviani *et al* (1993) of fifty soccer players aged 12-13 years. The criteria used for their choice of subjects was not mentioned. The group was subdivided into "real beginners" (B, n=26) and those with some "experience" (E, n=24). The subjects were systematically training 6.3 hours weekly (min. = 5 hours, max. = 7 hours) for an average 5.2 years (min.= 2 years, max.= 8 years). The subjects were participating in two additional hours of physical education at school. The subjects were measured according to Heath - Carter anthropometric criteria. No mention is made of the method of data collection, numbers of field observers, equipment used or the time of day the tests were done. The data were statistically analysed and the groups were compared, first with each other and then with data on sedentary boys of the same ages. Between the B and E groups, significant differences were found for weight, abdominal skinfold, calf circumference, body density ($0.05<p<0.01$), height, triceps skinfold, humerus epicondylar width, ponderal index, lean body weight and endo and ectomorphic components, ($p<0.01$). The B somatotype was 1.6-4.3-3.5 and that for E was 2.2-4.5-2.9. The distribution of somatotype according to component dominance was similar. The soccer players were compared with the sedentary group for height, weight and arm circumference only. The soccer players were taller, heavier and had a larger arm circumference than the sedentary group. When the soccer group was compared to older adolescent and adult soccer players, significant differences were found only in the latter group (for ectomorph component , $p<0.01$) indicating that the study group was already well fitted for soccer.

Table 2 from Viviani *et al*, (1993), is a summary of data in the literature, showing the anthropometric characteristics of peripubertal and adolescent soccer players. Statistical analysis was not possible for the parameters except, height and weight, due to the failure of the authors to report standard deviations. It seems that soccer players are generally tall, heavy and mesomorphic. Accurate comparisons are not possible as the meaning of experienced and sedentary players varied between studies.

Table 2 Comparison of various groups of peripubertal and adolescent Soccer players (Table from Viviani *et al*, 1993)

Source	C	L	N	Age	Height	Weight	Endo	Meso	Ecto
Viviani (1993)	It	B	26	13.5	164.1(8.6)	52.1(9.1)	1.6	4.3	3.5
		E	24	12.6	155.0(5.8)	47.0(8.0)	2.2	4.5	2.9
		S	40	16.6	175.5(5.8)	65.5(5.8)	2.0	4.0	3.3
Boennec(1980)	Fr	N	8	17.5	173.9(5.7)	67.0(3.8)	2.3	4.8	2.8
Sobral (1984)	Po	B/E	29	14/17	-	-	2.6	4.6	2.4
Matsudo***	Br	B	30	13	155.1(9)	44.2(7.6)	2.4	4.3	3.6

* C=country, L=level, N=number, Endo=Endomorph, Meso=Mesomorph, Ecto=Ectomorph, It=Italy, Fr=France, Po=Portugal, Br=Brazil.

** B=beginners, E=experienced, S=semi professionals, N=nationals

*** As reported by Viviani *et al*, 1993.

The somatotypes of sedentary boys varied considerably between countries (Table 3). The Indonesians and Hungarians were more mesomorphic whereas the Italians and Czechoslovakians showed no predominance for somatotype. The ages however were similar, but it is not known whether these are mean ages. Thus, the sedentary boys from the various countries were either muscular or well balanced for somatotype.

Table 3 Comparisons of somatotypes in sedentary boys from various countries (Table from Viviani *et al*, 1993)

Source	Country	N	Age	Endo	Meso	Ecto
Viviani *et al* (1993)	Italy	20	12	2.9	3.1	3.2
Stepnicka (1977)	Czechezlovak	96	12	3.2	3.6	3.6
Holopainen *et al* (1994)	Finland	43	12	3.7	3.2	3.5
Viviani *et al* (1991)	Indonesia	15	13	2.0	4.4	4.1
Farmosi (1985)	Hungary	31	13	3.0	4.4	3.6
Rangan*	India	60	13	3.4	2.6	4.9

* As reported by Viviani *et al*, 1993.

Soccer players seem to acquire certain qualities because of sport participation. Sturbois *et al* (1992), studied 427 French - speaking Belgian soccer players aged 11-20 years. It was concluded that the build (size and weight) of soccer players is superior to the reference population and that the improvement of "metabolic possibilities" (VO_2max.) begins before puberty and does not end even at age twenty. This improvement, which lasts longer than the anthropometric growth must probably be placed in relation to the extent and the volition of the players' training. Regarding muscular development and anthropometry, Leatt *et al* (1987), compared the Under 18 and Under 16 Canadian National Soccer team with a sample of Canadians. The results indicated that the soccer groups were taller and leaner than the sample of Canadians according to the Canadian fitness survey (1983).

Cacciari *et al* (1990), looked at the effects of sport (soccer) on growth, anthropometry and hormonal aspects. Soccer players numbering 174 participated in the study and were divided into prepubertal (10-12 years) and pubertal (12-14 years and 14-16 years) players. The control group comprised of 224 boys who had never performed sporting activities. The results showed *no significant differences* in growth indices between prepubertal players and the control. The players however had elevated levels of dehydroepiandrosterone sulphate (Dhea - s), testosterone, growth hormone and cortisol. The pubertal group were taller than their controls and were advanced in all biological indices of maturity ie: pubic hair, testicular volume and bone age. The conclusion reached was that the raised Dhea - s was already higher in the prepubertal soccer players and thus precedes all other indices of growth and maturation associated with puberty. It was further hypothesised that adrenaline hyperactivity was mainly responsible for the early onset of pubertal growth and maturity in exercising males.

Banos *et al* (1990), concluded that when selecting soccer players during adolescence, it is necessary to take into account their pubescent maturity, as it is a more reliable indicator of physical capacity than their chronological age. Chronological age is however, widely used to define divisions in soccer and players are selected into divisions accordingly. Boys have their peak stature growth at about 14 years ($\pm$2 years). In males the growth spurt is more intense, with the growth of testis, pubic hair and penis related to the maturation process. Peak strength in males, occurs a year or so later than peak height. Maturation indexing has been recommended to profile athletes so that they may compete with others of similar maturity. The belief is, that this will reduce the potential for injury in those with a low maturity level who are inappropriately matched with more mature individuals. There are however no data to support this. Maturity may be assessed by tridimensional computer graphics in growth - curve analysis, skeletal age (by x - ray), onset of menarche (but this occurs late in the maturation of girls) and secondary sexual characteristics according to the Tanner system. Tanner devised a system for both males and females based on the development of male genitalia, female breasts and pubic hair. The development of each variable occurs in five stages based on size, shape, appearance and relative changes therein. Tanner stage 1 represents pre - adolescence, stage 2 through to 4, various levels within adolescence and stage 5, adulthood.

Rangan's study,(as reported by Viviani *et al,* 1993) on sedentary Indian boys aged 13 years indicate an ectomorphic predominance in somatotype. Ming - Kai Chin *et al* (1992), had similar findings in studies conducted on Hong Kong elite football players. The conclusion reached was that the Hong Kong soccer players were smaller and lighter than their European counterparts. It was postulated that this could be a key factor contributing to the lack of success of the Hong Kong soccer teams in international soccer competition. Singh SP *et al* (1988), in a study of young (17-25 years) sedentary Jat - Sikh men of India also concluded that the Indian sample was smaller and lighter compared to the European and American populations.

2.5 EXERCISE PHYSIOLOGY IN CHILDREN

According to Kulling (1994), studies on children's fitness seem to indicate that the young people of today are not as fit as they once were or should be. There are various reasons for this, amongst them being sedentary prone leisure pursuits, eg. computer games. The interpretation of physiological characteristics is heavily age - and sex - dependant, therefore using chronological age to identify developmental benchmarks is inadequate. The Tanner classification system (discussed under anthropometry) is more acceptable.

The physiological variable associated with the cardio - respiratory capacity is the maximum oxygen uptake (VO_2max). VO_2max requires the integrated functioning of the heart (providing adequate cardiac output), alveolar tissue (adequately perfused with air and capillary blood), circulatory system (to deliver blood and remove metabolic by - products) and active tissue that must be capable of oxidizing food substitutes to produce energy.

Studies further investigating VO_2max in children, found that values for boys were higher than girls and this may be due to differences in body composition. Since activity requires the movement of body and body segments through space, VO_2max values are often examined relative to body size (ml/kg/min) for comparative purposes. Kulling *et al* (1994), reported that childrens' VO_2max values were historically consistent for two decades and the values in boys remained stable for ages 6 to 16 and then declined each year thereafter. Boys' values encompassed a 45 to 57 ml/kg/min range throughout childhood and adolescence.

The anabolic threshold (AT) is often mentioned as a measure of activity potential because it represents the upper limit of activity intensity that can be maintained without subsequent accumulation of endurance - limiting lactate. Cooper *et al* (1988), (as reported by Vecchiet *et al*, 1992) tested 109 boys and girls aged 6 -17 years, and found the mean AT to be 58% of VO_2 max. In adult males the AT ranges from 49 - 63 % of VO_2max, whereas in adult females it is 50 - 60 % of VO_2max. Anaerobically children are inferior to adults, but progression to adult values is continuous with growth and maturation. The anaerobic inefficiency is due mainly to the limited activity of phosphofructokinase (PFK), a key enzyme in anaerobic glycolysis (Kulling *et al,* 1994).

Childrens' muscle is similar to adults' with respect to number, type and distribution ratio of muscle fibres but children are at an increased risk of musculoskeletal injury especially at the epiphysis. Due to their large surface area, decreased sweat production and less subcutaneous fat, children do not adapt to heat or cold as well as adults. Children also do not perceive the intensity of exercise as adults do, they are thus more likely to forego warmup and cooling down, thus increasing the risk of musculoskeletal injury.

2.6 PHYSIOLOGICAL CHARACTERISTICS FOR SOCCER PERFORMANCE

Physiological testing can indicate the athlete's strengths and weaknesses in relation to his or her sport and provides baseline data for individual training program prescription. By comparing the athlete's results with his previous test results, the athlete gains important feedback and can alter his training accordingly. The tests also provide information on the health status of the athlete, may reveal abnormalities and are an educational process by which the athletes learn to better understand their body and the demands of the sport.

There are limitation in identifying potential talent as one cannot determine the "genetic - limits" and therefore cannot predict the degree to which an athlete has the potential to improve. Limitations also exist in the ability to simulate in the laboratory the physiological demands of the sport, these test results are therefore of little practical value. Using a battery of physiological tests to predict performance is less appropriate in sports where technical, tactical and psychological components may play a more important role. Also, information gained from field tests are not as reliable as those gained from laboratory tests, but often more valid because of their greater specificity. The main problem with field tests is that the variables cannot be controlled eg. wind velocity, temperature, track conditions and athlete performance variations. Field tests are however very useful where sports cannot effectively be simulated in a laboratory setting. Furthermore a larger more representative sample can be tested at one time which may be beneficial for the creation of norms.

The tests of energy potential are designed to measure the maximal capabilities of the different reactions and pathways that supply ATP.

In the alactic anaerobic system, ATP and creatine phosphate are used as energy sources. It is not oxygen - dependant and no lactic acid is formed. According to Vecchiet *et al* (1992), this is the metabolic area most heavily involved by the soccer player in the practice of the sport. The mean duration of high intensity activity in soccer is 4.4 seconds but Withers *et al* (1982), (as reported by Vecchiet *et al*, 1992) calculated a mean time of maximal involvement to approximate or equal 3 seconds per action.

Both figures fall within the times estimated for alactic anaerobic metabolic activity. The assessment of alactic anaerobic power involves various tests eg. maximum speed to climb 10-12 stairs, the maximum pedal pushes in 10 s, maximum jump on a potentiometric platform and 10m or 40m sprint with change in direction to simulate conditions on the field.

In the absence of oxygen, carbohydrate (mainly muscle glycogen) is broken down to form ATP in the lactacid anaerobic energy pathway. The tests for this energy pathway are more complex and maybe carried out both in the laboratory and on the pitch. Laboratory tests include exercising on a cycle ergometer or treadmill to exhaustion. Remember that these tests may not be specific to the sport. The parameters assessed include oxygen consumption (VO_2) carbon dioxide production, heart rate and lactate production.

Aerobic metabolism utilises fuels from within (free fatty acids and glycogen) and outside the muscle (FFA of adipose tissue and glucose of liver origin) to produce energy in the presence of oxygen. The view that energy requirements from aerobic metabolism in soccer players is high is not confirmed by analysis of the match as reported in Vecchiet *et al* (1992). Soccer is a sport of intermittent exercise, where the mean level of intensity of exercise is about 80% of VO_2 max (as reported by Vecchiet *et al*, 1992). Vecchiet *et al* (1992), reported that the average distance covered during the course of a match was 10 500m. The type of work fulfilled in this distance is sprint, speed, fast or normal walk. According to Withers *et al* (1982), (as reported by Vecchiet *et al,* 1992), of the 11 195m covered during a match, 26.3% was walked, 44.6% slow run, 18.9% fast run and sprint and 1.1% as time in possession of the ball. Also approximately 5% of sprints reach a distance of 60m, most being less than 20m long. Thus, the alactic - lactacid anaerobic pathways are important in soccer and if this system is underdeveloped, fatigue sets in and limits performance. Most time (44.6%) is spent on a slow run that uses the aerobic system more than other systems. A good aerobic capacity helps a player to rapidly recover between energy bursts and impose less of a burden on other energy systems. A 1 to 3km run (aerobic power), 40m sprint (power), shuttle run for 30 seconds (endurance and agility) should all form part of a soccer training program.

Montanari *et al* (1990), in his chapter on physiological aspects of soccer, states that type IIa and b muscle fibres occupy 65% of the total muscle. Montanari *et al* (1990), studied 9 semi - professional soccer players and found them to have 34.5% type I fibres, 39.5% type IIa, 21.4% type IIb and 4-6% type IIc fibres. When comparing these results to those of young track and field athletes, the soccer player can be compared to a 200-400m specialist with regard to the percentage of type IIb fibres, to a middle distance runner with regard to type IIa fibres and type I fibres differed from any track specialists examined. The high percentage of type II fibres in soccer players shows their adaptation to utilize anaerobic pathways for energy, depending on the position played.

Flexibility refers to the range of motion at a single or series of joints and reflects the ability of the muscle - tendon unit to stretch within the constraints of the joint. Flexibility can be static or dynamic, and it is the static flexibility that decreases with age. This and agility are important for sport performance, injury prevention, rehabilitation and to perform the required skills. Flexibility, tested with the sit - and - reach method provides us with information such as whether:

- the soccer player can perform skills with minimal stress on the muscle tendon tissue
- training improves flexibility
- there are problem areas with regard to execution of a skill.

In soccer, movement patterns involve multiple joints and good flexibility levels are required. This aspect was not tested.

Soccer is a sport that requires strength and power to execute skills. Many skill patterns involved in soccer are 'open' (ie. Influenced by the opponent's actions and tactics etc.) and this complicates the measurement of strength and power. The process is simplified by correlating tests of strength and power with a single measurable skill (eg. explosive jump) rather than overall performance (MacDougal JD *et al,* 1991). The "vertical jump height" and "standing broad jump" are two tests conducted in this study to test explosive strength and leg power. These tests are specific to the large muscle groups of the lower limbs and are relevant to soccer. Speed and power in these muscles assist the player in rapidly reacting to situations such as dribbling, tackling, jumping up for headers and intercepting the ball in mid - air, sprint, kick and ball control. These tests assist in creating a norm against which a player's profile can be compared, to determine his strengths and weaknesses and also evaluate the training programme followed. Leatt *et al* (1987), in his comparison of the Under - 18 and Under - 16 Canadian national soccer team with the sample of Canadians (Canadian fitness survey, 1983), found the Under - 18's showed greater isokinetic leg extension force and explosive strength relative to the younger players. It is explained that part of this gain may be due to local training of the hip and leg muscles and part as a result of a more general muscular development.

Montanari *et al* (1989), (as reported by Vecchiet *et al,* 1992), performed jump test on nationals, defenders, midfielders and forward players from the Italian National team and recorded jump heights of 40, 41, 39 and 36 cm. respectively, indicating that the nationals and defenders had greater sprint and acceleration power than the forwards.

Withers *et al* (1982), (as reported in Vecchiet *et al,* 1992), examined the individual's actions in relation to position played and made the following conclusions. The central defender tackled, headed and achieved total control with the ball more often than the other positions of play. The forwards jumped more but the full back performed more turns and foot - ball control.

Push - ups and sit - ups were simple specific tests chosen to test muscular endurance of the upper body and abdominals respectively. Upper body endurance although not as important as lower body endurance in soccer, is relevant for goalkeepers, who utilise their upper body to defend goals and to execute overhead and underarm hand - passes to the players. Bodily controls stem from the abdomen, as it affects sprinting, running, marking, agility and other skills. Kulling *et al* (1994), reported baseline data for sit - ups in 1 minute for males aged 12, 13 and 14 years as 19, 25 and 27 respectively.

Soccer is thus a sport of speed, rapidity, agility, muscle power, complex and varied technical actions, which utilises alatic and lactacid anaerobic capacities widely and aerobic capacity to a lesser extent. The average soccer player is a well balanced mesomorph or an ecto - mesomorph. Depending on the position of play, the height, weight and skinfold thicknesses varied, but generally the soccer players are tall, body mass proportional to length and with fat mass values that are not great. Other important factors in soccer include ball control, strength, agility, hand - eye coordination, dribbling skills etc, but these are not part of this study.

CHAPTER 3 METHODS

3.1 SUBJECTS

Ninety adolescent junior high school boys were randomly selected from the suburb of Phoenix and the Towns of Verulam and Tongaat. Consent from parents, subjects, The Education Department, principals and coaches were sought prior to testing. Based on data from previous studies, the sample size to show significance was projected to be 20-25 subjects per group. Their ages ranged from 12 years and 2 months to 14 years and 8 months. The sample was divided into 3 groups comprising 30 subjects each. The experienced (E) group consisted of players participating in organised soccer for more than 2 years. The beginners (B), were defined as those subjects who played organised soccer for less than 2 years. The sedentary (S) group comprised of school pupils who did not participate in any organised sport. Organised sport referred to sport at a club level.

All groups participated in school physical education (PE), which occurred twice a week and lasted 35 minutes per session. Besides athletics the pupils also played volleyball, cricket, rugby, soccer, table tennis and basketball during PE. The B and E groups, in addition, attended soccer training twice weekly with each session lasting 1 to 1.5 hours. The E group played soccer for an average participation time of 2 years and 6 months.

3.2 TESTING PROCEDURES

The children were tested at their schools between 8.00am and 11.00am. They were dressed in shorts and T - shirts or shirts. They were barefeet. The tests were performed in the following order: weight, height, skinfold, bone width and girth measurements, vertical jump height, broad jump, sit - ups and finally push - ups. All subjects were shown the tests before attempting them. Nursing assistants from a private practice were educated about the tests and were responsible for recording height and weight. Their services were also utilized for the fitness tests and accumulation of personal data of the subjects. Skinfold, girth and width measurements were conducted by the researcher.

No questionaire was filled, but the following information was acquired: name, age, school address and standard, home telephone number, name of soccer club, duration of participation in club soccer, frequency and duration of soccer training, PE training at school and frequency and duration of the PE lessons and participation in other sports.

3.3 ANTHROPOMETRIC MEASUREMENTS

The measurements were administered according to the Heath - Carter rating form (Carter JEL, 1980), (Table 1), and include height, weight, skinfold thicknesses of triceps, subscapular, suprailiac, and the calf. Humerus and femur width and biceps and calf girths were also measured.

3.3.1 The instruments for anthropometric measurements

1. For the measurement of body weight a beam balance scale is the best, but a bathroom scale was used.
2. Height was measured using a measuring tape applied to the wall.
3 Girths were measured by using a tape which was 8mm thick (for better flexibility), not stretchable, calibrated in centimeters with millimeter graduations, 1.5-2.0 m long and enclosed in a case with an automatic retraction mechanism.
4. Bone callipers were used to measure humerus and femur widths.
5. Skinfolds were measured with skinfold callipers. This instrument has a constant jaw pressure of 10 grams per square millimeter. It accomodates a thickness of 50mm and has a dial indicator that permits 2 and 1 half revolutions. The dial is calibrated in 0.2mm intervals and readings may be interpolated to the nearest 0.1mm. The instrument was calibrated regularly.

3.3.2 Techniques

3.3.2.1 Body mass or weight

The weight was recorded to the nearest 0.1kg and measurements are best recorded in the nude, but this was not practical. The subjects were weighed barefoot and in shorts. The most stable values for weight are obtained in the morning, 12hours after ingesting food and after voiding (Jones PRM *et al*, 1994). This was not practical in the present study.

3.3.2.2 Height

There are four general techniques to measure stature or height, free - standing stature, stature against a wall, recumbent stature and stretch stature (Jones PRM *et al,* 1994). The stature against the wall technique was used. A measuring tape was applied against the wall and a right - angled headpiece was lowered onto the subjects head and the appropriate level was read off the tape. The subject stood erect, feet together, against the wall and looking forward. The head was in the Frankfort position where the line joining the inferior portion on the margin of the eye socket and the tragion (the notch superior to the flap of the ear at the superior aspect of the zygomatic bone) was horizontal. The heels, buttocks, upper part of the back and head were in contact with the wall.

3.3.2.3 Skinfold measurements

Using the left thumb and left index finger, a skinfold was raised and included a double layer of skin and the underlying adipose tissue but not the muscle. A skinfold calliper was applied to obtain the skinfold thickness. The fold was grasped firmly and held throughout the measurement. The calliper was applied at right angles to the skinfold about 1cm below the thumb and index finger. The calliper trigger was released completely and the measurement was read two seconds later to allow full pressure of the calliper jaws to be applied. Waiting longer results in water being compressed out of the skinfold giving an incorrect reading (Jone PRM *et al*, 1994).

The sites for skinfold measurements are shown in Figure 3. The subject stood erect, facing forward, hands by the side with palms facing forward and fingers pointing downwards, and feet together with toes pointing forward. The measurements were taken on the right side of the body. The measurements should preferably be taken at the same time of day, as tissue water varies throughout the day (Jones PRM *et al*, 1994). In this study exact timing was not practical, but most tests were conducted between 8.00am and 11.00am.

Triceps, subscapular, suprailiac and medial calf skinfolds were tested as per Heath - Carter somatotype form (Carter JEL, 1980), (Table 1). The exact sites are as below.

Triceps: The site chosen was the point of greatest muscle girth when the elbow was flexed. The calliper was applied 1cm distal to the left thumb and index finger on the right side. The fold was taken parallel to the long axis of the arm.

Subscapular: The calliper was applied 1cm distal to the left thumb and index finger, raising a fold that is oblique to the inferior angle of the scapular in a direction running obliquely downward and laterally at an angle of 45 degrees from the horizontal ie. it is parallel to the axillary border of the scapular.

Suprailiac/supraspinale: This site was 5cm superior to the anterior superior iliac spine, in the mid - axillary line, running medially downwards at about 45 degrees from the horizontal. The skinfold was picked up vertically approximately 1cm above this landmark.

Medial calf: With the subject seated, knees bent to 90 degrees and the calf muscle relaxed, a vertical fold was raised at the point of greatest circumference. The calliper was applied here.

The biceps and calf girths were measured at right angles to the long axis of the body segment. The technique required practice to achieve economy and precision of movement. The tape was passed around the part to be measured and placed so that the scale calibrations were in juxtaposition. The tape must neither depress the flesh contour nor be too loose.

Biceps girth: With the elbow flexed to 90 degrees and the forearm fully supinated, the point of maximum circumference was the site of measurement.

Calf girth: With the subject seated and relaxed, the maximum horizontal circumference was measured using the belly of the gastrocnemius as a guide.

Bone callipers, used to measure widths were held by the thumb and index finger, while the middle finger was used to locate the landmark. In this study humerus and femur widths were measured only.

Humerus width: This is the distance between the medial and lateral epicondyles of the humerus when the arm is raised foward to the horizontal and the forearm flexed to a right angle at the elbow. Once the epicondyles are located, the pressure plates of the calliper were firmly applied upon them, thus compressing skin and soft tissue against the epicondyle resulting in a more accurate reading. The distance between the epicondyles is somewhat oblique because the medial epicondyle is lower than the lateral.

Femur width: This is the distance between the medial and lateral epicondyles of the femur when the subject was seated and the knee flexed to 90 degrees. Once again the epicondyles were located, pressure plates applied firmly and a reading obtained.

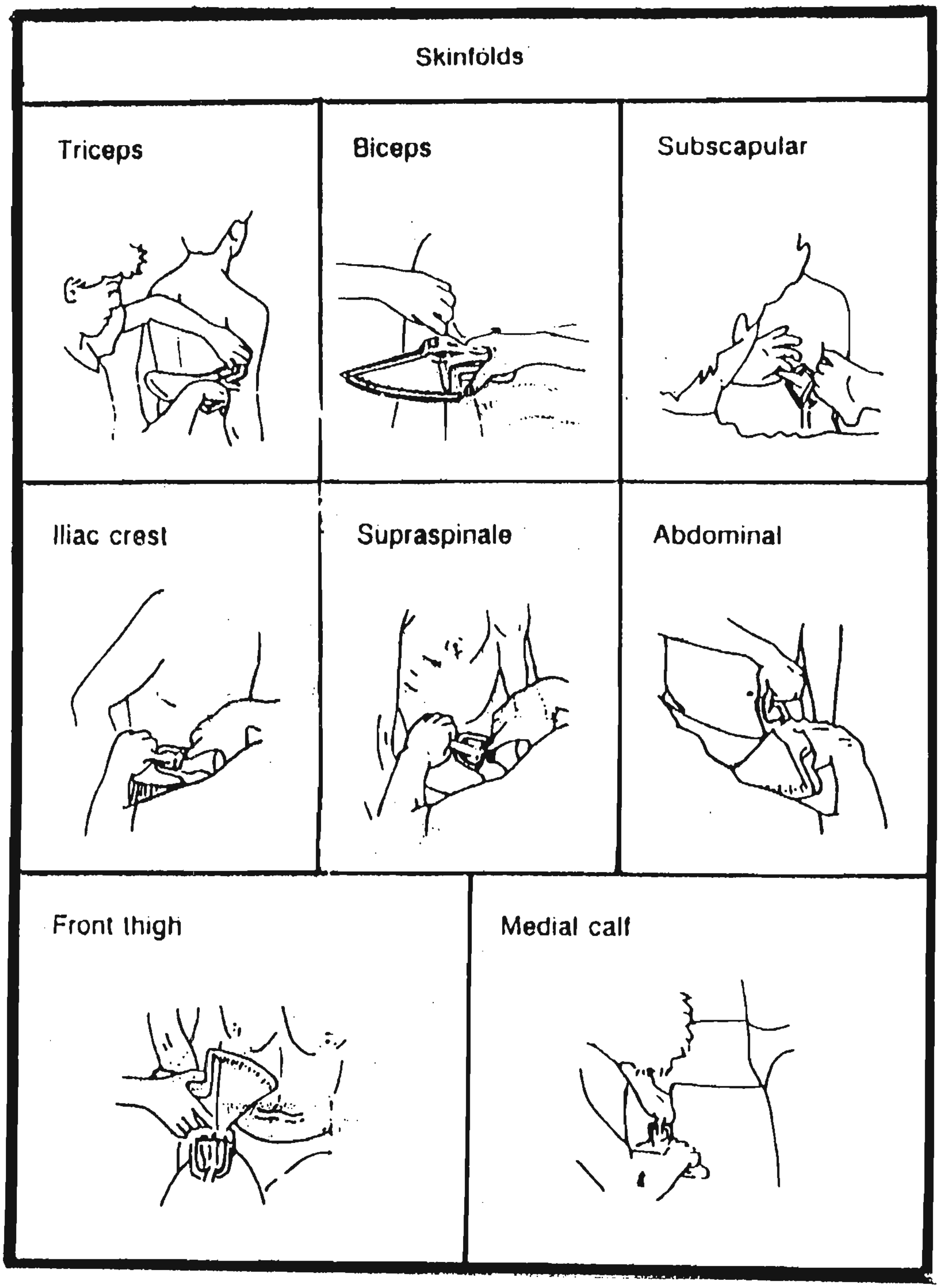

Figure 3: Skinfold sites (MacDougal J.D. *et al*, 1991)

3.4 PHYSIOLOGICAL MEASUREMENTS

3.4.1 MUSCULAR ENDURANCE TESTS

3.4.1.1 PUSH - UPS

This is a test for muscular strength and endurance of the upper body (MacDougal JD *et al*, 1991). The hands were placed flat on the ground in line with the shoulders and backs kept straight throughout the test. The subject lowered his body until the chest touched the clenched fist of the assistant, which was held in line with the sternum. The elbow was then immediately straightened. If the subject stopped at any time during the test, his knees were not to touch the floor, if they did the test was complete. The number of correct push - ups done in one minute was recorded. If the subject could not continue for the full minute, the number of correctly completed push - ups was recorded.

3.4.1.2 SIT - UPS

This tests muscular strength and endurance of the abdominal musculature (MacDougal JD *et al*, 1991). The subjects lay on their backs with the knees bent to 90 degrees. The hands were rested on the thighs. On starting, the subject pulled up to a 30 degree crunch position and then returned to the lying position, where his shoulder blades had to make contact with the floor. The number of sit - ups completed correctly in one minute was recorded.

3.4.2 POWER AND STRENGTH TESTS

3.4.2.1 VERTICAL JUMP HEIGHT

The subjects were barefeet, with the right or left shoulder facing the wall. The middle finger was chalked. The subjects marked the highest point reached on the wall without elevating the heels. They were instructed to bend the knees to any angle, jump up and mark the wall with the chalked finger. After a practice jump only one attempt was allowed. The distance measured between the two chalk marks was recorded in centimeters as the vertical jump height.

3.4.2.2 STANDING BROAD JUMP

The subjects were asked to place both feet with toes on the start line. With knees bent they jumped forward with both legs and on landing, were not to move until a mark was placed at the heel closest to the start line. The distance was measured in centimeters. After a practice jump, the subjects were allowed only one jump for recording purposes.

3.5 STATISTICAL METHODS

Descriptive statistics consisted of the calculation of means and standard deviations for each of the parameters within each of the 3 groups. The 3 groups were statistically compared using analysis of variance. Where a significant F - statistic was found, Duncans Multiple range test was used as a post hoc test for pair wise comparisons (Armitage P, 1983).

The weights and heights for the various groups of the present study were compared to that of Viviani *et al* (1993), using students unpaired t - test (Armitage P, 1983). Standard deviations were not reported by Viviani *et al* (1993), for the other parameters, hence statistical comparisons were not possible.

CHAPTER 4 RESULTS

Measures for anthropometric and physiological characteristics were analysed for differences between the sedentary(S), beginner(B) and experienced(E) groups. Tables 4 and 5 and Figures 4,5 and 6 show the main anthropometric characteristics for the various groups. For mean skinfold thicknesses no statistical difference was demonstrated between groups by analysis of variance (Armitage P, 1983). The S group recorded the maximum in the range for triceps (26mm), subscapular (21mm) and suprailiac (30mm) skinfolds. For calf skinfold the maximum was recorded in the E group (31mm). The highest and lowest values for total skinfolds were recorded in the S group.

Table 4 Comparisons of anthropometric characteristics in the sedentary, beginner and experienced groups

		Sedentary (n=30)	**Beginners (n=30)**	**Experienced (n=30)**
Triceps sf.	mean & std range	10.3 (4.8) 5.2 - 26.0	10.3 (4.1) 4.8 - 20.2	10.0 (2.9) 5.6 - 6.0
Subscapular sf.	mean & std range	7.0 (3.7) 1.9 - 21.0	7.1 (3.1) 4.0 - 18.4	6.5 (1.7) 4.2 - 11.0
Suprailiac sf.	mean & std range	8.9 (7.5) 3.0 - 30.0	7.4 (4.0) 2.8 - 18.0	6.6 (2.3) 3.0 - 10.8
Calf sf.	mean & std range	9.4 (4.9) 4.2 - 26.0	9.3 (3.9) 4.2 - 20.0	8.5 (4.7) 5.0 - 31.0
Total sf.	mean & std range	26.8 (15.7) 12.4 - 75.0	24.7 (10.4) 14.2 - 55.4	23.2 (5.9) 13.8 - 34.4
Humerus width	mean & std range	6.0 (0.6) 5.0 - 7.5	6.1 (0.6) 5.0 - 7.0	5.8 (0.6) 4.5 - 7.0
Femur width	mean & std range	8.5 (0.5) 7.2 - 10.0	8.4 (0.5) 7.5 - 9.5	8.3 (0.9) 6.0 - 10.0
Biceps girth	mean & std range	21.5 (3.0) 16.9 - 28.2	21.3 (2.3) 16.2 - 25.6	21.9 (2.6) 17.7 - 27.0
Calf girth	mean & std range	29.0 (3.4) 23.2 - 39.2	29.2 (3.0) 23.1 - 34.5	28.7 (2.4) 24.3 - 33.3

* sf = skinfolds

** std = standard deviation (indicated in brackets)

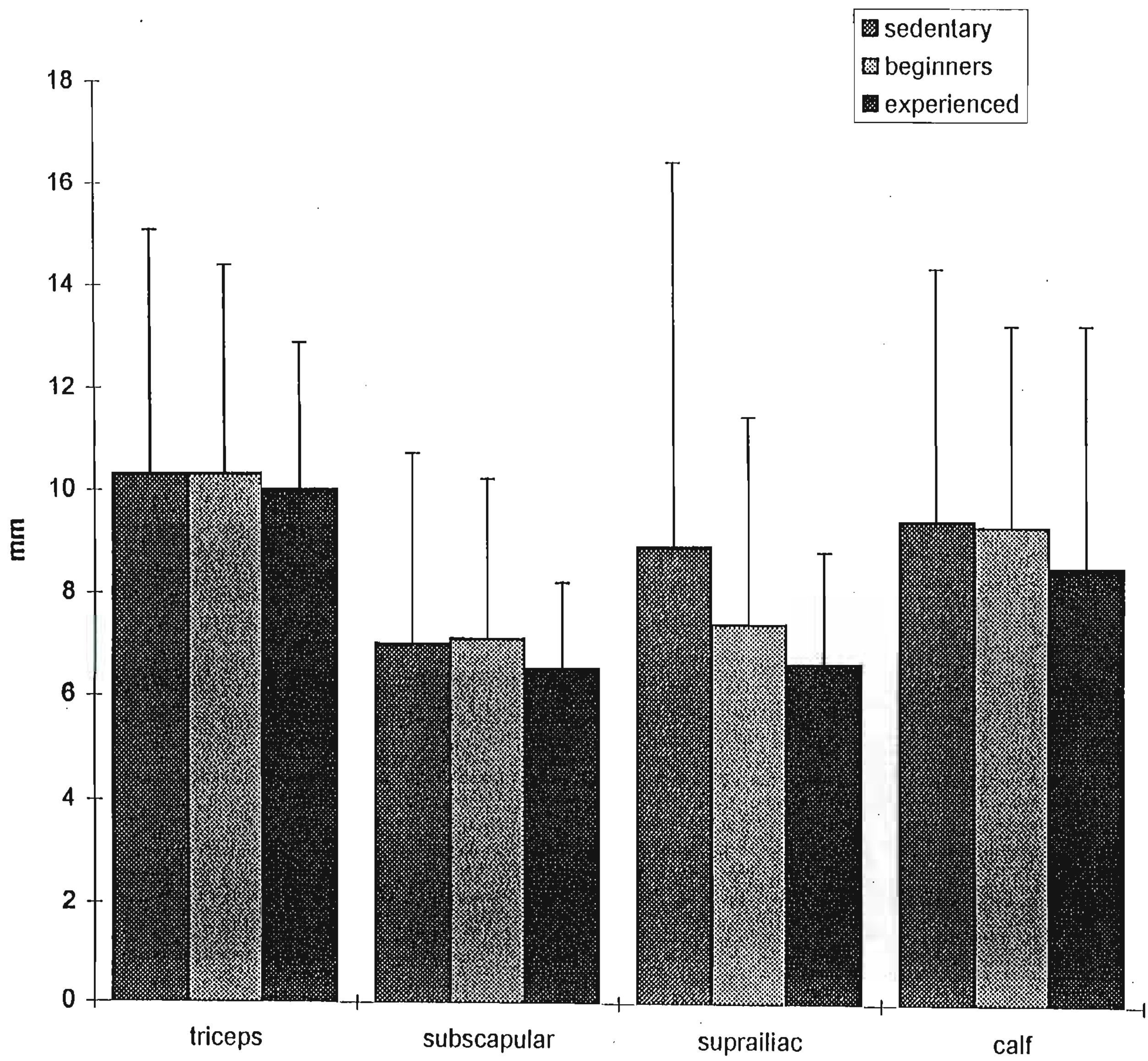

Figure 4: Anthropometric results (skinfolds)
Bars indicate standard deviation

No statistical difference was demonstrated between the 3 groups for humerus and femur widths. The lowest readings for humerus and femur widths were recorded in the E group (4.5cm and 6.0cm respectively). The highest for humerus width and calf girth occurred in the S group (7.5cm and 39.2cm respectively). Biceps girth for the 3 groups showed no difference.

The results for mean age, height and weight between the S, B and E groups revealed no statistical differences. The ages were similar, with the youngest subject in E group (12.2 years). The mean age for all groups was the same (13.3 years). The mean height for E group (156.7 cm) was marginally lower than the S and B groups (158.1 cm respectively), with the shortest persons recorded in the S and E groups (both were 134cm), while the tallest was represented in the B group (177cm). The minimum and maximum weights were recorded in the the S group (26.0 kg and 71.0 kg respectively) (Table 5 and Figure 5).

Somatotypically no difference was recorded between the 3 groups. The mean endomorphy for the S, B and E groups was 2.6, 2.4 and 2.3; mesomorphy 3.2, 3.3 and 3.2 and ectomorphy 5.1,5.4 and 5.0 respectively. The maximum endomorphy was recorded in the S group (2.6), whereas those for mesomorphy and ectomorphy were recorded in the B and E groups respectively (3.3 and 8.0 respectively), (Table 5 and Figure 6). In Table 5 there were 30 subjects per group.

Table 5 Comparison of anthropometric characteristics with mean and standard deviations and range for sedentary, beginner and experienced groups

Parameters		Sedentary	Beginners	Experienced
Age (yrs)	mean & std range	13.3 (0.4) 12.5 - 14.4	13.3 (0.6) 12.4 - 14.7	13.3 (0.7) 12.2 - 14.7
Height (cm)	mean & std range	158.1 (10.1) 134.0 - 174.0	158.1 (10.0) 140.0 - 177.0	156.7 (9.6) 134.0 - 173.0
Weight (kg)	mean & std range	39.7 (12.9) 26.0 - 71.0	40.3 (8.3) 27.0 - 61.0	40.2 (7.9) 30.0 - 59.0
Endomorphy	mean & std range	2.6 (1.6) 1.0 - 7.0	2.4 (1.2) 1.0 - 5.5	2.3 (0.8) 1.0 - 3.5
Mesomorphy	mean &std range	3.2 (0.9) 1.5 - 5.0	3.3 (1.0) 1.5 - 7.0	3.2 (1.1) 1.0 - 5.5
Ectomorphy	mean & std range	5.1 (1.8) 1.5 - 7.5	5.4 (1.3) 2.0 - 7.5	5.0 (1.8) 0.5 - 8.0

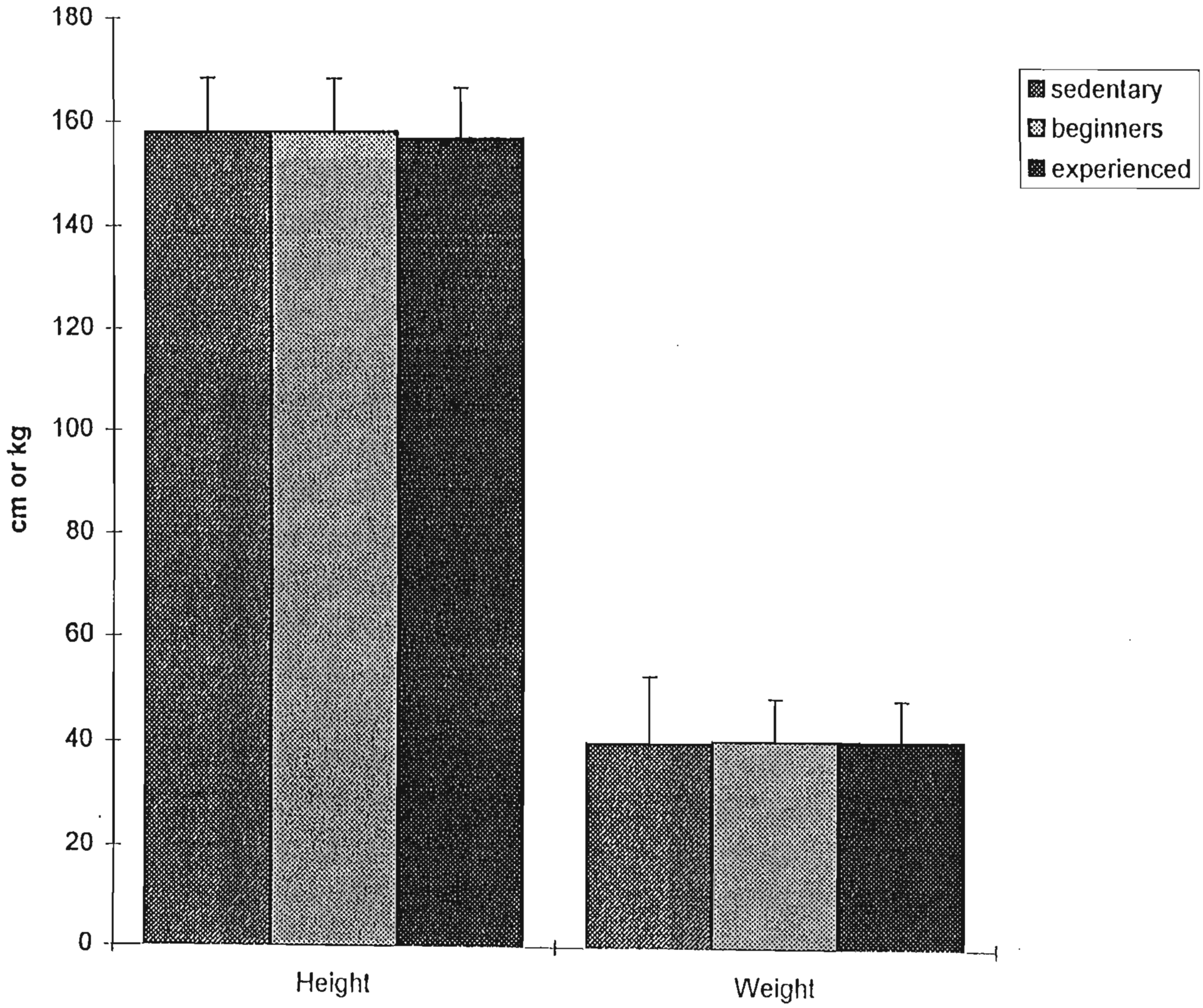

Figure 5: Anthropometric results (height and weight)
Bars indicate standard deviation

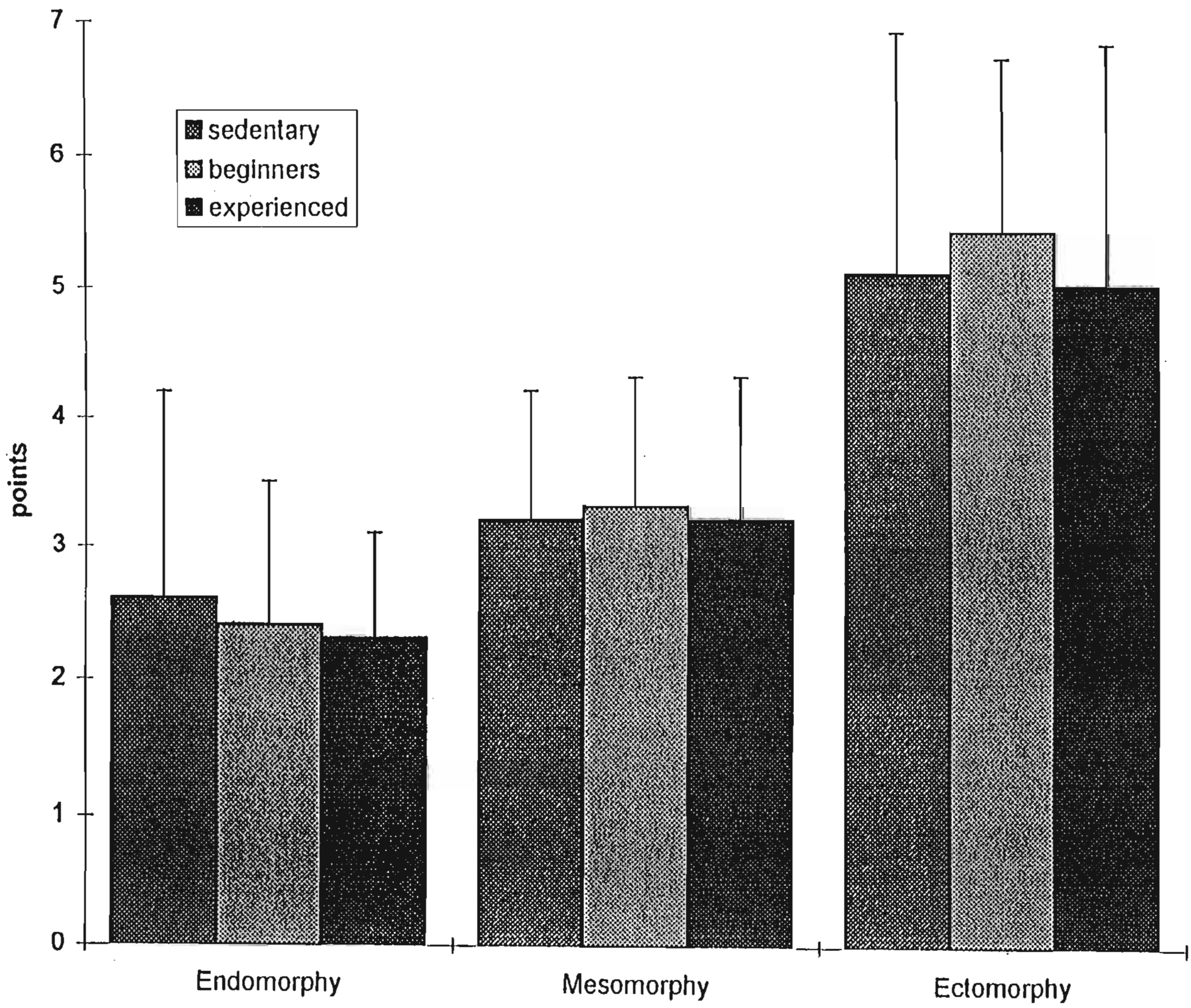

Figure 6: Anthropometric results (somatotyping)
Bars indicate standard deviation

The fitness tests were compared for the 3 groups by analysis of variance (Armitage P, 1983). Significant differences were found for the standing broad jump, where the mean value for E (184.4 cm) was significantly higher than the S (163.9 cm) and B (169.4 cm) groups, (p = 0.005). For push - ups, the S group (17.4) recorded significantly lower readings than the B (24.5) and E (29.0) groups, (p= 0.013) and for sit - ups, the mean value for the E (31.6) group was significantly higher than groups S (24.6) and B (29.2), (p = 0.036), (Table 6 and Figures 7 and 8).

Table 6 Comparison of fitness variables in the sedentary, beginner and experienced groups

Variables		**Sedentary**	**Beginners**	**Experienced**	**p-value**
Vertical jump	mean	31.5	31.8	34.9	ns.
	std	8.3	8.6	6.9	
Stand. Broad	mean	163.9	169.4	184.4	p=0.005
jump.	std	31.0	22.3	19.4	
Sit - ups	mean	24.6	29.2	31.6	p=0.036
	std	9.4	10.9	11.0	
Push - ups	mean	17.4	24.5	29.0	p=0.013
	std	10.2	13.1	12.5	

* std. denotes standard deviation.

** There were 30 subjects per group.

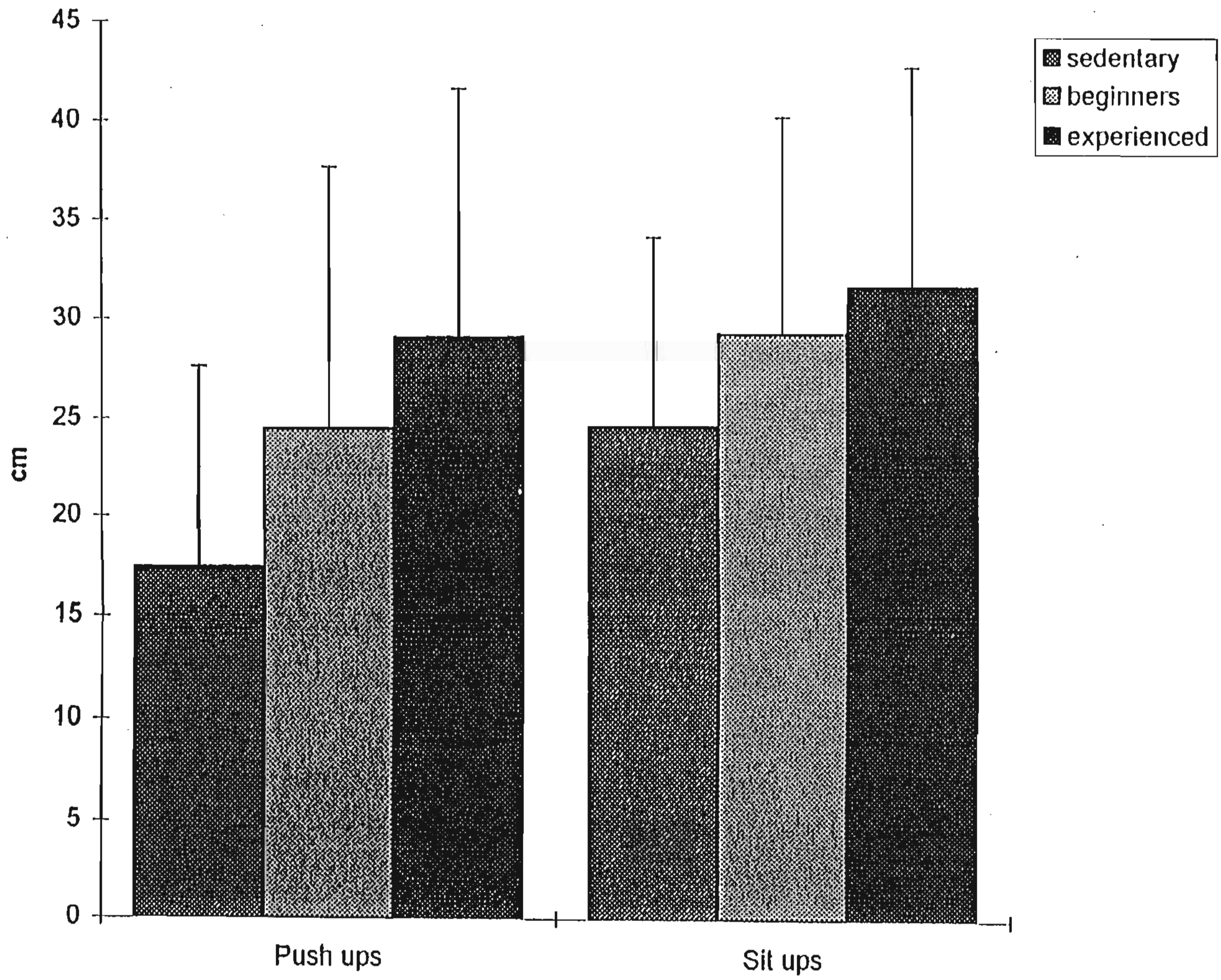

Figure 7: Physiological performance test results (muscle endurance)
Bars indicate standard deviation

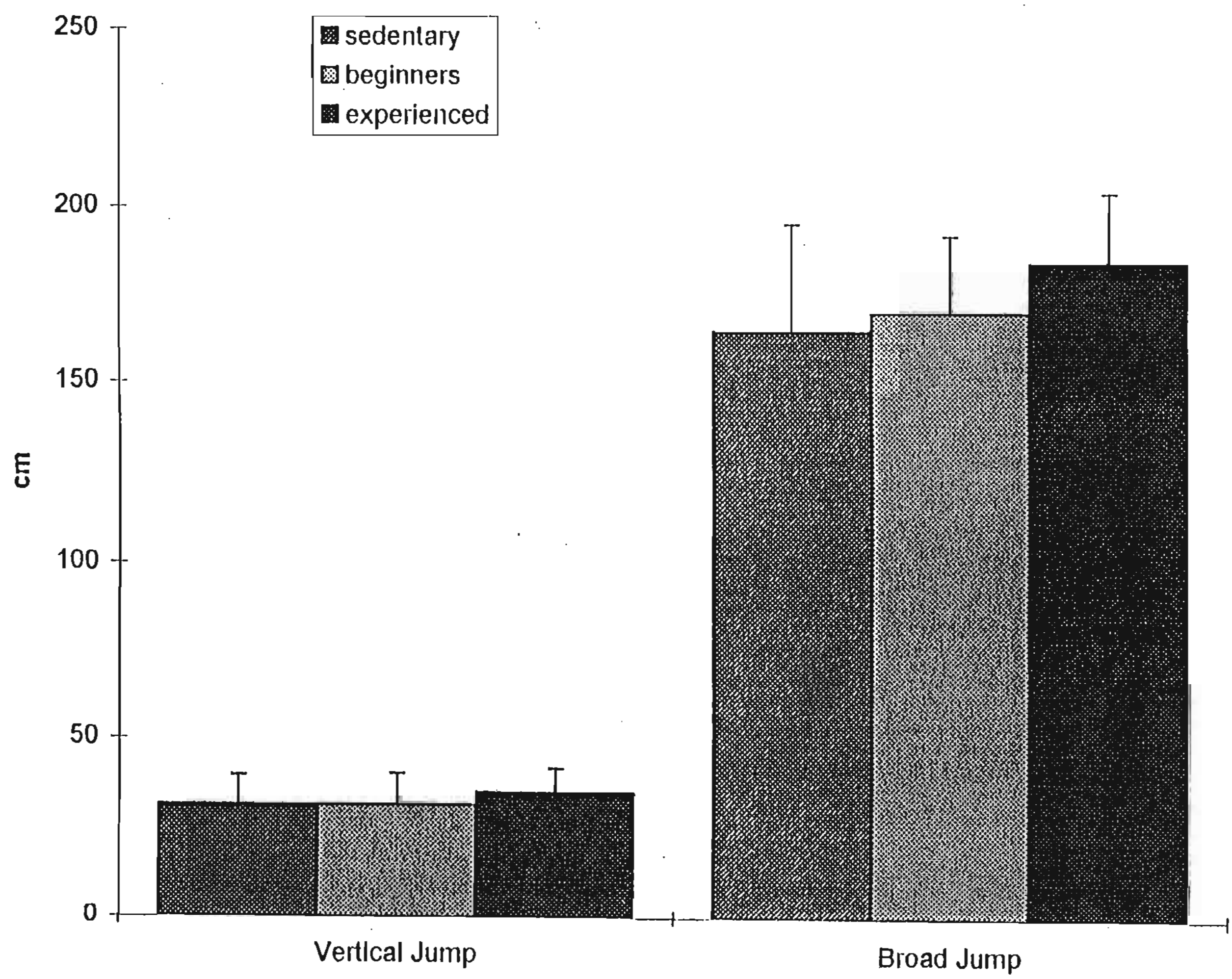

Figure 8: Physiological performance test results (standing jumps)
Bars indicate standard deviation

CHAPTER 5 DISCUSSION AND CONCLUSION

Somatotyping is one of the many factors that need to be considered as part of the soccer players profile. Other factors include physiological characteristics, psychological characteristics and skills. There is no perfect somatotype for any particular sport, though studies assist by setting norms towards which a player may strive.

Martirosov *et al* (1987), found young soccer players to be mesomorphs and ecto - mesomorphs. The present study shows Indian youth soccer players in South Africa to be predominantly ectomorphs, although no statistical difference was demonstrated with respect to somatotype between groups. This was contrary to the expectations that the E players would be more mesomorphic as they have been participating in soccer for an average of 2 years and 6 months. This lack of difference may be explained by the E players not training adequately. (According to Viviani *et al* (1993), the Italian children trained an average 6.3 hours per week, whereas the subjects in the present study trained an average 2.5 hours per week). Other contributing factors may include, the lack of parental enthusiasm, lack of knowledge on fitness aspects and training methods. Furthermore, the S group may be participating in unorganised activities which renders them at a level similar to the E group.

Comparisons between the groups for triceps, subscapular, suprailiac and calf skinfolds showed no statistical difference (Table 4). Thus the E group had similar measurements to the S group. This was somewhat surprising, as with training, players should become leaner, with a reduction in subcutaneous fat. Furthermore, because the soccer player utilizes the lower limb muscles actively, it was expect that the calf girth would be greater due to muscle hypertrophy or hyperplasia, but the greatest calf girth was recorded in the S group. Skinfold measurements are operator dependant, therefore comparisons between studies have their limitations.

Statistical differences were shown for explosive strength (standing broad jump) and muscle endurance for the upper body (push - ups) and the abdominal (sit - ups) between the three groups (Table 6). To excel at broad jump, powerful hip, thigh and calf muscles are required. The E group were significantly better than the others ($p=0.005$), yet their calf girths were not in keeping with this. This may point to other factors involved in improving performance in these tasks, such as, neuromuscular coordination, genetic endowment, muscle fibre proportion eg. higher type II fibres, training, fatigueability of the muscle, health status of the player (injury, diet and drugs), psychological preparedness, familiarity with tests and other non performance related factors such as data capture and operator - dependant factors. For sit - ups, the E and B groups performed better than the S group (p=0.036), whereas for push - ups, the E group outperformed the B and the S groups (p=0.013). These results are acceptable as the E group have been training for a longer period and therefore should show improvement for endurance, strength and power. Kulling FA, (1994) reported the lowest 5th percentile for sit - ups in 1 minute as 25 for the sedentary population aged 13-14 years. The S group of the present study performed similar at a mean of 24.6 sit - ups per minute.

With age and practice, soccer players increase in height and weight, but there occurs a decrease in skinfold thicknesses, especially in the arm, (Viviani *et al*,1993). The whole sample of the present study was compared to that of Viviani *et al* (1993). It showed the present sample to be significantly older (p=0,0342), lighter (p<0.001), more endomorphic (p= 0.002), less mesomorphic (p<0.001) and more ectomorphic (p<0.001). The mean height was not statistically different (Table 7). Boys in the present study despite being older were lighter than those in the Italian study. This may be explained by the group's linearity and lack of muscularity compared to the Italian study.

Table 7 Comparison of anthropometric characteristics between the South African and Italian whole samples (Viviani *et al*, 1993)

Variables	Italian (n=50)	S.African (n=90)	p-value
Age (years)	13.1 (0.5)	13.3 (0.58)	0.0342
Height (cm)	159.7 (8.6)	157.6 (9.8)	0.1905
Weight (kg)	49.7 (8.9)	40.1 (9.9)	< 0.001
Endomorphy	1.9 (0.7)	2.4 (1.2)	0.002
Mesomorphy	4.4 (1.0)	3.2 (1.0)	< 0.001
Ectomorphy	3.2 (0.9)	5.1 (1.7)	< 0.001

* Students unpaired t - test was used to compare the two groups.

* * Standard deviation indicated in brackets.

The S group was compared to overseas data as accumulated by Viviani *et al* (1993). Statistical comparisons were not possible due to the failure of the authors to report the standard deviation. Table 3 shows the somatotypes of sedentary boys of various countries. The present study sample size was average, with a mean age slightly above the others. The endomorphic and mesomorphic components were average but the children in this study were predominantly ectomorphic (linear). This linearity is also prevalent in the B and E groups. Comparison of the present study with the Indian study (Rangan, as reported by Viviani *et al*,1993), reflected the S group in this study to be less endomorphic (fat), more mesomorphic (muscle) and more ectomorphic (linearity) than the Indian sedentary group.

Table 2 lists results on anthropometric characteristics of peripubertal and adolescent soccer players from various countries. The B group in this study were taller than the Brazilians (158.1cm vs 155.1cm respectively) but shorter than the Italians (164.1cm), while the E group was taller than the Italians of similar age (156.7cm vs 155.0cm respectively). The endomorphic components were similar to the other studies but the children of the present study lacked muscularity (mesomorphy) and were the most linear (ectomorphic) of all the groups. Figure 9 compares the skinfold results of the present study with the Italian (Viviani *et al*, 1993) and the Louisiana group (as reported by Viviani *et al*, 1993). Statistical comparisons were not possible due to the failure of the authors to report standard deviations. Local children generally had the highest triceps skinfold, while the suprascapular, suprailiac and calf skinfolds were comparable to the Louisiana study.

Table 8 Comparisons of height and weight between the South African and the Italian samples (Viviani *et al*, 1993) in relation to the various groups

Groups / Variables		Italian Study	Present Study	T - Value	P - Value
Beginner	Height	164.1 (10.0)	158.1 (10.0)	2.36	p < 0.05
	Weight	52.1 (9.1)	40.3 (8.3)	4.96	p < 0.01
Experienced	Height	155.0 (5.8)	156.7 (9.6)	0.79	ns
	Weight	47 (8.0)	40.1 (7.9)	3.31	p< 0.01

* Standard deviations indicated in brackets.

Although Viviani *et al* (1993) failed to clearly define their beginner, experienced and sedentary groups, we nevertheless compared them to our groups. Comparison was only possible for height and weight, due to the lack of the authors reporting on standard deviations for other variables. In the beginner group the Italians were taller and heavier than the present study (p<0.05 and p<0.01 respectively). For the experienced group the subjects of the present study were lighter (p<0.01), but no significant difference was found for height. Standard deviations were not reported by Viviani *et al* (1993) for the sedentary group, therefore comparisons with the present study were not possible (Table 8).

The results of the present study being different to that of Viviani *et al* (1993), may be explained by the following: genetic factors, cultural differences, environmental factors and possibly a lack of training in our children. The Italian children trained an average 6.3 hours per week for an average 5.2 years, whereas the experienced group of the present study trained an average 2.5 hours per week for an average 2.5 years. Thus, with training and growth the somatotype of the present study can become more mesomorphic.

Although there are limitations in this study, the fact that our results showed no statistical differences for somatotyping and physiological characteristics between groups, suggests that we need to further investigate the selection criteria, training methods, coaching and level of commitment in our prepubertal Indian soccer players. On comparing with international data we are different in the sense that our group is more ectomorphic whereas the international studies show a more mesomorphic to ecto -

mesomorphic picture. Anthropometrically, although the present study is not similar to the Italian and Europeans, they are similar to international studies on Asians. Rangan's study of sedentary Indians, (as reported by Viviani *et al*, 1993) showed them to be ectomorphs, much like our sample. A study on Hong Kong elite soccer players revealed similar findings (Min - Kai Chin *et al*, 1992). The sedentary population of Jat-Sikh men in Punjab, India, are also smaller and lighter than the European and American populations (Singh SP *et al*, 1988). It is possible that Indians/Asians have a tendency towards ectomorphism world wide. According to Birrer and Levine (1987), young athletes are generally leaner, more mesomorphic and less endomorphic than non-athletes and additionally, team sport participants are slightly taller. The comparison of this study to that of the Italian indicates the present study to be generally lighter and shorter. As this was a possible reason for the poor performance of Hong Kong soccer players (Min - Kai Chin *et al,* 1992), a similar hypothesis can be used to explain the poor performance and lack of Indian soccer players in the national team.

Although one cannot base one's choice of sport on anthropometry, it seems that Indians may not have the somatotype for soccer, but data on non - Indian South African junior soccer players is required to validate this. This study exposes the fact that deficiencies exist in prepubertal Indian soccer players and these must be addressed if we want to see an improvement in the calibre of South African Indian players.

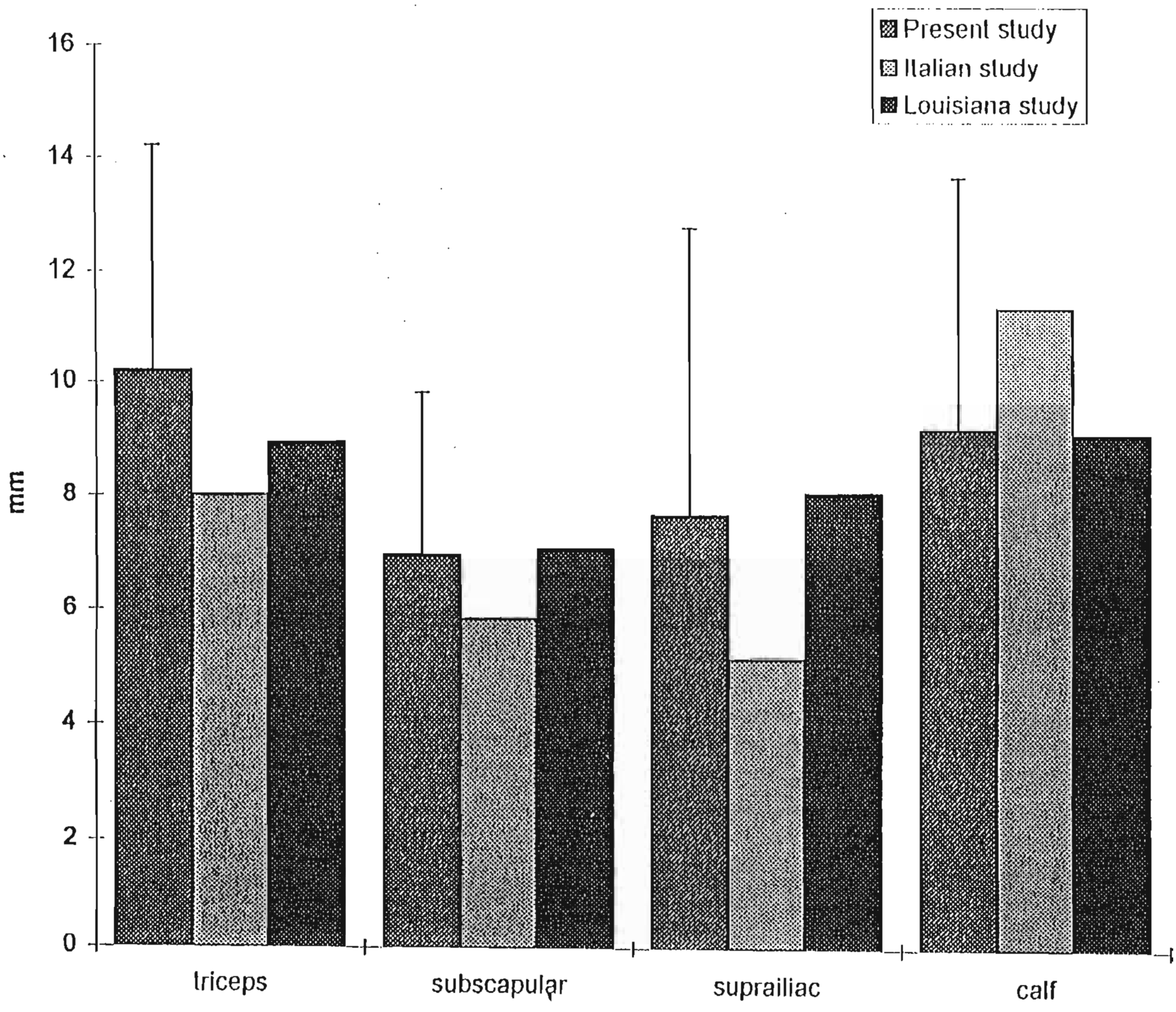

Figure 9: Comparison of skinfold results
Bars indicate standard deviation

CHAPTER 6 REFERENCES

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CHAPTER 7 APPENDIX

Table 9 Results for the sedentary (S) group

Variable	N	Mean	Std	Min	Max
Triceps Skinfolds	30	10.3	4.8	5.2	26.0
Subscapular	30	7.0	3.7	1.9	21.0
Suprailiac	30	8.9	7.5	3.0	30.0
Total Skinfolds	30	26.8	15.7	12.4	75.0
Calf skinfolds	30	9.4	4.9	4.2	26.0
Height	30	158.1	10.1	134.0	174.0
Humerus width	30	6.0	0.6	5.0	7.5
Femur width	30	8.5	0.5	7.2	10.0
Biceps girth	30	21.5	3.0	16.9	28.2
Calf girth	30	29.0	3.4	23.2	39.2
Weight	30	39.7	12.9	26.0	71.0
Age(years)	30	13.3	0.4	12.5	14.4
Endomorphy	30	2.6	1.6	1.0	7.0
Mesomorphy	30	3.2	0.9	1.5	5.0
Ectomorphy	30	5.1	1.8	1.5	7.5
Vertical jump ht	30	31.5	8.3	15.0	46.0
Standing broad jump	30	163.9	31.0	106.0	260.0
Sit - up	30	24.6	9.4	2.0	37.0
Push - ups	30	17.4	10.2	0	36.0

* Min = minimum, Max = maximum, Std = standard deviation

Table 10 Results for the beginner (B) group

Variables	N	Mean	Std	Min	Max
Triceps skinfold	30	10.3	4.1	4.8	20.2
Subscapular	30	7.1	3.1	4.0	18.4
Suprailiac	30	7.4	4.0	2.8	18.0
Total skinfold	30	24.7	10.4	14.2	55.4
Calf skinfold	30	9.3	3.9	4.2	20.0
Height (cm)	30	158.1	10.0	140.0	177.0
Humerus width	30	6.1	0.6	5.0	7.0
Femur width	30	8.4	0.5	7.5	9.5
Biceps girth	30	21.3	2.3	16.2	25.6
Calf girth	30	29.2	3.0	23.1	34.5
Weight	30	40.3	9.1	27.0	61.0
Age (years)	30	13.3	0.6	12.4	14.7
Endomorphy	30	2.4	1.2	1.0	5.5
Mesomorphy	30	3.3	1.0	1.5	7.0
Ectomorphy	30	5.4	1.3	2.0	7.5
Vertical jump ht.	30	31.8	8.6	16.0	56.0
Standing broad	30	169.4	22.3	113.0	195.0
Sit - up	30	29.2	10.9	1.0	46.0
Push - ups	30	24.5	13.1	5.0	65.0

* Min = minimum, Max = maximum, Std = standard deviation

Table 11 Results for the experienced (E) group

Variables	N	Mean	Std	Min	Max
Triceps skinfold	30	10.0	2.9	5.6	6.0
Subscapular	30	6.5	1.7	4.2	11.0
Suprailiac	30	6.6	2.3	3.0	10.8
Total skinfold	30	23.2	5.9	13.8	34.4
Calf skinfold	30	8.5	4.7	5.0	31.0
Height (cm)	30	156.7	9.6	134.0	173.0
Humerus width	30	5.8	0.6	4.5	7.0
Femur width	30	8.3	0.9	6.0	10.0
Biceps girth	30	21.9	2.6	17.7	27.0
Calf girth	30	28.7	2.4	24.3	33.3
Weight (kg)	30	40.2	7.9	30.0	59.0
age (years)	30	13.3	0.7	12.2	14.7
Endomorphy	30	2.3	0.8	1.0	3.5
Mesomorphy	30	3.2	1.1	1.0	5.5
Ectomorphy	30	5.0	1.8	0.5	8.0
Vertical jump ht.	30	34.9	6.9	21.0	49.0
Standing broad	30	184.4	19.4	144.0	220.0
Sit - up	30	31.6	11.0	7.0	63.0
Push - ups	30	29.0	12.5	10.0	70.0

* Min = minimum, Max = maximum, Std = standard deviation