

EFFECTS OF AN ENRICHED PHYSICAL ACTIVITY PROGRAMME ON
SELECTED ANTHROPOMETRIC, PHYSIOLOGICAL AND PERFORMANCE
CHARACTERISTICS OF AN UNDERPRIVILEGED ETHNIC GROUP

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ABSTRACT

Fifty pre-pubescent Xhosa-speaking children from two primary schools within the township of Rini, Grahamstown, were selected in this study to determine the effects, if any, of an enriched physical activity programme. Subjects were divided into experimental and control groups with only the experimental group physically participating in the enrichment programme. Selected anthropometric, physiological and motor performance tests were administered on both groups, before and after the programme, to monitor the effect of the enrichment programme on growth, cardiovascular efficiency and physical performance.

Somatotype ratings showed no change after the training programme. However body composition showed greater gains in fat mass in the control group and marked drops in fat mass and increases in lean body mass in the experimental group. Longer running distances, higher predicted VO_2 max mean values and improved recovery heart rate (HR) as well as larger gains in relative power, absolute power and velocity were experienced by individuals who participated in the training programme. The performance of the experimental group in the two motor performance tests out-weighed by far the performance of the control group as a result of the additional programme.

The enrichment programme not only produced a positive effect on body composition but also improved aerobic and anaerobic efficiency. Improvements in both motor performance tests favoured the experimental group.

CHAPTER 1

INTRODUCTION

South Africa is characterised by polar opposites. On the one hand the privileged minority enjoys sufficient facilities, physical programmes and sound nutritional status within a sophisticated environment. On the other, the underprivileged groups encounter poor facilities, inadequate physical programmes and in many cases, deficient nutritional status, which may have a detrimental effect on many within the new South Africa. It is therefore important that each and every individual has an equal opportunity of becoming a healthy 'fit' human being.

While it is difficult to formulate a precise definition of 'fitness' (McArdle and Katch, 1988), it is appropriate to conceptualise a state of physical well-being that incorporates a balance between optimal performance components such as adequate muscular strength and endurance, reasonable joint flexibility, an efficient cardio-vascular system with a good level of aerobic power and favourable body composition in respect of performance capacity.

School children should have the opportunity to participate in activities that will improve their physical performance. However, the academic subjects within many schools, especially within the underprivileged 'black' schools, are more emphasised and better accommodated than is physical education. Some of the reasons for the present situation can be related to the inadequacy of facilities and

equipment, poor educational standards and teachers who lack enthusiasm and ability to innovate. This can only have detrimental effects as regards the physical development of the pupils and also their attitudes towards physical activity.

It is generally recognised that after the fifth or sixth year (on average) no new basic skills appear in the child's motor repertoire (Rarick, 1973). Lamb (1985) has argued that the ages between 7-11 years are optimal for the development of personal motor skills. After 9-10 years children begin to take an interest in making their actions effective and efficient, concentrating on the development of certain skills. Motor performance and strength gradually increase, both quantitatively and qualitatively during pre-pubescent and pubescent years. Thus the quality of performance continues to improve through refinements in movement patterns.

Over two decades ago, Sloan and Hansen (1969) recognised that a full explanation of inter-racial differences in physical performance capacities had not been found. In the closing decade of the 20th Century this problem remains unanswered. The degree of habitual physical activity of different groups of children, however, may be a major factor in determining their relative physical performance capacities.

Much research has been done as regards the anthropometric, physiological and motor characteristics of different ethnic groups, not to mention 'fitness' testing

within the framework of the different 'fitness' components. It is, however, apparent that many research projects have combined 'Black' ethnic groups under a single label. This obviously is problematic because ethnic groups differ at least in their anthropometric, and hence functional characteristics. Very little is known about the physical abilities of Xhosa-speaking children in South Africa. This lack of information highlights the importance of establishing norms on specific physical performance tests, so that developmental curves can be established for this group. These general trends and performance levels can then be compared against other ethnic groups.

By exploiting a self-expressed activity, such as soccer, through a controlled programme, one can determine the effects it has on the anthropometric, physiological and performance characteristics of Black children. Recommendations can then be made, if necessary, as regards the improvement of physical performance among Black children. Consequently the interest is not only in determining what effect the physical activity will have on Black children, but also to develop suggestions for improvement by making use of one of the sports which is most commonly practised within Black society.

Statement of the Problem

There can be little doubt that physical activity enhances physical performance. Numerous research projects have substantiated the fact that it favourably contributes to the improvement of physiological and motor performance.

Macdonald (1983) indicated a significant increase in a number of components such as muscular strength and endurance, joint flexibility, cardio-vascular efficiency, aerobic and anaerobic-power and body composition after a six-week training programme.

Give a Black child, regardless of age, a round ball, irrespective of size, and one finds him, most of the time, playing the ball with his feet. Soccer has become a popular sport amongst Blacks in South Africa. It not only attracts tens of thousands of spectators but also provides a means of physical activity. Training for soccer includes methods which can contribute to the improvement of aerobic and anaerobic capacities and other physical performance characteristics.

The present problem was to determine the anthropometrical, physiological and motor performance characteristics of pre-pubescent Xhosa-speaking children and to determine the effect, if any, of an enriched soccer programme on these characteristics.

Formulation of the Hypothesis

Physical Education in many Black schools is either non-existent or poorly organised. This contributes to the fact that little is known about the performance levels of pre-pubescent Xhosa-speaking children. It is however, evident through research on different ethnic groups that when subjected to an enrichment programme, positive changes occur. It is reasonable therefore to presume that the same would

occur if Xhosa-speaking children participated in an enriched physical programme.

Research Hypotheses

1. That selected biophysical, physiological and motor performance characteristics of the experimental group will show no significant difference attributable to participation in an enrichment programme.
2. Then following the enrichment programme the biophysical, physiological and motor performance characteristics of the experimental group will show no significant difference when compared to that of a control group denied access to the programme.

Delimitations

The study was restricted to 60 Xhosa-speaking children from the Township school register of Grahamstown. Minimal equipment was used because of mass testing and to encourage fitness testing in schools through simple but accurate means. The majority of schools do not have sophisticated equipment. Biophysically only percentage fat, somatotype and growth were determined. Physiologically the resting, working and recovery HR, anaerobic and aerobic capacities were evaluated. Motor fitness testing comprised the 18-Item Motor Fitness Test as well as the CAHPER Motor Fitness Test.

Limitations

A number of factors which could not be controlled may have influenced the results. Factors such as nutritional changes and psycho-social parameters such as township conditions, personal motivation and enthusiasm could affect the results. Nutritional status could only be determined through observation because no sophisticated equipment would be used during the programme.

CHAPTER 2

REVIEW OF LITERATURE

Trainability

It is widely recognized that a vigorous programme of physical exercise will produce substantial anatomical and physiological training effects on those undergoing training.

The basic physiological responses to a single bout of exercise, or to repeated exercise stimuli, are similar in people of all ages. However, it is possible that there may be a minimal age at which an exercise programme becomes physiologically effective. In the Trois Riviers experiment, the experimental group first showed gains of aerobic power and muscle force relative to the control group at 8 years of age (Shephard et al., 1980a).

A number of researchers cited by Milna (1978) have postulated the existence of critical periods during which the growing body is most sensitive to growth stimulating effects of physical training programmes. Dick (1980) regards the primary-secondary school bridge ranging between 8-12 years as being the most important period in an individual's life. Almost all measures of physical achievement have their greatest rate of improvement during this stage with speed, agility and aerobic endurance showing the most pronounced rises. Some evidence exists that pre-pubertal as compared with post-pubertal activity may have a better carry-over to spontaneous activity in adult years and a greater influence on growth.

Brace (1930) has earlier argued that the 9-12 year age range is the period when most abilities emerge for the performance of complex skills.

Many of the tasks undertaken by pre-pubescent children are fairly gross in nature, requiring less refined movement than those skills performed in later years. It is however the period in which familiar forms of movement are vastly improved and many new forms learned and established, often without instruction.

According to Bar-Or (1987) no definite answers can be found in the literature concerning a specific developmental age at which trainability is especially low or high, although children under the age of ten are trainable. However, the question regarding their ability to improve maximal aerobic power needs to be answered. Many researchers have shown a significant improvement in running performance, but without an obvious increase in VO_2 max (Bar-Or, 1987; Yoshida and Ishiko, 1979).

Be this as it may, children are becoming increasingly involved in athletic programmes at younger ages and much still has to be done to facilitate the harmonious physiological development of the pre-pubescent child. There is substantial evidence of the favourable physiological responses to exercise when comparing young, trained athletes to non-athletic children.

Nutrition

Nutrition plays an important role in physical activity and performance. Under-nutrition as well as over-nutrition

impact negatively on physical activity, lessening performance levels. Problems such as cardio-vascular disease, diabetes and obesity associated with over-nutrition and growth retardation and specific deficiency diseases associated with under-nutrition are examples of such disorders.

The problem of malnutrition and less severe malnourishment is mostly present in under-developed countries, but also among poor socio-economic groups in developed countries. In South Africa the problem of under-nutrition is mainly represented in the underprivileged 'Black' urban and rural societies.

In Fincham (1984) Richardson compared the nutritional status of 'Black' and 'White' school children in the Transvaal and concluded that approximately 30% of rural 'Black', 15% of urban 'Black' and only 5% of urban 'White' children fell below the Harvard 3rd percentile of weight for age.

In a survey on nutritional status in the Ciskei, bordering the Eastern Cape, Du Plessis, in Fincham (1984), reported that 34% of Black rural children and 22% of Black urban children 7-8 years of age, fell below the Boston 75% standard weight for age.

According to Richardson (1980) two-thirds to three-quarters of South African black school children have not only a height but also a weight deficit for their age. However, when the children's weight was looked at in relation to their stature, the observations were not consistent with the results based on weight-for-age and height-for-age which

revealed a state of malnutrition. The weight-for-height measures indicated that only 1-6% of young school-going and 2-11% of 11-14 year olds were on or below the 80% of the Harvard Standard.

Chinn and Morris (1980) argued that group comparisons of weight are possibly meaningless unless height is taken into account. According to Richardson (1980) height-for-age give a more realistic assessment of nutritional status. It seems, however, that black pre-pubescent children suffer because of an unbalanced diet, limiting the essential nutrients that facilitate growth.

During a nutritional status survey done on a group of Xhosa-speaking children in the Ciskei, it was shown that maize provided more than 80% of the carbohydrate intake in the 7-8 year age group. Furthermore it was concluded that Xhosa women considered maize-based foods to be their children's major food preference, with 30% of the women believing that a child could remain healthy on maize alone. The dietetic estimation of energy intake within the same age groups indicated low energy intake as well as low protein intake (Fincham, 1984).

Protein energy malnutrition is found where cereals such as maize, rice and wheat are a dietary staple and where consumption of animal protein is very low. It is less well-defined forms of energy and protein deficiencies that hamper many under-privileged groups.

According to Brooke (1978) adolescents who are mainly on a diet excessively rich in carbohydrates and poor in animal protein and fat have lower indices of physical status and performance capacities than adolescents whose diets are richer in protein, fat and calcium.

In many cases the under-privileged urban and rural black groups have small body size and weight due to their nutritional status: a deficit which remains throughout life.

However, because of lifelong heavy manual work and physical activity, they develop a higher degree of physical work capacity than adult city dwellers. According to Suzuki et al. (1978) the more advantaged city dweller has a more balanced diet but is often obese from excessive caloric intake and exhibits inferior physical capacity because of limited activity.

From studies done on Tunisian boys, Parizkova and Rogozkin (1978) found there to be lower somatic development in boys from poorer families than those from healthier families. He also concluded that the boys from the poorer groups had higher functional capacities, better cardiovascular reactions during exercise, quicker post-exercise recovery, less obesity, greater relative muscle strength and better sport performance. Individuals of a poorer family are not usually faced with the temptations of over-nutrition and they are subjected to more demanding levels of habitual physical activity. Harrison et al. (1988) also found that children from different socio-economic levels differ in average body size at all ages, the upper groups always being

larger and the differences in height being about 5 cm at adolescence. The differences in weight are relatively less. A major indicator of malnutrition is growth failure. These children are underweight and undersized but have relatively normal body proportions.

Spurr et al. (1983) investigated the functional consequences of marginal malnutrition in upper and lower socio-economic urban and rural Columbian boys. The study showed a reduced body size and an impaired work capacity in the malnourished groups when compared to the well-nourished groups. Bar-Or (1983) found that a reduced body mass, specifically lean mass, results in low work performance among protein and caloric malnourished children.

Protein energy malnutrition causes the body to enter a hypo-metabolic state. The decreasing metabolic rate causes a parallel decline in cardiac output. The heart also loses mass in proportion to the erosion of lean body mass. Other causes of protein energy malnutrition are a reduced blood volume, haematocrit and serum albumin level. There is also a decreased globin synthesis and thus a decrease in red blood cell production.

Adequate nutrition and physical activity during youth, if maintained through life by means of an appropriate pattern of habitual and organised physical activity is thought to benefit the locomotor, respiratory and cardio-vascular systems as well as improve cell metabolism and organ physiology.

According to Krahenbuhl (1980), developmental growth will occur with a minimal amount of physical activity whereas vigorous activity is essential for compensatory growth. This is especially true for pre-pubescent children because of their low androgen levels. Muscle mass in these children does not increase because of insufficient circulating androgens (Birrer and Levine, 1987). Testosterone fulfills an important function in the human body. It provides the protein synthesis in skeletal muscles, increasing muscle mass and force and enhances the morphological training effects and inhibits catabolic destruction.

Physical activity influences protein synthesis and bodily function in a variety of ways. Light physical activity, according to Shephard and Sidney, has little effect on growth hormone although vigorous activity increases plasma growth hormone levels (Krahenbuhl, 1980).

Among the effects brought about by growth hormone, according to Goldberg and Goodman, are an increase in the rate of protein synthesis which could enhance muscle growth and an increase in fat metabolism which may diminish total body fat (Krahenbuhl, 1980).

Insulin promotes protein synthesis and thus muscle development. During and after exercise growth hormone is elevated which suppresses the insulin action on carbohydrate metabolism thus increasing protein synthesis and promoting compensatory growth (Krahenbuhl, 1980). According to Guyton (1976) non-physical stress contributes to the loss of muscle and the gain of fat since little energy is expended. If

however, the stress of physical activity is intermittent and kept within reasonable limits hydrocortisone, insulin and growth hormone facilitate the process of compensatory growth.

The need for Physical Activity

Shephard (1984) postulates that some authors have argued that the average school child is far below potential and that the hormone environment of adolescence is particularly fruitful for stimulation of a training response. Others have maintained that the young child naturally sustains a high level of habitual physical activity so that physical potential is realized even in the absence of structured physical education (Shephard, 1984).

Simons-Morton et al. (1987) however, make it clear that physical education itself cannot produce, among children, the amounts of fitness or physical activity necessary to provide all possible health benefits. Recent studies of supervised physical activity classes done by Goode and Watt, and school physical education classes by Thompson, Crawford, Virgin and Goode, cited by Goode et al. (1976), indicated that the amount of active movement and intensity of that movement (11 minutes of actual movement in a 50 minute physical education period with a HR well below 150 beats per minute for children 11-12 years old) is less than that considered necessary for a training effect. Thus the traditional school centred physical education programme does not per se provide sufficient stimuli to improve or maintain physical working capacity across ages (Cunningham, 1980).

Many underprivileged ethnic groups, including the Xhosa-speaking groups, have no formal physical education in the curriculum and due to limited facilities, in many case, have only one afternoon for extra-mural activities: the only time set aside for physical activity.

Sloan and Hansen (1969) investigated the physical work capacity of White, "Coloured" and Black South African children ranging from 12-18 years of age and concluded that White boys were taller and heavier than Coloured and Bantu boys and were superior at 6 of 7 fitness tests (AAHPER). Epigenetic reasons for the morphological and performance differences could include a number of factors such as malnutrition, economic status, and the lack of opportunity to participate in regular and formal physical activity. Sloan stresses that the degree of habitual physical activity of different groups of children may be a major factor in determining their relative physical fitness. Genetic differences, of course, cannot be excluded: Whites in South Africa are taller than Blacks regardless of environment.

The intensity of habitual activity is mostly higher than in supervised activities and thus plays an important role in meeting the physiological needs of the growing child. High levels of habitual activity correlate significantly with strength, aerobic power, basic skills and general co-ordination (Macek, 1988). Individual differences in these abilities are strongly related to a lack of physical activity.

It is difficult to find objective evidence concerning the physical activity patterns of children. Kemper et al. (1983) and Smith (1984) did, however, establish that habitual physical activity of teenagers declined with age. Ross, Dotson and Gilbert (1985) concluded that approximately half of American children in grades 5 through 12 do not meet the minimum weekly requirement of vigorous activity necessary for an effectively functioning cardio-respiratory system. This raises the question whether the same applies in the case of underprivileged Black South African children, many of whom must be physically very active. Typically many Black children have to walk great distances to schools or even to the nearest water taps, often carrying heavy containers that hold water. Limited sports facilities ensure that these groups have to cover great distances in order to indulge in an activity of their fancy. In many cases young individuals have to help support the family by doing manual labour. Walking great distances, playing games and fulfilling manual work is a part of their everyday life as opposed to the luxuries of automated equipment that can be afforded by the more affluent groups, making life comfortable, easy and eventually sedentary.

Cashmore (1982) argues that blacks have turned to sport as a compensation for the discrimination against them. Even here they are denied participation in various sports because of inadequate facilities and also little or no sporting equipment. This could be one of the reasons why soccer has become a favourite pastime for many blacks. All that is

needed is a ball and an open field. Arguably there should be some difference as far as physical work capacity is concerned.

The fact that South Africa is emerging from a formalised system of advantaged and disadvantaged groups stresses the necessity to determine performance levels of disadvantaged children and youth in order to appraise the level of their physical development.

Exercise Response

In adults one can assume that physical activity could result in physiological and performance changes. This is not necessarily the case in children. Motor development accompanying physical growth may have similar results to that elicited by physical training. It is therefore necessary to distinguish the effects of physical activity *per se* from changes due to the normal growth and maturation occurring within the child. This can be done by using experimental and control groups of pre-adolescent children of similar chronological and maturational ages.

As height, weight and percentage of body fat changes during childhood, the potential for physical performance also changes. Bookwalter (1952) found in the children he studied that between the ages of 9-11 a steady slow growth of about 5 cm in stature and 3 kg in mass could be expected. The greatest spurt in growth occurred between the 11-14 year age group and much of it was muscular. Smith, cited by Strauss (1984) noted that dramatic differences that occur in chronological age and adolescent growth and physical

development are most evident during the junior high school years, at ages 13-15. Differences in the rate of maturation do not suddenly arise during puberty but are present even at birth (Tanner, 1978). The rate of growth falls continuously from birth onwards and just before puberty it reaches its lowest point. In the year preceding the growth spurt, the average body grows approximately 5.0 cm. The spurt in height and other body dimensions begins on average approximately a year after the first testicular enlargement and reaches its maximum after about a further year.

The first signs of puberty in boys are the enlargement of the testes accompanied by changes in texture and colour of the skin of the scrotum. Soon after this penis growth is accompanied by the appearance of pubic hair. The acceleration of penis growth begins on average at approximately 12.8 years of age but may be as early as 10.5 years or as late as 14.5 years.

With physical performance being directly related to maturational status it is important to distinguish between early- and late-maturing individuals. Boys who are physically more mature are more likely to become successful in certain sports (Clarke and Peterson, 1961). This, however, in most cases only implies that such boys are heavier, stronger and faster than the rest. The greatest concern for such individuals is the loss of the size and strength advantage during high school years. This does not mean that they might not have unusual sports skills but rather limited opportunities to develop these skills.

Late maturation or delayed puberty is likely to affect physical performance and therefore seriously interfere with sport because of the influences maturation has on a variety of physiological characteristics. Late-maturing children may experience attenuated muscle mass, lower strength and less endurance when compared to average and early maturers. This can discourage them from participating in various physical activities which can cause them to miss the advantages of early training.

Morphological Growth

Populations differ in their average adult size, their tempo of growth, as well as their bodily shapes. The intricate interactions of genetic and environmental factors play a significant role in determining size, shape and tempo of growth. African and American Negroes are more advanced in skeletal ossification and motor skills than are Whites in the U.S.A. (Tanner, 1978). This difference, especially in Africa, is closed by the age of three due to the effects of inadequate nutrition. It is interesting to note that when subjected to similar environments the African remains ahead of the European in bone age. This is emphasised in a nationwide survey in the U.S.A. in which the mean age of puberty for Africans was 12.5 and that for Europeans 12.8 years (Tanner, 1978).

Children from lower income groups frequently showed signs of delayed puberty and restricted stature, mass, lean body mass and muscle mass when compared to middle or upper

income groups (Lowenstein and O'Connell, 1974; Neyzi et al., 1975).

Schutte (1980) found that growth differences between different income groups became pronounced after 11 years of age, suggesting that the smaller sized children of low income groups have a delayed adolescent growth spurt. Chronic malnutrition can certainly retard and diminish growth, resulting in a small-sized adult. During even a short period of malnutrition growth is slowed. When conditions improve, however, the body catches up on that which was lost. Height, weight and skeletal maturity are caught-up at a rapid rate, so that the final state is hardly distinguishable from the original state. It is not only the socio-economic status that plays a significant role in determining the size and tempo of growth of individuals but also the size of the family. The more mouths there are to feed in a family it seems, the more slowly the children grow (Tanner, 1978).

The height and weight differences in South Africa follow a similar trend to that uncovered in other countries. Various investigations and comparisons of ethnic groups in South Africa have suggested that white boys are taller and heavier than the less privileged ethnic groups (Sloan and Hansen, 1969; Goslin and Burden, 1986). The difference in height and weight between white and non-white children in South Africa could be due to a number of factors, as already noted by other investigators, among which nutrition and economic status are critical.

Several authors cited by Brooke (1978), argued that physical education programmes, or even more strenuous physical training sessions, apparently do not affect growth in stature. Contrary to this there have been a number of studies suggesting a gain in height does occur during a short period of physical activity. Goode et al. (1976) Rarick, 1974; Milicer and Denisiuk 1964; Ekblom, 1969).

According to Sloan (1966) the smallness of stature attributed to racial factors in South Africa is really due to malnutrition. A privileged group of Bantu children in South Africa has been shown to achieve the same heights and weights as white South African children.

According to Franks and Deutsch (1973) length of various segments of the body or as a whole, appears to be less susceptible to change by environmental stimuli, although activity in early childhood may have more effect on growth than has been generally assumed.

In a longitudinal study examining the growth of 546 French Canadian school children aged 6-12 years, from a medium-sized town and a rural school, half of the samples took only the regular 45 minute period of physical education per week while the other half were given an hour of physical activity per day. The added activity had no effect upon the size of the children, but it produced significant gains in VO_2 max, physical work capacity, muscle strength, and physical performance as shown in CAHPER test scores (Shephard et al., 1980b).

Weight

Just as malnutrition may hamper physical performance and growth, so too does over-nutrition. The sedentary, obese, under-muscled individual is handicapped in physical activity and obviously physical skill. Fat hinders performance in that it causes friction between muscle fibres contributing to the inefficiency of muscle contractions and adds "dead-weight" to body parts, increasing resistance against movement (Allson, 1978).

Physical activity plays an important role in the regulation and maintenance of body mass which can be divided into lean body mass and body fat. The amount of body fat that is stored is determined by the number and size of adipocytes. According to Oscai (1978), fat cells accumulate at a rapid rate in early life, followed by a slower but continuous increase in adipocyte number into early adulthood.

Strauss (1984) argued that habitual activity and balanced diet programmes introduced during early childhood lead to a reduction in both the number and size of the adipocytes. According to Lohman (1987) pre-adolescent boys average approximately 13-15 percent body fat with 6-10 percent body fat classified as being low. The older the child the higher the percent body fat, the greater the risk for the child to become obese as an adult.

Physical training generally produces an increase in lean body mass and a decrease in body fat. If an obese boy were to lose some of the surface adipose tissue, his strength per unit body weight would be increased, even without altering

his absolute strength. According to observations by Milna (1978) on teenage boys of closely similar dimensions and maturity, exposed to different degrees of physical training over a seven year period, the most active boys evidenced higher lean body mass and lower body fat than the less active boys at the end of the study. Body size differences and maturity status did not differ significantly between the different groups all through this period.

Physical activity has a significant effect on body weight. Children who are very active have less body fat and more lean body mass than those who are less active. Parizkova (1968) found that the differences among groups of boys with different physical activity patterns were most pronounced in body composition. It is likely that an overweight child will lose adipose tissue while the thin child may increase in lean weight.

Cardio-vascular Status

VO_2 max is a good indicator of cardio-respiratory capability. This variable is highly related to endurance performance (Wells, 1986).

The circulatory-respiratory changes that occur as a result of training during childhood are consistent with those experienced by adults. There is a lower resting heart rate (HR) consumption of O_2 at a given work load, faster HR recovery and an ability to perform greater loads of work.

Eriksson and Koch, cited by Wells (1986), have found that the heart rate in trained children is lower during rest and all levels of exercise. A slower heart rate reflects

reduced myocardial work and oxygen uptake leaving more reserve for muscle activity (Bar-Or, 1983). Astrand and Rodahl (1986) have pointed out that increased work capacity coincides with a greater heart stroke volume and thus a lower mean heart rate. There is also an increase in maximal cardiac output in children during training. Blood volume, haemoglobin concentration and consequently total haemoglobin are lower in children than in adults (Astrand, 1952). As body size increases, however, so too do these variables. Oxygen carrying capacity increases with age until about puberty. According to Kock and Rocker (1977) total blood volume and total haemoglobin concentration were higher in trained boys than in untrained boys. This would indicate that training in children not only increases total amount of oxygen carried by the blood, but also results in an improved stroke volume and heat tolerance. Bar-Or (1983) summarised training responses in children as a decrease in respiratory rate, an increase in tidal volume and an increase in maximum pulmonary ventilation. Thus, with training children become more efficient in breathing.

Aerobic Capacity

Children respond to exercise in a similar manner as do adults and adolescents. Some researchers have concluded that physical exercise improves VO_2 max and therefore aerobic capacity. Others have found no significant increase in VO_2 max, but have however noted an increase in distance run. VO_2 max is distinctly lower in children. Being lighter, a child may not need as high a VO_2 max as that needed by a heavier

adolescent. VO_2 max, when expressed per kilogram, is about the same as that of adolescents and young adults.

The majority of cross sectional studies indicate that VO_2 max values for trained groups are higher at all ages with the difference being less in younger children. Wells (1986) supports Krahenbuhl and co-authors, who concluded that the maximum aerobic power of children from 8-14 years can be significantly increased following regular intensive training. Gains of $4-5 \text{ ml.kg}^{-1}.\text{min}^{-1}$ (i.e. 8-10% VO_2 max) were recorded.

Rowland (1990) has shown that when training protocols conform to criteria set for adults, pre-pubescents do increase maximum aerobic power at a similar rate to other age groups. Contrary to those showing a positive relationship between VO_2 max and training, others have reported insignificant increases in VO_2 max. Gillian and Freedom in Bar-Or (1988) and Yoshida and Ishiko (1979), concluded that pre-pubescent children are even less trainable than adolescents or adults. Cumming, Goulding and Baggley, and Baggley and Cumming, cited in Goode et al. (1976) found that aerobic power values were unlikely to change in school children during a school year, regardless of the time spent or the facilities provided.

Endurance is developed with increasing aerobic power in pubescent and adolescent age groups. In pre-pubescent children, however, endurance training improves the running performance without a significant increase in VO_2 max (Bar-Or, 1988; Rowland 1990). The lack of improvement in aerobic

power in endurance training in children could be explained by initial high values of VO_2 max.

Macek (1988) observed no significant changes in VO_2 max after an endurance programme for ten pre-pubescent boys with no special endurance training. Thus improvement in aerobic power during endurance training is inversely related to the level of aerobic fitness at the onset of the training programme. Even when aerobic training fails to increase maximum oxygen uptake, the running performance of children can markedly improve (Bar-Or, 1988). One of the reasons could be that a decrease in oxygen uptake at any given submaximal running speed will increase the metabolic reserve of the child.

The efficiency of movement progressively improves throughout childhood and into early adolescence and is highly dependent on environmental influences. A lower anaerobic and aerobic capacity reduces performance in the child. Performance levels are also reduced if nutrition is inadequate. In addition to reflecting cardio-respiratory capacity, a VO_2 max test is also related to the percentage of body fat. Body fat negatively affects both VO_2 max and distance running performance.

Anaerobic Performance

Physical activity can be a short burst of intense activity, a long period of submaximal work or a combination of both. Most activities utilize both aerobic and anaerobic sources, but can be sub-divided into high-power short duration (anaerobic) and low-power long duration (aerobic).

Muscle contractions cannot be sustained from anaerobic sources for longer than about 1 minute (Kemper, 1990).

During a brief period of intense activity, the body responds by depleting local reserves of oxygen and phosphate compounds and by breaking down glycogen (energy) to lactic acid. This obviously results in a deficit of oxygen that must be replenished. The rate at which the body can meet this demand for short term intense activity is called anaerobic power and the maximum oxygen deficit that can be tolerated is called anaerobic capacity (Haywood, 1986).

Anaerobic capacity according to Bar-Or (1983), whether expressed relatively or absolutely, is lowest in children and increases progressively with age. This increase parallels improvements in speed, strength and endurance capabilities. According to Borms (1986), the exact reasons for this lower capacity are unknown. Shephard (1982) on the other hand, identifies the lower anaerobic capacity with the smaller absolute quantity of energy reserves because of less muscle mass. Birrer and Levine (1987) supports the findings of Krotkiewski and Eriksson and Saltin who postulate that reduced glycolysis as a result of testosterone and also because of lower concentrations of some of the enzymes involved in the break-down of glycogen, also influences the anaerobic capacity of children.

Cross sectional studies on Italian, African, British and American males have indicated an age related progression in the performance of the Margaria Step Running Test (Inbar and Bar-Or, 1986). A number of researchers have postulated that

in addition to this natural change in anaerobic capacity and power, accompanying growth, the anaerobic capacity can be improved through training in anaerobic activities (Grodjinovsky, Inbar, Doton and Bar-Or, 1980). Rotsten, Dotan, Bar-Or and Terenbaum (1986), evaluated the effects of a nine-week training programme of high intensity exercise on 10-11 year old boys and found an increase of 14% in anaerobic capacity and a 8% increase in $VO_2 \text{ max.kg}^{-1}$.

Becker and Vaccaro (1983), demonstrated an increase in relative anaerobic threshold from 67-71% of $VO_2 \text{ max}$ after an eight week cycling programme. In a study by Haffor et al. (1990), improvements in anaerobic and aerobic metabolism were experienced in a group of 11 year old children despite the fact that the training programme was designed to be aerobic.

Even though children have a lower anaerobic adaptation to the demands of short term intense activity, it is much the same as that of adults. One must however be careful when determining the changes in anaerobic capacity. Both exercise and growth positively contribute to an increase in anaerobic capacity. As muscle mass increases with age so too do the ATP and CP contents of the muscle tissue, allowing for greater energy reserves (Rowland, 1990). This obviously has a direct effect on the absolute anaerobic output that can be generated. Once adult body size is attained, improvements in anaerobic power and capacity can only be achieved through training.

MOTOR FITNESS CHARACTERISTICS

Strength

Throughout the span of childhood, children show marked differences in body composition. Some show a predominance of endo-chordal bone formation in which linear growth is accentuated, resulting in long slender bones. In others, there is a greater oppositional bone formation resulting in heavier shorter bones. These individuals tend to have a mesomorphic physique with a sturdy heavy bone structure, which can therefore support a well muscled body as opposed to those with a light slender skeleton (ectomorphic), who are less well endowed with muscle tissue (Rarick, 1973). One can therefore assume that the child with a heavy bone structure should be stronger than children with an ectomorphic build. This was clearly the case in an Adolescent Growth Study conducted by Jones (1949), where the mean strength scores for the mesomorphs were substantially above the means of the ectomorphs and endomorphs. There was also an increased strength superiority in the mesomorphic groups with advancing age, significantly noticeable in the pre-adolescent years. Tuddenham and Snyder (1954) determined that in terms of strength per unit of body weight, the mesomorphs were stronger on average than ectomorphs and endomorphs at 11 years of age and older.

Muscle strength is determined by the number and cross sectional area of the muscle fibres in a given contraction. Muscle fibre number is largely fixed shortly after birth, but growth is accompanied by an increase in fibre diameter. Thus

strength increases linearly with age until 13-14 years of age in boys, after which there is an acceleration in strength development (Rowland, 1990). According to Haywood (1986), muscle strength increases more rapidly than muscle size during the growth period, which is largely due to improved co-ordination in recruiting the muscle units needed to exert force. Asmussen (1973) postulates that strength applied to a definite task demands skill. A steady state of running can only be achieved through a series of explosive contractions which demand a high degree of co-ordination and skill. Therefore maximal speed is proportional to the maximal work of the muscles and to body weight.

Strength is roughly proportional to muscle mass which constitutes approximately 40% of body weight. The correlation between weight and stature with measurements of strength is within the range of .50 to .60. The correlation between height and strength is lower, approximately .30 (Asmussen, 1973). Thus the variance in strength attributable to differences in body weight is only 30-38%, whereas the variance accounted for by differences in stature amounts to less than 10%.

There is a good deal of controversy regarding pre-pubescent strength training. Many researchers are of the opinion that pre-pubescent subjects were incapable of increasing muscle strength with resistance training because of the absence of circulating androgens (Vrijens, 1978). The natural development of muscle strength reaches its peak about a year after the growth spurt in males. It is thus not

surprising that some researchers believe that the degree of strength trainability is lower before puberty. Contrary to this many researchers believe it is possible to accelerate this growth of strength, at least over certain periods. Rohmert, cited in Haywood (1986), believes that because children begin at a relatively lower level of strength, there will be relatively more progress in training than that experienced by adults.

It is often found that children and adolescents who participate regularly in sport are stronger than those who do not (Bailey et al., 1978). Recent studies, showing significant strength gains in both boys and girls with weight training, appear to have dispelled the myth regarding additional strength gain during pre-puberty years. Preist and Holshouser (1987) reported an improvement not only in strength, but also in power, bone density, muscular endurance, as well as tendon-bone interface strength and ligament strength. Nielson et al. (1980) concluded that pre-pubescent boys and girls can significantly improve their strength through training.

Rowland (1990) contradicted Vrijens, postulating that pre-pubertal subjects demonstrated greater strength gains as opposed to post-pubertal subjects, showing more improvements in strength. Similar results were observed by Pfeiffer and Francis (1986) and Weltman et al. (1986). Nielson et al. (1980) concluded that pre-pubescent children have a greater strength trainability than older age groups.

De Vries (1980), observes that even if there is not any hypertrophy of the muscles, there may well be an increase in performance because of the better recruitment and synchronization of the muscle fibres. Thus improvements in strength can enhance athletic ability and performance, reduce the risk of injury, as well as speed up rehabilitation should injury occur. In addition, these studies indicate that supervised strength programmes for children can be conducted safely with little risk as well as no loss of flexibility.

Flexibility

The range of motion of any joint is dependent on its anatomical structure, as well as the extent of its habitual use. It is therefore generally accepted that a loss of flexibility is a characteristic of old age. Changes in cartilage, ligaments and tendons of the joint occur with ageing. According to Adrian, there is however, no evidence that these changes are the cause of decreased flexibility (Haywood, 1986). Undoubtedly one of the factors that will cause a loss of flexibility is the limited range of motion required in everyday life. One can therefore say that it is likely that individuals who are not habitually active lose flexibility because everyday living rarely requires movement of joints through their full range of motion. Other factors that may inhibit range of motion are age, body type, sex and factors such as temperature, humidity and warm-up.

Flexibility plays an important role not only in elite sport but also in daily habitual physical activity. It is therefore important to ensure that optimal mobility of the

various ligaments is maintained, to meet the demands for daily habitual activity, as well as for general physical capacity and well-being.

According to Haywood (1986), some improvements in flexibility with age have been noted in young children, but most studies show a decline in flexibility beginning in the early teens. Clarke (1975) concluded that boys tend to lose flexibility after the age of ten. More recent studies have noted even younger ages for the turning point. Krahenbuhl and Martin (1977), found that flexibility declined over the age range 10 - 14 years. Boone and Azen, cited by Haywood, 1986, found a steady decline in flexibility over time in subjects ranging from 18 months to 54 years. The greatest losses occur in movements not habitually performed. This trend towards declining flexibility after childhood represents the average state among representative groups of people (Haywood, 1986).

Malina and Bouchard (1991), on the other hand, postulate that flexibility when measured by the sit and reach test, is stable during the years from 5-8 in boys and then shows a subsequent decline with age, reaching its lowest point at 12 and 13 years and then follows an ascending line through to the age of 18. This lowest point in boys sit and reach performance is generally coincident with the adolescent spurt in leg length and coincides with the adolescent growth spurt in sitting height and upper extremity length. Both Renson and Ostyn in Borms (1986) showed gradual increases in flexibility with age in Belgian boys 12-18 years of age.

The same decline in sit and reach flexibility was demonstrated in Australian children to the ages of 11 and 12, after which there was a steady improvement (Pyke, 1986).

It is generally accepted that training can improve the range of motion in joints of young children. Flexibility declines without training even during childhood and adolescence (Haywood, 1986). Both static stretching and ballistic forms of stretching result in significant gains in flexibility. Changes brought about by stretching exercises persists for 8 weeks or more after stretching has been discontinued (De Vries, 1980). Both De Vries (1980) and Haywood (1986), have shown that dynamic as well as static flexibility can be significantly improved by exercise in young children.

Balance

Balance is a component of the effective performance of many motor tasks. Balance is specific to the environmental situation; whether one is standing or moving, has ones eyes open or closed, or is supported by one or more limbs (Haywood, 1986). In a sport such as soccer, individuals need to be able to balance in a variety of situations, while controlling a soccer ball.

Strong evidence indicates balance performance improves as children advance from 3 to 19 years of age (Bachman, 1961). The amount of improvement depends largely on the task at hand. On some balance tasks the average performance of a group of children does not always change significantly from year to year. On others, improvement is steady over a number

of years. Repetition of certain tasks will obviously facilitate the eventual performance.

Contrary to this general trend of improved balance ability with increasing age, instances of no improvements or even declines in performance scores have been noted (Bachman, 1961).

Some literature suggests a period of awkwardness during the adolescent growth spurt, which is generally attributed to the differential timing of the growth spurts of the lower limbs and muscle mass (Malina and Bouchard, 1991). This awkwardness during the male growth spurt can present problems with balance, agility and co-ordination.

According to Meszoros, cited by Macek (1988), regular physical training in pre-pubescent age groups speeds up the rate of development of physical abilities, including co-ordination and balance. High levels of habitual activity or supervised sports training correlate significantly with strength, aerobic power, basic skills and general balance and co-ordination. Individual differences in these abilities are strongly related to a lack of physical activity.

Co-ordination and Agility

To be agile one must also be well co-ordinated. Thus co-ordination and agility cannot be separated.

A child's mastery of developmental skills has a significant impact on potential for success (Nelson, 1991). Appropriate co-ordination is essential in any type of sport. Both the activation of different motor units and different muscles have to be timed accurately to achieve optimal

performance. An activation of as many motor units as possible, in a synchronous fashion would be advantages for rapid force production (Thorstensson, 1988).

The consolidation of co-ordinative capabilities is highly related to biological age. Hertz, cited by Tittel (1988), identified a period of stagnation or even regression in the developing co-ordinative capabilities during the pubescent years. Individuals who were biologically younger, approximately 11 years, showed better co-ordination results than children biologically aged 13 or 14 years.

There is consensus that the period in which the child best learns all kinds of movement patterns can be located between 9 and 12 years of age (Singer, 1970). By the age of 11 and 12, children are able to integrate information from multiple sources and respond to verbal instruction. Because specific motor skills are influenced by chronological age, skill must be seen as a neuromuscular learning process.

Thus from the above, one can say that a better potential for developing and training co-ordinative capabilities can be found prior to pubescence. The focus of learning must therefore be at an early age. For some sports it is even contended that skill training cannot start too early and that pre-school years offer the optimal conditions for the systematic learning of co-ordinative exercises (Borms, 1986).

While emphasis on fundamental skills should continue, one must consider the fact that by late childhood most children are able to enter and compete successfully in complex sport skills, such as soccer, basketball and

baseball. High levels of habitual activity or supervised sports training correlate significantly with strength, aerobic power, basic skills, agility and co-ordination (Macek, 1988). Individual differences are strongly related to a lack of physical activity. Therefore it can be argued that regular physical training of pre-pubescent children can speed up the rate of development of physical abilities, including co-ordination, agility and balance.

A 5-year longitudinal motor capability study on male Ice Hockey players aged 8 to 12 was conducted by Macnab (1979). The competitive groups displayed extremely high levels of achievement for boys, in their respective age groups. Macnab concluded that the execution of more complex motor skills, such as agility and co-ordination, lead to a greater separation between competitive and non-competitive groups.

The training of co-ordinative capabilities, the effects of which result from the dominance of practising the corresponding motor pattern, can be supported during childhood and adolescence by changed external conditions, such as ball size, ball weight, net height and field size adjustments (Tittel, 1988).

Agility plays an important role in soccer and many other sporting activities. The soccer player is required to show great agility when manoeuvring the ball past his opponents while zig-zagging down the field. The quick changes in body positions are necessary to prepare oneself for defensive and offensive play. Fast starts and stops as well as changes in direction are fundamental for good performance. Agility may

be seen as a combination of various physical components such as power, strength, speed, flexibility and co-ordination.

Physique, age and body mass are factors which can directly influence agility (Jensen and Fisher, 1979). Individuals who are of medium height or shorter and are well muscled, tend to be highly agile. Children increase steadily in agility to about the age of 12. Haywood (1986) found, when the "140-ft Shuttle Run" was used as a test of agility, a consistent improvement for boys between 5 to 18 years, with times ranging from 13 to 16 seconds at 5 years and improving to approximately 10 seconds in the mid-adolescent years.

Average running performance in both the dash and agility runs improves during pre-adolescence and adolescence. Jensen and Fisher (1979) however, describe a period of stagnation or even regression in agility during the growth spurt years, with a return to normal once the rapid growth spurt is over and a continued steady-rate increase until maturity is reached. Excess weight increases the inertia of the body and its parts, reducing the speed of muscle contraction and thereby causing changes in direction to be less rapid.

Even though there are various components directly influencing agility, the best way to improve agility in specific movement patterns is to practise the movements correctly and repeatedly at high speed. This approach emphasises the development of specific co-ordination and helps contribute to developing some of the other components.

Power

Strength and power are essential elements in physical performance. In normal subjects muscle strength can easily be increased by a variety of methods, provided that the training loads exceed those of normal daily activity. This would obviously lead to improvements in activities that require high muscular power, such as jumping, throwing, sprinting etc (Bar-Or, 1988). Performance in these tasks is linear with age. In both throwing and running tasks there is a steady increase in performance, with no apparent indication of acceleration over the growth period. Performance in jumping tasks increases steadily with sharp indications of accelerations during the growth spurt (Malina and Bouchard, 1991). Grodjinovsky et al. (1980) found there to be gains in peak power and muscular endurance in children who trained for several weeks with short bursts of submaximal cycling and sprint running.

For the purpose of the present study, power was determined through performance of the Margaria Kalamen Step Test as well as the Illinois 18-Item Motor Fitness Test.

Endurance

The effects of training and age on cardio-vascular endurance and performance have already been discussed. As with other components of fitness, muscular endurance improves linearly with age from 5 to 14 in the case of boys, followed by a spurt similar to that of strength (Malina and Bouchard, 1991).

Muscle endurance is closely related to strength so that an increase in strength will lead to improvements in absolute muscle endurance. Even though weight training will ensure increases in strength and endurance, it should be recognised that muscle endurance can be increased by any form of exercise that results in overloading the muscles, either in weight or in repetition (Jensen and Fisher, 1979). One must, however, remember that muscle endurance is highly specific, and therefore significant increases will be limited to the muscles that experience regular overloading. Endurance increases with age, to a certain point, after which it decreases as age increases.

Morehouse and Miller (1976) state that endurance increases steadily to about the age of 20 in males. Training will allow endurance to increase beyond this age.

Although studies indicate an improvement due to training, certain factors such as lifestyle, habitual physical activity, the quality and quantity of structured activity programmes may influence performance. Other factors that may influence performance are skill and physique.

During performance a certain amount of energy is wasted in unnecessary and unco-ordinated movements. A skilled individual wastes less energy. It is important that soccer players not only possess great skill, but should also be able to pace themselves for the duration of the game. Repeated practice improves skill and efficiency, and therefore influences endurance (Jensen and Fisher, 1979).

Morehouse and Miller (1976) claim that individuals of a moderate build have the greatest ability to sustain prolonged muscular effort. Sills and Everett (1953) and Bookwalter (1952) found that mesomorphs were only slightly better than ectomorphs in endurance tests, and that endomorphs were far inferior to the other two body types.

CHAPTER 3

MATERIALS AND METHODS

INTRODUCTION

Soccer plays an important role in the daily life of the Xhosa-speaking male. Yet organised soccer programmes are limited to clubs and high schools. In order for young individuals to make the top teams it is imperative that they show excellent skill. Thus we find many Xhosa teenage boys participating in un-organised soccer games and physical activities where soccer skills are learnt and practised.

In order to assess the performance capabilities of this ethnic group as well as the effects of a soccer enrichment programme a number of tests were administered with the use of unsophisticated equipment.

Method of Selection

Selection of subjects was limited to Xhosa-speaking children from the Township of Rini, Grahamstown. Two local primary schools were approached and initially a group of 50 pupils aged 11 years (25 from each school), was selected from volunteers willing to participate in the enrichment programme.

The group was divided into experimental and control groups. 30 pupils, 15 from each school, were randomly selected for the Control group and the remaining 20 pupils, 10 from each school, acted as Experimental subjects.

Both the control and experimental groups participated in two testing sessions. The experimental group participated further in a supervised 10-week Soccer Enrichment Programme.

The Programme

The programme was undertaken over a period of 10 weeks during the second school term, from 13-04-1992 to 22-06-1992. Training was done Mondays, Wednesdays and Thursdays from 16h00 to 17h00. The training programme consisted of anaerobic, aerobic and muscle-strengthening exercises, as well as soccer skill drills and game (match) practice. The training routine consisted of the following phases:

- (I) Warm-up
- (II) General run
- (III) Conditioning
- (IV) Skill practice
- (V) Match practice

Programme time charts were as indicated in Figure 1 below.

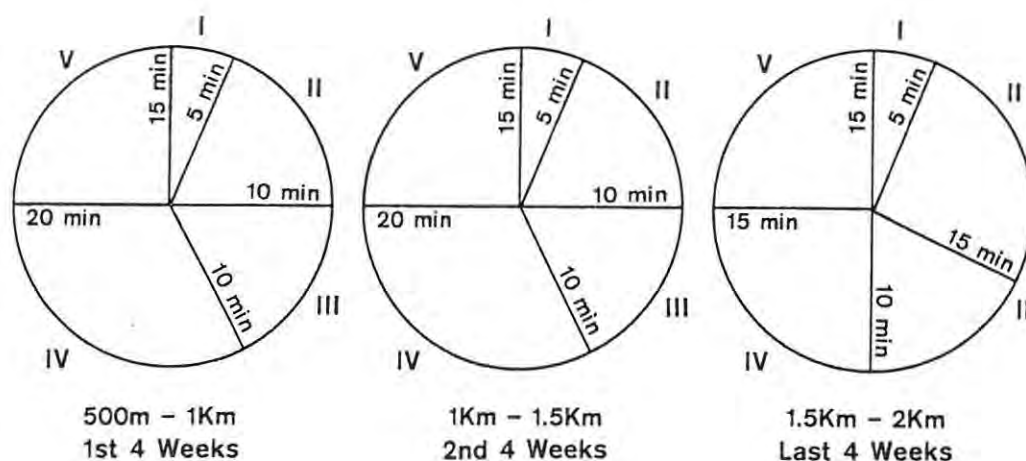


FIGURE 1: Programme Time Appointments.

The warm-up session consisted of stretching exercises. This was followed by a distance run, ranging from 500m - 2km. Slower individuals were allowed a head start, motivating both the slower and faster runners. A conditioning period followed, lasting for approximately 10 minutes. Exercises associated with the 18-Item Illinois Motor Fitness test were used as a basis for the conditioning.

Skill practice was then introduced for periods ranging from 25 min in the beginning, to 15 min during the last 2 weeks. The training session was culminated by a game between the two rival schools.

Testing

Both control and experimental groups completed a battery of tests before and after the 10-week training programme. Testing was done during the afternoon after school. Subjects were transported from the Township to the Human Movement Studies Department where assessments were done using unsophisticated yet reliable equipment. To keep all subjects active the group was limited to 10 individuals per session, facilitating the organisation and preventing individuals from becoming restless.

Except for the Illinois 18-Item Motor Fitness Test, when selected and trained undergraduate students were used to assist in evaluation, all tests were administered by the author. Initial testing was completed during the first two weeks of the second school term and post-Programme testing during the last two weeks of the same terms.

The Testing Protocol

Selected anthropometric, physiological and performance tests were administered in order to monitor the effect of the enrichment programme on growth, cardio-vascular efficiency and physical performance. The results of both the initial and final tests were statistically analysed, evaluating the changes, if any, that occurred as a result of participation in the programme.

The following tests were administered:

I. Anthropometric Measures:

These measurements determined the effect of the programme on growth and percent body fat.

Stature

The stature of the individuals was measured using a Harpenden Anthropometer. Subjects were bare-footed and stood with their heels together, buttocks, shoulders and head in contact with the wall. Subjects then took a deep breath and the head was aligned with the Frankfort Plane. Stature measurements were read to the nearest 0.1 cm.

Body Mass

Mass was measured in minimal clothing on an electronic scale to the nearest 0.1 kg.

Skinfold Measures

Harpenden skinfold callipers with a jaw pressure of 10 g/mm² were used to measure skinfolds to the nearest 0.5mm. The skinfold was lifted away from the underlying muscle, 2 cm above the site where the calliper jaws would be placed at a depth of 1 cm. Three measurements were recorded of each

skinfold and the mean used on the final score. All measurements were taken on the dominant side.

Biceps Skinfold

Was measured anteriorly on the upper arm approximately mid-way between the acromion and the olecranon processes. Measurements were taken with the subject in a standing position, upper limbs pendent.

Triceps Skinfold

Was measured posteriorly on the upper arm approximately mid-way between the acromion and olecranon processes. Measurements were taken with the subject in a standing position, upper limbs pendent.

Subscapular Skinfold

Was measured with the fold in an oblique plane descending laterally at an angle of 45° over the inferior angle of the scapula. Measurements were taken with the subject in a standing position and arms relaxed at the sides.

Suprailiac Skinfold

Was measured with the fold in an oblique plane descending medially at an angle of 45° above the anterior-superior iliac spine. Measurements were taken with the subject in a relaxed standing position.

Calf Skinfold

Was measured with the fold running vertically at the centre of the medial surface of the calf having the greatest calf girth. Measurements were taken with the subject seated, the foot placed on the ground and the knee flexed at a right angle.

Bone Diameter

A Harpenden sliding steel calliper was used to determine the measurements of both the left and right limbs which were recorded to the nearest 0.1 cm.

The Humeral Bi-epicondylar Width

The distance between the outermost parts of the medial and lateral epicondyles was measured. The subject's arm was raised horizontally with the elbow fixed at a right angle.

Femoral Bi-condylar Width

The distance between the lateral and medial femoral condyles was measured. The subject remained seated with the knee flexed at right angles.

Muscle Girth

A flexible steel tape was used to measure the muscle girths. The tape was passed around the limbs in the region where the muscle was largest, in a plane which was at right angles to the long axis of the particular segment. Care was taken that the tape, in light yet firm contact, did not deform the contours of the skin.

Flexed Arm Circumference

The maximum girth of the arm with the biceps fully contracted was measured on both right and left limbs. The subject's arm was held in a horizontal plane, elbow fully flexed and the fist clenched. The muscle was contracted and the measurements recorded.

Calf Circumference

The subject was measured in a standing position, upper limbs pendent and body mass equally distributed on both feet.

The maximum calf girths on both right and left sides were measured. Before the tape was removed a 1 cm line was placed directly above the tape on the medial side of the calf indicating the level at which the skinfold should be measured.

II Percentage Body Fat

The percentage body fat was calculated using the Durnin and Womersely technique (Kirkendall et al., 1980):

$$1. \text{ Density} = 1.533 - (0.0643 \times L)$$

where L is the total of 4 skinfolds; biceps, triceps, subscapular and supra-iliac, converted to a common logarithmic value.

$$2. \% \text{ Body Fat} = 100 \frac{(4570 - 4.142)}{D} = \text{RBF}$$

where D = Density; RBF = Predicted Relative Body Fat

$$3. \text{ ABF} = \frac{\text{RBF} \times \text{BM}}{100} = \text{Predicted Absolute Body Fat}$$

III Somatotype

The values obtained from stature, mass, the four skinfolds, the bone diameters and the muscle girths were used in the following formula to calculate the somatotype (Carter and Heath, 1990):

Equations for a decimalized anthropometric somatotype

1. Endomorphy

$$-0.7182 + 0.1451 (x) - 0.00068 (x^2) + 0.0000014 (x^3)$$

where x = sum of triceps subscapular + supraspinae skinfolds. For height correction endomorphy multiply x by 170.18/height in cm.

2. Mesomorphy

$[(0.858 \times \text{humerus breadth}) + (0.601 \times \text{femur breadth}) + (0.188 \times \text{corrected arm girth}) + (0.161 \times \text{corrected calf girth})] - (\text{height} \times 0.131) + 4.50$

3. Ectomorphy

$\text{HWR} \times 0.732 - 28.58$

The component ratings were then rounded off to the nearest one-half unit.

IV Tests administered to evaluate cardio-vascular efficiency

1 The modified Harvard Step Test

The Physical Efficiency Index was calculated as follows:

$$\text{PEI} = \frac{\text{duration of exercise in sec} \times 100}{2 \times \text{sum of pulse counts in recovery}}$$

The bench height was adjusted to 35.6 cm to accommodate children aged 11.

2 Cooper 12-minute run.

Subjects ran on a standard 400 m athletics track for 12 min. The distance covered was used as a measure to predict maximal oxygen consumption as well as running performance.

3 The Margaria-Kalamen Power Test

This test measured anaerobic capacity. The scores of the individuals were converted to Watts per kilogram. The following formula was used:

$$\begin{aligned} P &= (\text{Body mass} \times \text{gravity}) \times \text{velocity} \\ &= N \text{ m} \cdot \text{s}^{-1} \text{ (W)} \end{aligned}$$

Subjects stood 4 m from the bottom step of a 14 step stairwell. Each step being 16 cm. Time was recorded from the bottom step to the top step.

V. Tests administered to evaluate physical performance:

Two tests from Charteris and Walker (1971) were administered. The Illinois 18-Item Motor Fitness Test which made use of nominal variables, i.e. pass or fail, and the CAPHER Test which tested ratio variables.

1. The Illinois 18-Item Motor Fitness Test.

The test was administered to evaluate performance in strength, power, endurance, agility, balance and flexibility.

2. The CAPHER Test.

The test measured performance in endurance, power, agility, strength and speed.

3. Flexibility Test

The Sit and Reach flexibility test was used to show the effect, if any, of the enrichment programme on flexibility.

MATCH-SKILL EVALUATION

With few exceptions ball control skill was not lacking in the experimental group. Individuals lacked match interpretation and discipline. Individuals with excellent skill retained the ball for as long as possible, irrespective of the fact that there may have been a variety of better options. Crowding occurred frequently, with everyone chasing the ball, except those not fortunate enough to have as high a skill level as the rest. Looking for space and "having the ball do most of the work" was initially lacking. Even though ball control was exceptional the basics were often overlooked. The period for skill training was used to re-emphasise the basics, as well as to give individuals the

opportunity to improve their skill. Match practise taught the players to correctly "read" certain situations, allow the ball to do the work and to recognise that there was more than one player on the field.

CHAPTER 4

RESULTS AND DISCUSSION

SUBJECT CHARACTERISTICS

Initially a group of 50 pre-pubescent Xhosa-speaking children were selected for the study. A sample of 20 was selected for an enrichment programme, while the rest continued with habitual activity. Absence of pubic hair in those selected indicated that these subjects were pre-pubescent. Care was taken to select individuals who had not yet played either first team soccer or organised club soccer. Individuals were highly motivated because of the opportunity to participate in an organised soccer enrichment programme.

Nutrition, eating habits and physical activity levels were not controlled in either experimental or control groups, except in so far as the enrichment programme *per se* was concerned.

No drop-outs occurred from the experimental group. However six subjects from the control group were unavailable for re-testing because of sickness, drop-out from school and similar reasons.

ANTHROPOMETRIC MEASURES

Although the programme was completed before the adolescent growth spurt proper (as determined from Tanner, 1978), there was still a significant increase in linear growth over the test period.

TABLE I: Summary of Anthropometric Measures Mean Values (with standard deviations in parentheses)

VARIABLE	EXPERIMENTAL GROUP		CONTROL GROUP	
	TEST	RE-TEST	TEST	RE-TEST
Mass (kg)	30.86(6.20)	31.57(6.10)	29.60(3.0)	30.62(3.20)
Stature (cm)	133.5(6.50)	134.4(6.50)	135.3(5.10)	136.0(5.20)
Humeral				
Epicondylar width (cm)	5.51(0.34)	5.57(0.32)	5.46(0.25)	5.52(0.25)
Femoral				
Bi-epicondylar width (cm)	8.12(0.50)	8.18(0.50)	8.06(0.36)	8.11(0.38)

Note: Bars indicate significant differences ($p < 0.05$)

Stature in control and experimental groups increased by 0.9 cm (0.6%) and 0.7 cm (0.5%) respectively over a three-month period.

According to Tanner (1978), in the year preceding the growth spurt, the average British boy gains approximately 5.0cm in stature. Extrapolated to a three-month period this growth increment is 1.25 cm. This, however, must be seen in relation to the stature of the child. The stature of the 11 year old Xhosa-speaking boys studied ranged from 133.5 to 136.0 cm, whereas the mean stature for British children of the same age is approximately 142 cm (Tanner, 1978). This equates to an increase in stature of 0.8% over a three-month period which is comparable to that of the Xhosa-speaking children in this study. According to Tanner, growth is terminated by about 18 years of age for boys.

Masipa (1989) found the mean stature for Xhosa-speaking boys of 18 years of age to be 168.6 cm; much shorter than the 174.0 cm measured for British boys of the same age. From

the above it appears that the children under study had grown to 80.7% of their estimated adult stature compared to the 81.6% for British children reported by Tanner, suggesting that the growth-rate of both ethnic groups was similar.

This was confirmed when a number of different ethnic groups were compared, except in the case of mal-nourished Nigerians who had only completed 75.8% of their growth (refer to Figure 2).

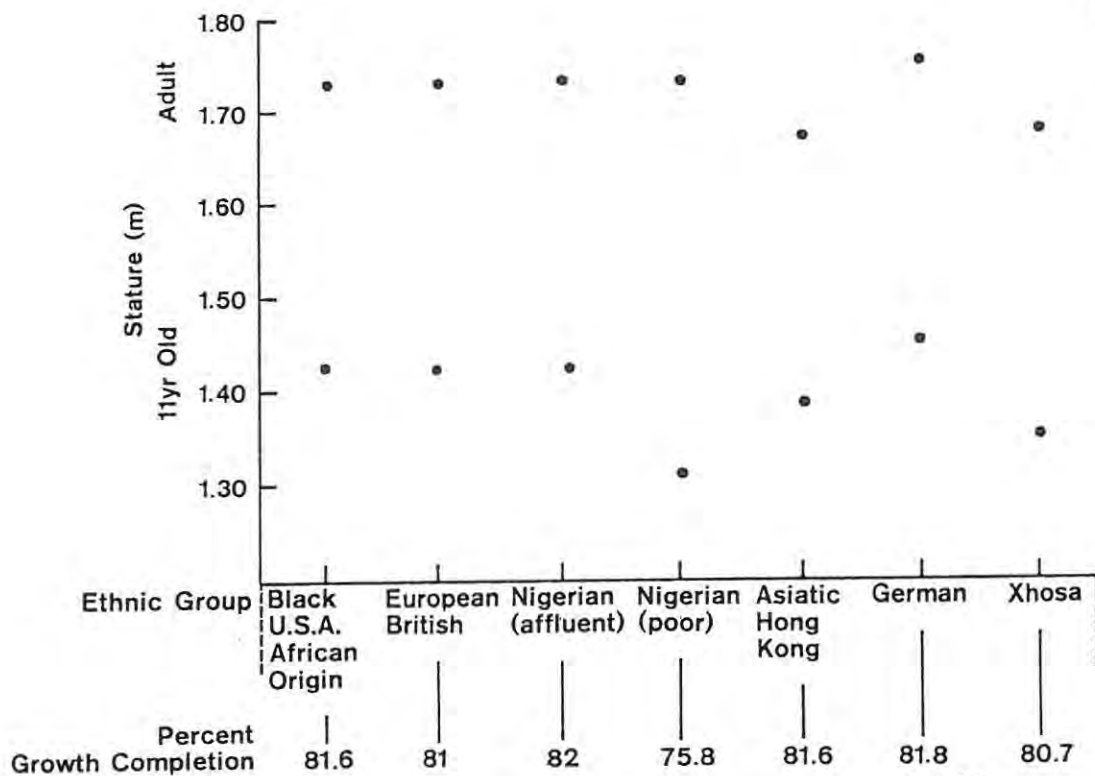


FIGURE 2: Comparison of adult and 11 year old stature among various ethnic groups with percentage growth completion.

Mass, in both experimental and control groups, shared significant ($p < 0.5$) gains over the study period. The amount gained by the experimental group over the three-month period was 0.71 kg as compared to 1.02 kg of the control group. Thus respective increases of 2.2% and 3.3% were experienced. There was however no significant between-group differences, either before or after the three-month period.

When the means of the experimental and control groups were plotted on NCHS Growth Charts (Malina and Bourchard, 1991), the experimental and control groups fell close to the 25th percentile suggesting that Xhosa-speaking boys, of 11 years of age, are smaller than American boys of the same age.

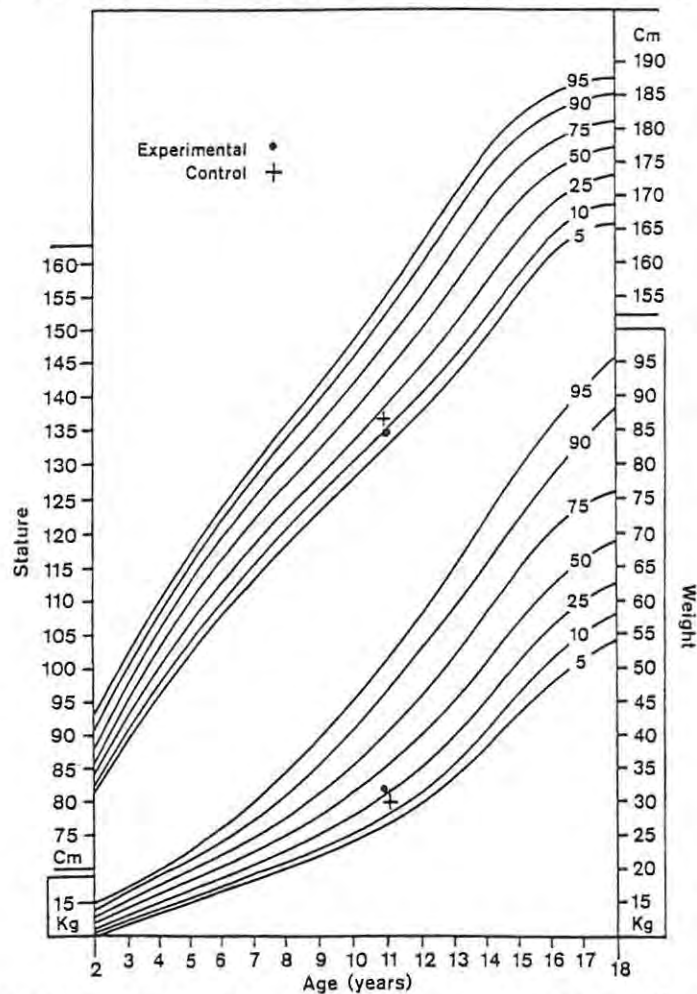


FIGURE 3: Mean Stature and Mass of Xhosa-speaking children plotted on NCHS Growth Charts.

According to Tanner (1978) the mass gained per year in 11 year old British children is approximately 3 kg. This gives an extrapolated rating of 0.75 kg over a period of three months, which is similar to the results obtained in the Xhosa-speaking children here investigated.

The annual Epicondylar diameter growth of the humerus in German boys aged 11 is estimated to be 1.5mm, whereas the Bi-epicondylar diameter of the femur is estimated to grow by 2.5 mm (Crasselt, 1988). In the present study the growth over the three month period for humeral epicondylar width was 0.6mm in both experimental and control groups. The difference in the femoral bi-epicondylar width over the same period was 0.6mm for the experimental group and 0.5mm in the control group. These increases were comparable to extrapolated values of 0.3mm for the humeral width and 0.6mm for the femoral width in German-speaking children of the same age. The values for the humeral epicondylar width in German 11 year olds was estimated at 5.8mm and that of the femoral bi-epicondylar width 8.5mm (Crasselt, 1988).

Nutritional Status

The nature of the experiment and the fact that limited information regarding Xhosa children exists, restricted the assessment of nutritional status solely to observation of individual appearance. Personal observation over the three-month period suggested that the subjects were economically deprived, but not to the extent of lacking in nutrition. As discussed earlier, it is possible that some of the children may have been marginally lacking in specific minerals and

vitamins, but this could not be determined purely through observation.

Mass and stature distribution charts for American children (NCHS Growth Charts; Tanner, 1978) and for White South African children (Grobbelaar, 1964) were used to compare the means of Xhosa-speaking children against other ethnic groups.

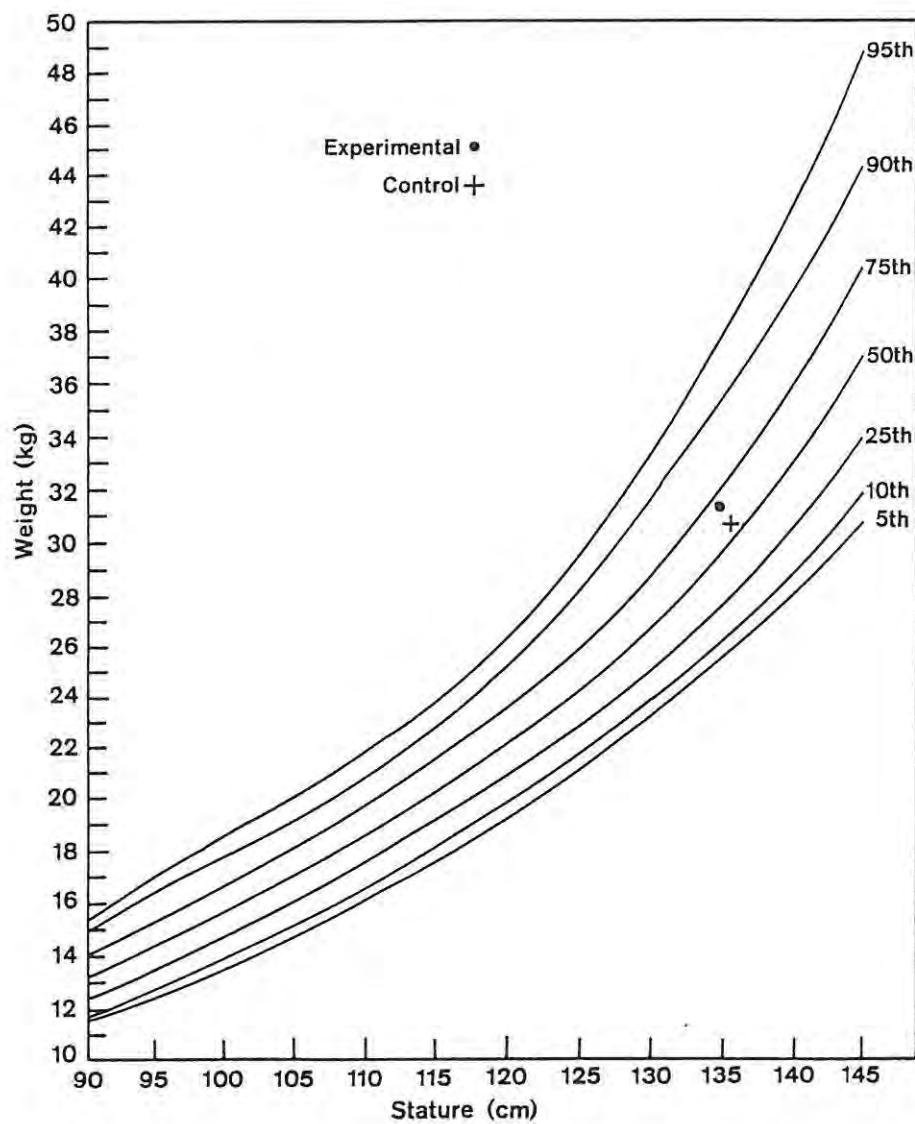


FIGURE 4: National Centre for Health Statistics Standards of weight for height for American Pre-pubescent children.

As can be seen in Figure 4, reflecting NCHS standards of weight-for-height for pre-pubescent boys, both experimental and control groups fell below the 75th and above the 50th percentile. A simple explanation for this is the fact that the children studied were shorter and thus lighter than American-speaking children (Figure 3), but comparable in body mass index (BMI) i.e. just smaller people (Figure 4). A similar trend was noticed when the means of experimental and control groups were plotted on the weight and height distribution charts for White South African boys of the same age.

When the stature and mass of the Xhosa-speaking children were plotted on the weight\height distribution chart for White South African pre-pubescent children (Figure 5), the control groups mean before and after the three month period fell within the inner circle which embraces 70% of the 11 year old White South Africans. The means of the experimental group fell on the border of the inner circle, below the indicated growth curve.

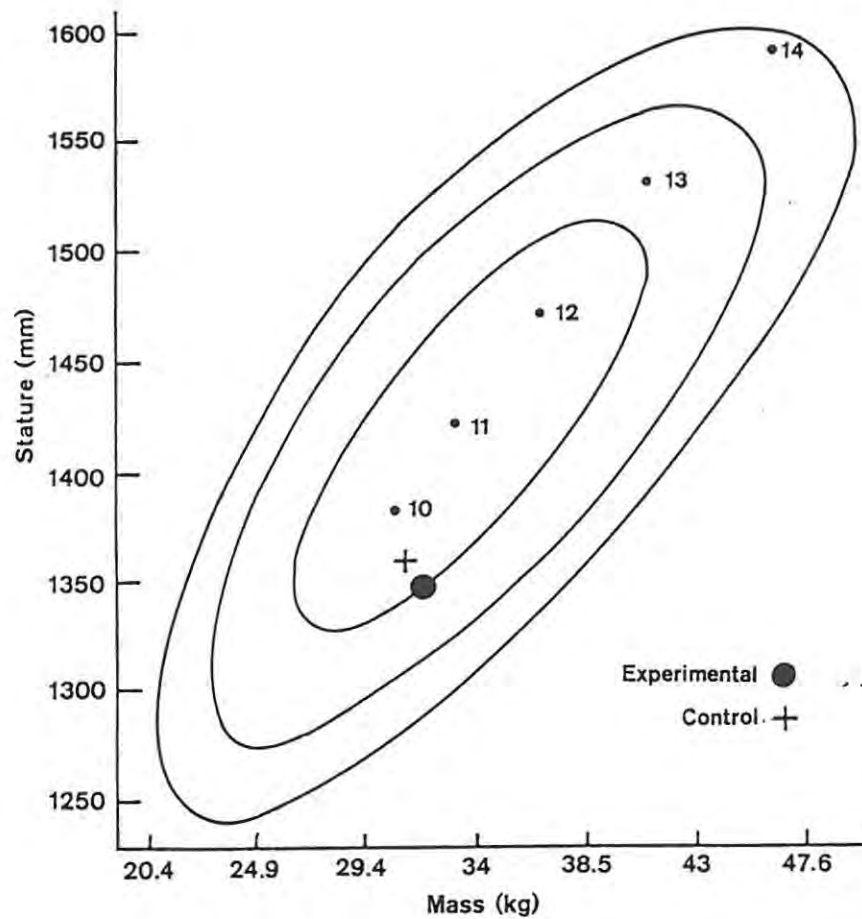


FIGURE 5: Height-weight distribution chart for White South African Children (after Grobbelaar, 1964).

Irrespective of the fact that the children fell below the norms of other ethnic groups due to genetic differences, the amount of linear growth at 11 years of age was similar to that found by other researchers in various other ethnic groups, except when compared to mal-nourished Nigerian children. This suggests that the subjects of the present investigation did not suffer from malnutrition even though their physical appearance suggested an austere life-style.

BODY COMPOSITION

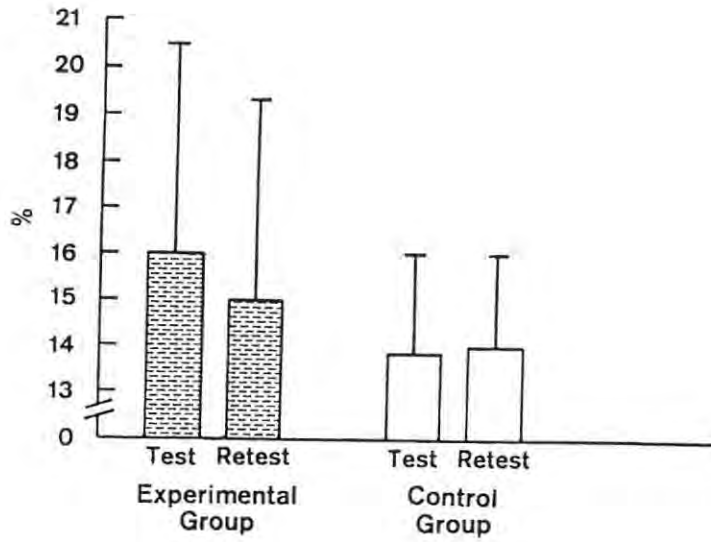
The larger gain in body mass in the control group (3.4%), as opposed to the 2.3% gain in the experimental group is directly related to the relative amount of fat lost and of lean body mass gained.

TABLE II: Summary of Skinfold Measures and Estimated Body Fat Mean Values (Standard Deviations in Parentheses)

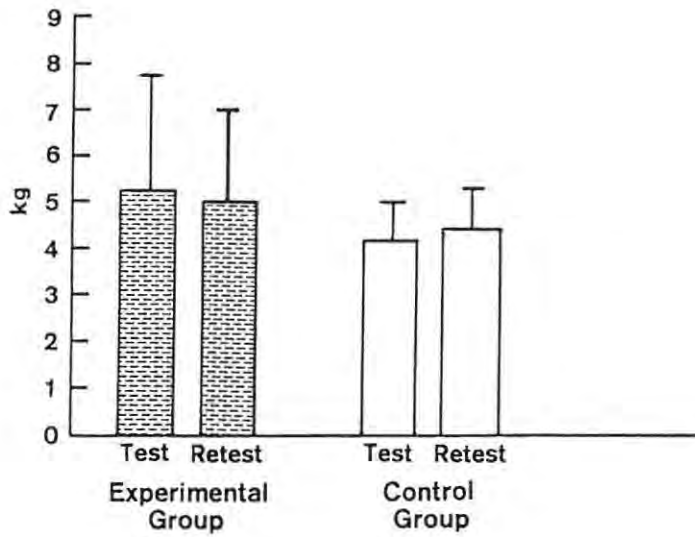
Skinfold Measures	Experimental Group		Control Group	
	Test	Re-test	Test	Re-test
Sub Scapula (mm)	6.97(2.2)	6.29(2.2)	5.88(0.94)	5.67(0.94)
Supra Iliac (mm)	5.86(3.1)	5.27(2.6)	4.23(1.2)	4.36(1.2)
Biceps (mm)	5.34(2.1)	4.81(1.7)	4.14(0.9)	4.16(0.8)
Triceps (mm)	9.99(4.0)	9.41(3.7)	8.27(2.3)	8.27(2.1)
Calf (mm)	10.31(4.9)	9.39(4.3)	8.04(3.1)	8.11(3.1)
Relative Body Fat (%)	16.08(4.3)	15.13(4.1)	14.00(2.2)	14.10(2.1)
Absolute Body Fat (kg)	5.23(2.4)	5.00(2.2)	4.16(0.86)	4.35(0.9)

NOTE: Bars indicate differences ($p < 0.05$)

On repeated testing relative body fat showed no significant difference in the control group (14.1%) over the three month period. This was in contrast to the significant drop in relative body fat from 16.08% to 15.13% experienced in the experimental group. There was a difference of 2.1% before the programme between the experimental and control groups. However, after the three month test period there was no significant difference. This was due to the fact that the experimental group before the programme had a higher relative body fat compared to the control group.



(A) RELATIVE BODY FAT



(B) ABSOLUTE BODY FAT

FIGURE 6: Relative Body Fat and Absolute Body Fat of the boys tested.

The reason for the non-significant difference in absolute and relative body fat measures between the groups is that the experimental group lost relative body fat whilst the control group gained relative body fat causing the two groups to become more alike.

Absolute body fat decreased significantly ($p < 0.05$) within the experimental group, by 0.23kg (4.4%), whilst the control group gained significant absolute body fat of 0.19kg. Before the programme the experimental group registered higher absolute body fat, a difference of 1.07kg (25.7%). However, by the end of the enrichment programme there was only a 0.65kg (14.9%) difference.

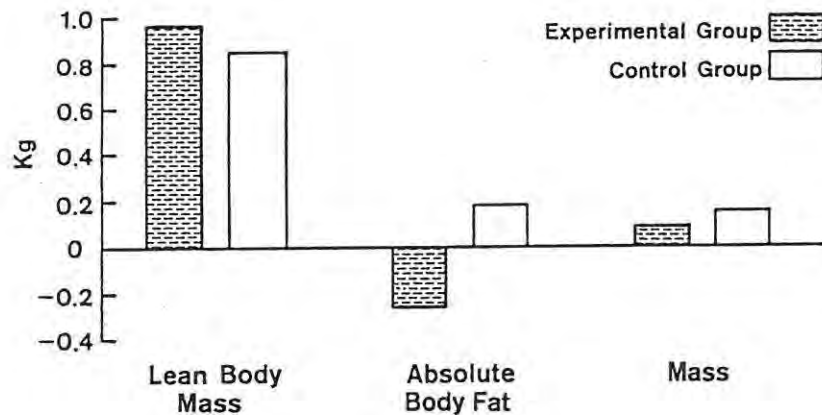


FIGURE 7: Body mass gains and losses over the test period.

The mean lean body mass (LBM) of the experimental group was 26.57kg, which was similar to that of the control group (26.27kg) before the programme. However, the experimental group increased in LBM by 0.94kg, whilst the control group

only increased by 0.83kg. Thus the experimental group increased by 13.3.% more than the control group over a period of three months. While both groups increased in body mass, the experimental group gained more LBM and lost more in absolute body fat, explaining why the control group gained 43.6% more body mass than the experimental group.

SOMATOTYPE

Boys tend to decrease in mesomorphy and increase slightly in endomorphy during the years leading to mid-adolescence, Carter and Heath (1990). The mean somatotype rating of the experimental group before and after the programme was 2.5 - 4.5 - 2.5, classifying the subjects as balanced mesomorphs. The control group, however, had a mean somatotype rating of 2.0 - 4.0 - 3.5 for both the test and re-test, classifying them as ectomorphic - mesomorphs.

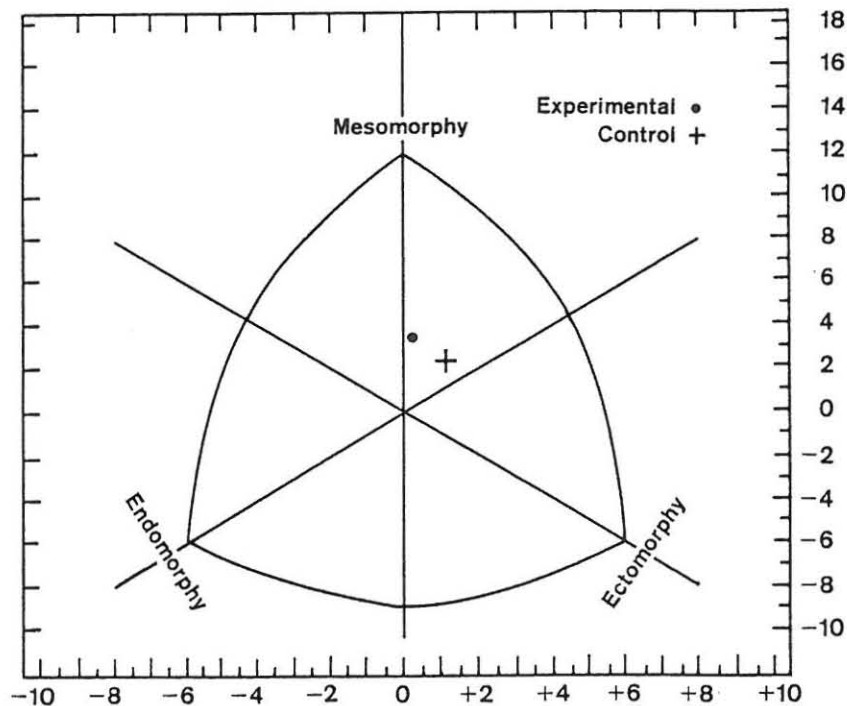


FIGURE 8: Somatotype of experimental and control groups.

The fact that there was a large variation within the sample probably accounts for the different mean somototype ratings of the experimental and control groups.

AEROBIC RESPONSE TO EXERCISE

According to Rowland (1985) controversy exists among researchers as to whether training regimes are capable of creating improvements in aerobic power in children. In the present study twenty pre-pubescent Black children underwent a soccer training programme which resulted not only in an improvement of aerobic power but also in running performance.

TABLE III: Summary of Cardio-vascular Test and Re-test results (with standard deviations in parentheses)

Variable	Experimental Group		Control Group	
	Test	Re-test	Test	Re-test
Resting HR (b.min ⁻¹)	81.5(6.25)	78.3(5.84)	83.0(4.0)	81.9(4.10)
Recovery HR	171.7(20.30)	151.3(22.40)	175.9(17.20)	172.6(20.80)
12 min Run (m)	2456(290.90)	2644(218.50)	2492(238.10)	2502(223.80)
Predicted VO ₂ max Relative (ml.kg ⁻¹ .min ⁻¹)	45.08(4.10)	47.77(3.10)	45.62(3.30)	45.75(3.10)
Absolute (l.min ⁻¹)	1.37(0.20)	1.49(0.23)	1.34(0.15)	1.40(0.16)

NOTE: Bars indicate these means which were significantly different (p<0.05)

The distance covered over the 12 minutes compare well with performances norms of Slovakian children of the same age (Komadel, 1988). There was, however, a significant increase in distance covered by the experimental group, a gain of 188m (7.7%) after the 3-month enrichment programme. The control

group on the other hand had only gained 10m (0.4%) over the same period. There was no significant difference between the groups before the programme.

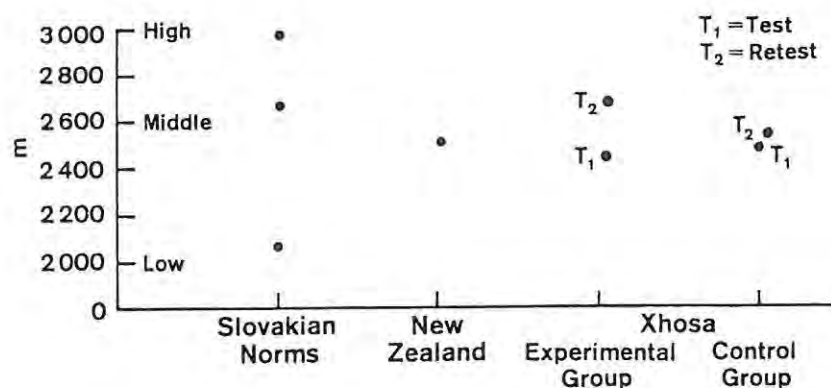


FIGURE 9: Comparison of distances covered over 12 minutes.

This gain in distance run directly affected the predicted relative and absolute VO_2 max of the subjects. Some researchers have found only moderate correlations between the 12 minute run performance and VO_2 max ratings, especially in children (Boutcher, 1990; Armstrong and Davies, 1984).

Motivation plays an important role as far as children are concerned. In order to ensure that individuals performed maximally pupils of one school were set to compete against those from another, with prizes such as small sums of money, sweets and cooldrinks providing extra incentives.

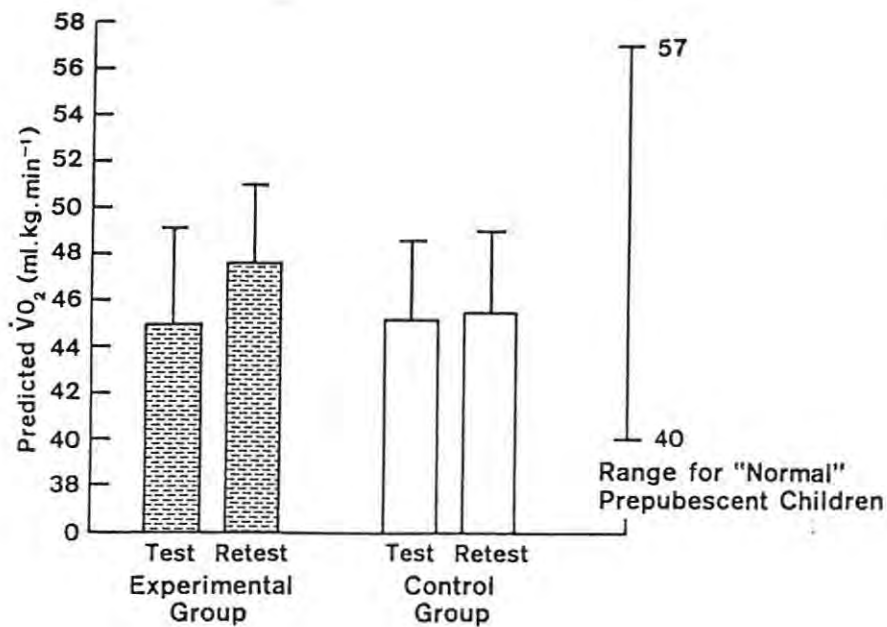


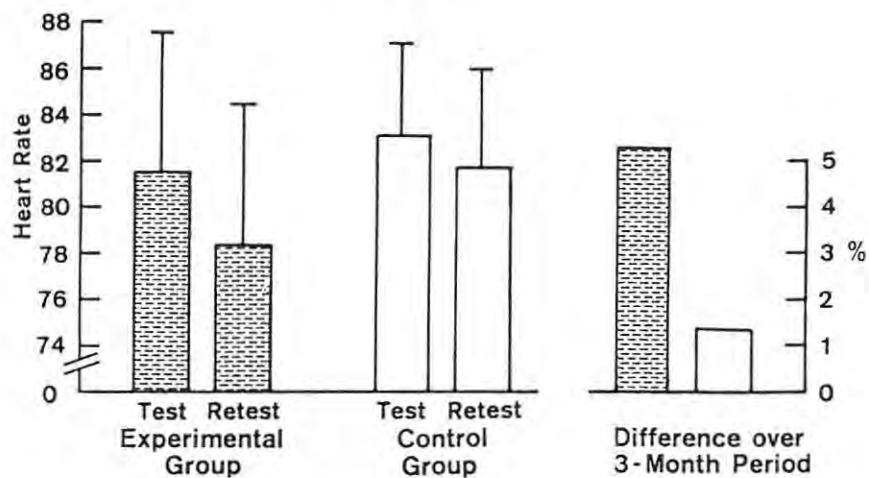
FIGURE 10: Predicted Aerobic Capacity

Before the programme there was no noticeable difference between experimental and control groups. The experimental group produced a predicted $\dot{V}O_2$ max of $45.08 \text{ ml.kg}^{-1}.\text{min}^{-1}$. It is generally accepted that 1MET equates to $3.5 \text{ ml.kg}^{-1}.\text{min}^{-1}$, which means the initial experimental group and control group test performances registered 12.9 METs and 13 METs respectively.

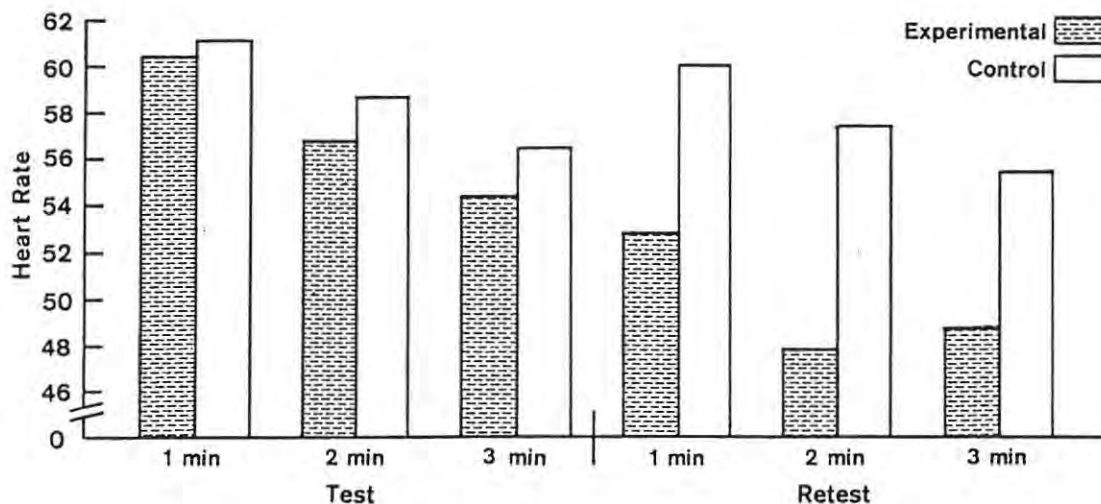
The means of both groups for predicted $\dot{V}O_2$ max over the three-month period were within the ranges of 40-57 $\text{ml.kg}^{-1}.\text{min}$ reported by other researchers for "normal" pre-pubescent children (Mirald and Bailey, 1981; Mero et al., 1990).

The resting heart rates (HR) of both groups before the programme were the same. The experimental groups resting HR before the programme was 82 b.min^{-1} whereas the control had

a resting HR of 83 b.min⁻¹. After the three month period the experimental groups resting HR had dropped to 78 b.min⁻¹, a decrease of 5.1%. The control group's mean resting HR showed an insignificant drop of 1.2%.



(A) RESTING HR



(B) RECOVERY HR

FIGURE 11: Resting and Recovering HR test and re-test means.

There was no significant difference in recovery HR between the two groups prior to the three-month programme. The mean recovery HR (sum of three 30s HR) for the experimental group was 172 b.min⁻¹, as opposed to the 176 b.min⁻¹ of the control group, a difference of 2.3%. The mean recovery HR for the experimental group after the three-month programme dropped to 151 as opposed to the 173 recorded for the control group; a significant difference of 14.5% between the two groups. The experimental group experienced a significant drop of 21 b.min⁻¹ (13.9%) in comparison to the insignificant 3 b.min⁻¹ decrease (1.7%) experienced by the control group.

The enrichment programme not only caused a noticeable drop in resting heart rate but also in the recovery heart rates of the enrichment group, indicating a positive response by the cardio-vascular system to physical exercise.

ANAEROBIC RESPONSE

The effectiveness of the anaerobic energy system was estimated by measuring peak anaerobic power output through the use of the Margaria-Kalamen Step Test. The findings are shown in Table IV.

TABLE IV: Summary of Anaerobic Test Results.

Variable	Experimental Group		Control Group	
	Test	Re-test	Test	Re-test
Velocity $\text{m}\cdot\text{s}^{-1}$	1.22(0.07)	1.32(0.07)	1.21(0.12)	1.24(0.11)
Relative Power ($\text{w}\cdot\text{kg}^{-1}$)	12.01 (0.74)	12.95(0.72)	11.93(1.20)	12.16(1.10)
Absolute Power (w)	370.80(77.90)	410.90(83.60)	353.00(52.90)	373.06(57.70)

NOTE: Bars indicate significant differences ($p < 0.05$)

Both the control and experimental groups reflected significant predicted increases over the three-month period. When the groups were compared, relative power and velocity showed significant differences after the enrichment programme; absolute power was not significantly different on re-test.

Velocity increased by 8% in the experimental group whereas the control group only experienced an increase of 2.4% (a difference of 6.4% between the two groups). The difference between groups prior to the programmes was hardly noticeable (0.8%). An increase in velocity and body mass will directly influence predicted absolute power values. It is interesting to note that even with a difference of 6.4% between the two groups after the training period, there was no significant difference between the two groups in absolute power. This is possibly due to the fact that 0.07 m.s (6.4%) difference in velocity between the two groups is too little to cause a noticeable difference in absolute power. Both groups did however show gains of 10.8% (40.1 w) and 5.6% (20 w) respectively.

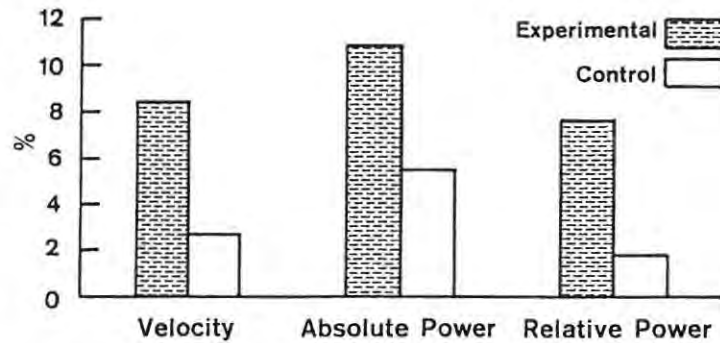


FIGURE 12: Percentage Improvements in Velocity and in Relative and Absolute Power.

These gains could be attributed to the increases in body mass and velocity in both groups over the training period. When absolute power was relativised for body mass the experimental groups showed a significant increase of 0.94 w.kg^{-1} (7.8%). The increase experienced by the control group was 0.23 w.kg^{-1} (1.9%). This brought about a significant difference of 0.71 w.kg^{-1} between the experimental and control groups after the three-month period. The change in both groups resulted from increases both in body mass and velocity over the enrichment period.

The reason for the noticeable difference favouring the experimental group is due to the higher absolute power values obtained in this group.

The amount of work performed was determined by multiplying the time required to run up the flight of stairs from the determined $\text{kg.m}^{-1}.\text{s}^{-1}$.

TABLE V: Summary of Work Done.

Variable	Experimental Group		Control Group	
	Test	Re-test	Test	Re-test
Joule	708.20	731.40	684.80	708.70
J.kg ⁻¹	22.94	23.16	23.13	23.14

The experimental group's absolute work output increased by 23.2J (3.3%) which was similar to the control group's 23.9J (3.4%). The experimental group, however, had higher absolute values both before and after the three-month programme, because of a heavier body mass than that of the control group.

Relative work, however, showed little difference between the groups, the reason being that while the experimental group was noticeably heavier in body mass than the control group (1.26kg) before the programme, they were only 0.9kg heavier after the three-month period. The preceding observations indicate that relative and absolute power increased not only with age but also as a result of an effective soccer training programme.

MOTOR FITNESS CHARACTERISTICS

Both the Illinois 18-Item Motor Fitness Tests as well as the CAHPER Motor Fitness Test were used to evaluate the motor fitness of Xhosa youth.

TABLE VI: Illinois 18-Item Motor Fitness Pass Rate (with standard deviations in parentheses).

Variable	Experimental Group		Control Group	
	Test	Re-test	Test	Re-test
Balance	1.8(0.69)	2.35(0.48)	2.12(0.79)	2.20(0.77)
Flexibility	2.7(0.47)	3(0)	2.62(0.57)	2.91(0.28)
Agility	1.7(0.57)	2.5(0.60)	1.58(0.50)	1.79(0.72)
Strength	2.05(0.60)	2.45(0.51)	2(0.51)	2.2(0.41)
Power	1.8(0.61)	2.4(0.50)	1.79(0.50)	1.87(0.44)
Endurance	1.55(0.51)	1.95(0.39)	1.41(0.50)	1.83(0.38)
Total Passed	11(1.6)	14(1.5)	11(1.7)	12(1.9)

NOTE: Bars indicate significant differences ($p < 0.05$)

The above mentioned test uses nominal data to evaluate the motor performance of the subjects. As can be seen from Table VI, test-re-test results show significant improvements in all six fitness components in the experimental group. The control group, on the other hand, only showed significant increases in flexibility and endurance. This is likely a result of the type of habitual activity to which these Xhosa boys are accustomed. The fact that the experimental group improved significantly over the test period can be attributed to the soccer training programme and the type of exercise used in the conditioning phase of this programme. The total number of tests passed for both experimental and control groups before the programme was 11; a pass-rate of 61.1%. After the three-month programme the experimental group's mean has risen to 14 (77.7%), as opposed to 12 (66.6%) for the control group. There was thus a significant difference of 16.6% between the groups after the training period. When the performance of the Xhosa pre-pubescent children was compared

against norms for the Illinois 18-Item Motor Fitness Test, they were classified as : "average" before the programme. The group that underwent training increased to a percentile ranking o 77.8 which ranked "above average". The control group remained "average" despite increases of 9% on re-test.

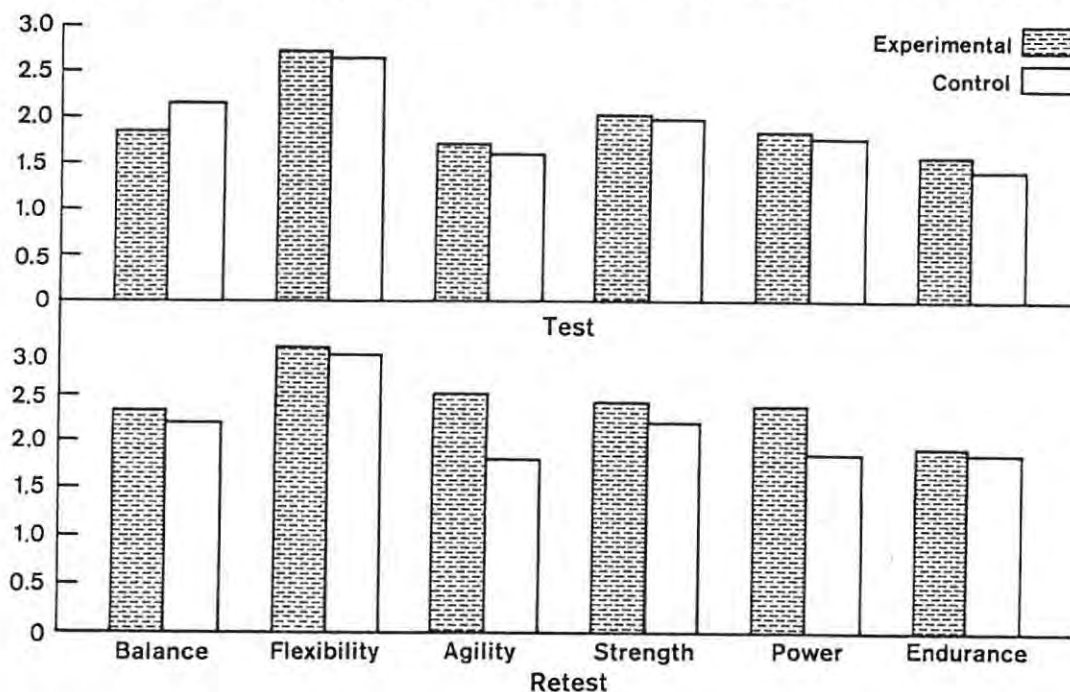


FIGURE 13: Illinois 18-Item Motor Fitness Pass Rate.

TABLE VII: CAHPER Motor Fitness Test results.

Variable	Experimental Group		Control Group	
	Test	Re-test	Test	Re-test
Shuttle Run (sec)	12.8(0.72)	12.2(0.54)	12.9(0.60)	12.9(0.58)
Flexed Arm Hang (sec)	29.6(10.40)	41.2(11.60)	29(10.60)	32.6(8.70)
Sit-ups	21(7.90)	32(5.60)	21(7.40)	24(6.20)
Stand Long jump (cm)	152(10.60)	162.4(11.90)	152.9(12.50)	155.6(14.20)
50m Sprint (sec)	9.2(0.66)	8.7(0.61)	9.3(0.52)	9.3(0.48)
300m Run (sec)	108(5.0)	105.6(3.8)	108.3(4.20)	108.9(4.0)

NOTE: Bars indicate significant differences ($p < 0.05$)

Because the above-mentioned test uses ratio variables the performance of the Xhosa children could be determined through time, distance and number. More information on performance abilities could therefore be determined.

Before the three-month programme there was no significant difference between the groups in motor performance ability by this test battery. This, however, changed over the enrichment period, resulting in significant differences in all tests except the standing long jump.

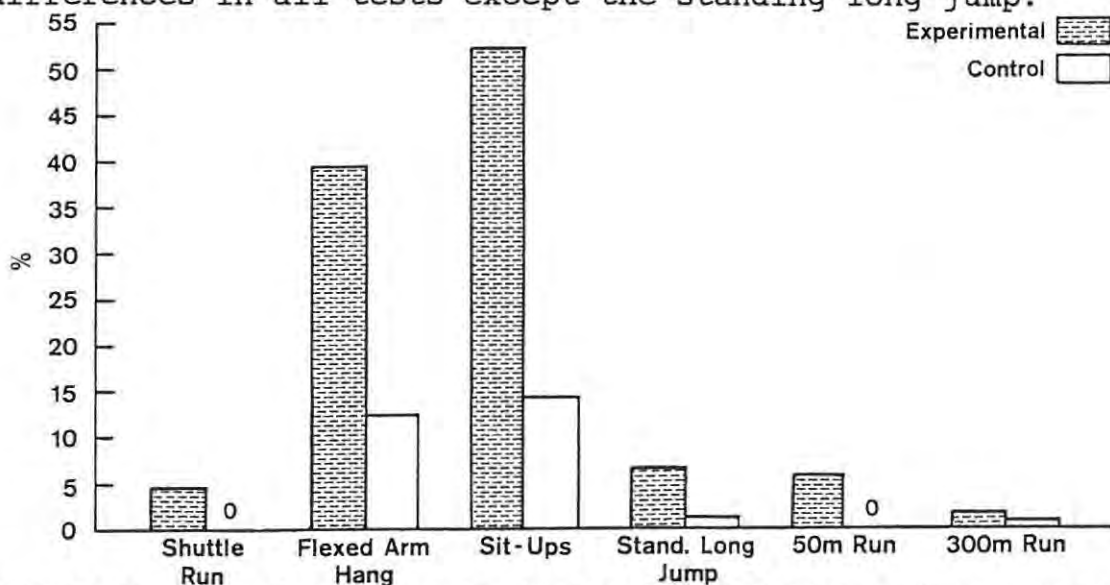


FIGURE 14: Improvements in the CAHPER Motor Fitness Test

Even though the experimental group increased its jump distance by 6.8% (10cm), as opposed to the 3cm (1.7%) gain experienced by the control group, the difference between the means of both groups, after the three-month period, was only 6.8cm. Both experimental and control groups showed significant gains in the flexed hang as well as the 60s speed sit-up test over the period. Despite these significant increases, there were still significant differences between the two groups; a 26.3% difference for the flexed arm hand and a 33.3% difference for the 60s speed sit-up test.

Both the Illinois 18-Item Motor Fitness Test and the CAHPER Motor Fitness Test presented valuable information regarding the effects that growth and an effective training programme have on motor performance. The group subjected to the training programme indicated a favourable overall response to the additional physical activity. For the purpose of this study the components of motor performance were measured and evaluated separately.

Balance

Numerous authors agree that the period in which the child optimally learns the widest variety of movement patterns can be located between 9-12 years of age (Borms, 1986); To determine the balancing capabilities of young pre-pubescent Xhosa-speaking children, the simple balancing tests of the Illinois 18-Item Motor Fitness Test were used. As can be seen from Figure 12 the experimental group mean, before the programme, was 1.8, a pass rate of 60%. After the enrichment programme the experimental group pass-rate had increased to 78.3% (2.35). The control group had a higher pass-rate of 70% (2.1) before the three-month period, but only managed to increase by 4.7% over the three months. Although there was an improvement in balance in both groups, the experimental group revealed a greater improvement over the training period. The improvements in both groups could be attributed to the type of habitual activity in the lives of these Xhosa children and additional training and skill practice for the experimental group.

Borms (1986) postulates that for some, sports training cannot start too early and that pre-school years offer the optimal conditions for the systematic learning of co-ordination exercise.

Flexibility

According to Haywood (1986), some improvement in flexibility with age has been noted in young children, but most studies show a decline in flexibility beginning in the early teens. Contrary to this statement, significant increases in the mean Sit-and-Reach flexibility of both the experimental and control groups were displayed on re-test.

TABLE VIII: Sit-and-Reach; Test and Re-test Results.

Variable	Experimental Group		Control Group	
	Test	Re-test	Test	Re-test
Sit and Reach (cm)	7.98(3.35)	10.07(3.65)	7.42(3.03)	7.97(3.80)

NOTE: Bars indicate significant differences ($p < 0.05$)

The experimental group increased by 2.09cm (26.2%), whereas the control group showed a gain of 0.55cm(7.4%). On initial testing there was no significant difference between the control and experimental groups. However, a significant difference of 2.1cm (26.3%) was noticed on re-test of both groups. This noticeable difference could be attributed to the fact that the greater gains were experienced in the experimental group that had undergone a routine of stretching exercises during the warm-up period before the training programme.

Comparison of the means of the Xhosa boys of this study with other ethnic groups reported in the literature, shows the performances of the Xhosa children were by far superior.

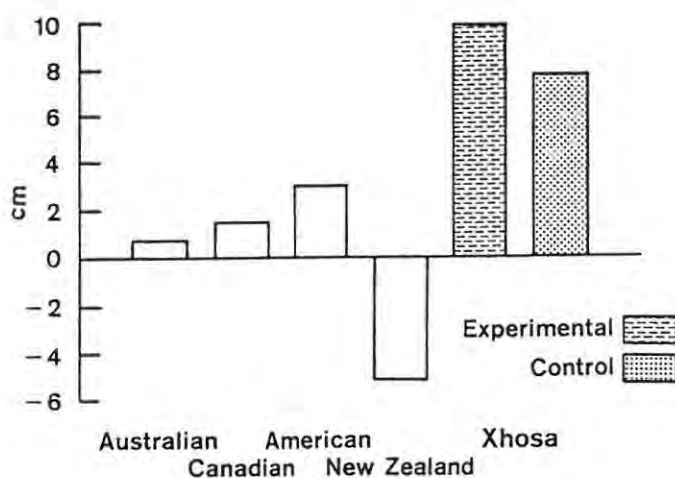


FIGURE 15: Comparison of Sit-and-Reach performances of Xhosa boys to that reported in the literature (after Pyke, 1985, Ross et al, 1985, Wilson and Russell, 1985).

Habitual activity associated with lower back and hamstring flexibility such as long distance running, lifting and carrying of objects and manual work, probably account for the superior sit-and-reach ratings.

Similar superior performances were obtained by both groups in the Illinois 18-Item flexibility component. The mean of the experimental group was 2.7 (a pass-rate of 90%), which was similar to the 86% pass-rate experienced by the control group prior to the three-month programme. Both groups increased their performances in flexibility by 11% on re-test. However, the experimental group experienced a pass-rate of 100%, as opposed to the 93% pass-rate of the control group in the re-test.

Agility

Agility, defined as the ability to rapidly change direction of the body or its parts, is dependant on components such as speed, co-ordination, balance and power. The fact that the experimental group experienced significant changes in the agility tests over the training period, reflects the contribution from the improvements in other motor fitness components. These will be discussed later.

The experimental group experienced an increase of 47% over the test period, whereas the control group only managed a 13.3% increase. This resulted in a significant difference of 39.6% after the three-month period. There was no significant difference between the groups before the programme (initial test).

In the CAHPER Motor Fitness Shuttle Run component there was a significant drop of 4.9% (0.6s) in the experimental group over the training period. The control group showed no change over the three-month period, their times being the same as in the initial test.

There was no significant difference between the experimental and control groups before the programme. However a significant difference of 5.7% (0.7s) was noticed after the three-month period. Sloan (1966), compared the Shuttle-Run performance of South African White, Coloured and African adolescent boys and postulated that White and Coloured boys improved progressively, while Africans improved irregularly with age. He found White boys to be better than Africans at most ages, but failed to attribute this to

relatively disadvantaged African backgrounds, at least as a primary explanatory factor. Campbell and Pohndorf (1961) used the CAHPER Motor Fitness Test to determine norms for British and American children. Both groups fared better in the Shuttle-Run component than Xhosa-speaking children in the present study. This may well have reflected lack of familiarity with this sort of "game-like" activity on the part of the subjects of this study.

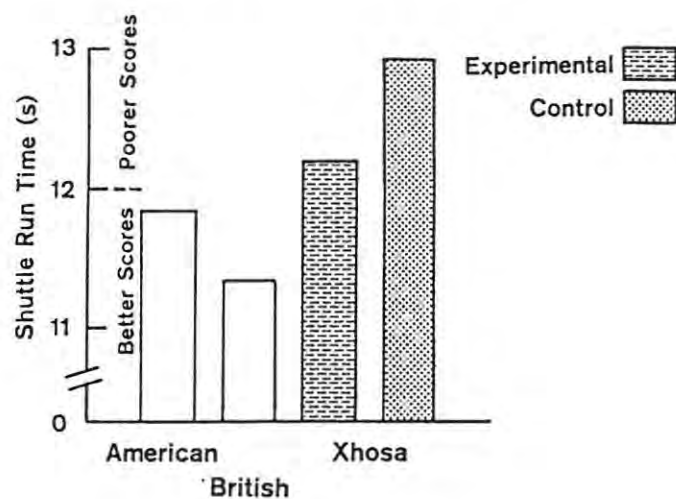


FIGURE 16: Comparison to British and American Norms for the Shuttle-Run.

The fact that they were slow in getting off the ground had an influence on the time required to complete the Shuttle Run. Never-the-less a considerable drop in the experimental group shuttle-run time was experienced due to the positive response of a soccer training programme.

Strength

Despite the controversy regarding pre-pubescent strength training, (as discussed in Chapter II) there is consensus that both pre-pubescent as well as post-pubescent children can respond to appropriate resistance training. This will

ultimately result in increased muscle strength. The same conclusion was reached with the experimental group after a training programme of three months. Even the control group experienced an increase in their strength performance over the three-month period. This supports the finding of Rowland (1990), that muscle strength increases linearly with chronological age from early childhood to 13-14 years of age in males, after which there is a marked acceleration.

In the Illinois 18-Item Motor Fitness Test, both the experimental and control groups passed at least two out of three strength tests (a pass-rate of 66%). After the three-month period there was an increase of 20% in the experimental group as opposed to only 10% in the control group. There was, however, no significant difference between groups prior to the training programme or after the three-month period. Because of the high pass-rate of both groups prior to the programme, and because there was an increase of only 1kg in body mass, it could be anticipated that after the enrichment programme there would be similar results between the two groups.

The CAHPER Motor Fitness Test, on the other hand, presents more valuable information regarding improvements in various strength tests. All six components of the CAHPER Motor Fitness Test are reliant on strength. However, for the purpose of the discussion, only the Flexed Arm Hang and Sit-ups are addressed because the other tests include velocity, making it more appropriate to discuss them under power.

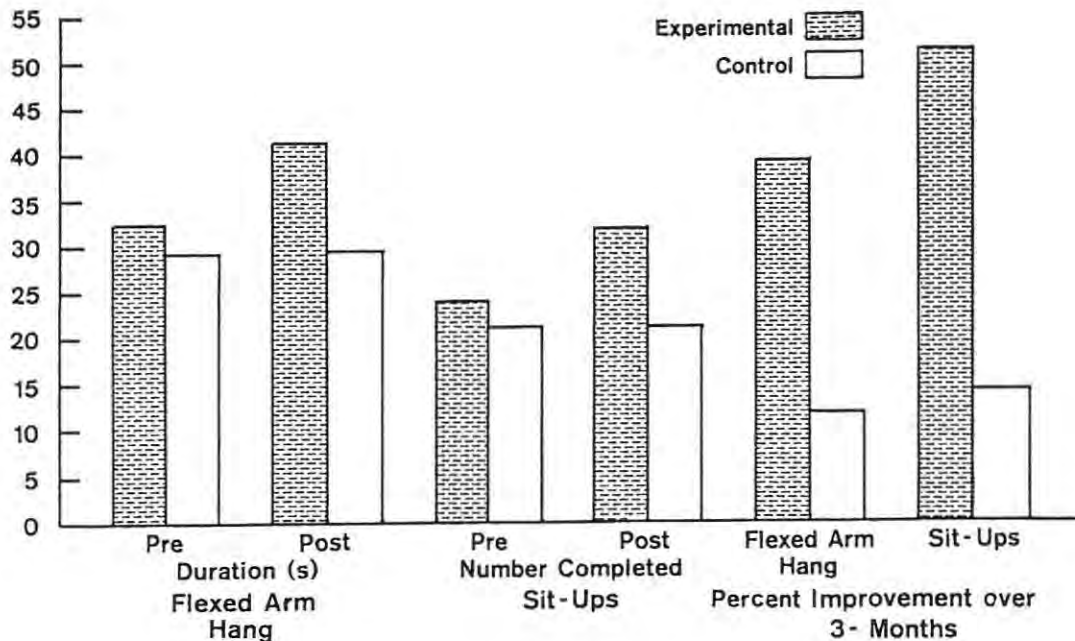


FIGURE 17: Results of Flexed-Arm Hang and Sit-ups.

Both experimental and control groups increased their hanging time in the Flexed Arm Hang over the three-month period. Significant gains of 39.1% for the experimental group and 12.4% for the control group were obtained. Even though both groups increased their hanging times noticeably, there was still a significant difference between the groups after the training period. This is attributed to the additional specific strength training received by the experimental group during the training programme.

A similar trend for both experimental and control groups was experienced in the CAHPER Sit-up Test. Both groups achieved significant increases over the three-month period, with the experimental group showing the largest increase of

11 sit-ups (52.3%), as opposed to the 3 sit-up improvement (14.2%) by the control group. The raw difference between the groups after the training period was 8 sit-ups (33.3%).

Sloan (1966) found a tendency to improve performance in sit-ups among White South African boys only; they were better than Coloured boys, who, in turn, were better than African boys of adolescent years.

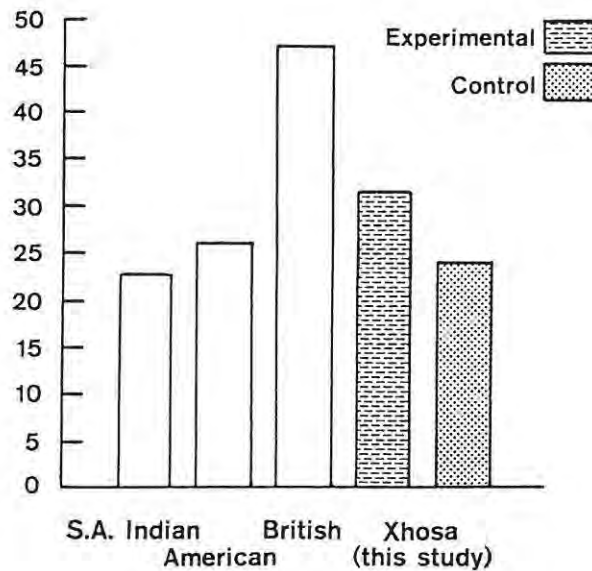


FIGURE 18: Comparison of Sit-up Results.

In comparison to the Sit-up performances of British, American (Campbell and Pohndorf, 1961) and South African Indian 11 year old children (du Toit et al., 1978), the mean number of sit-ups for both the experimental and control groups was inferior to all compared ethnic groups. However, after the three-month period, due to significant increases by both groups, the control re-test mean was similar to that of the American and South African Indian norms and the

experimental groups mean, because of additional physical activity and strength training was superior to that of American and Indian norms, although still well below the mean for British 11 year old children.

It can therefore be argued that, even though there are significant increases in strength due to growth and increased muscle mass, pre-adolescent children show visible gains in strength due to effective training programmes.

Power and Speed

An increase in strength will obviously directly influence power and speed. It has already been determined that not only growth, but also an effective training programme does increase strength performances. Before the experimental programme the mean pass-rate for the Illinois 18-Item Power Tests was 60% for the experimental group and 56.6% for the control group. After the training period the results indicated a significant increase of 33.3% for the experimental group as opposed to only 5.8% experienced by the control group. There had been no significant difference between the groups before the enrichment period. Of the three power exercises in this battery, straddled chinning presented the most failures and problems because of weak upper body strength.

Already when anaerobic capacity was determined, there were positive increases in power performance running up a flight of stairs. The results obtained for the Standing Long Jump also indicated gains in distance in both the experimental and control groups over the three-month period,

with the experimental group showing a significant gain of 6.8% (10.4 cm) and the control group increasing by only 1.7% (2.7cm).

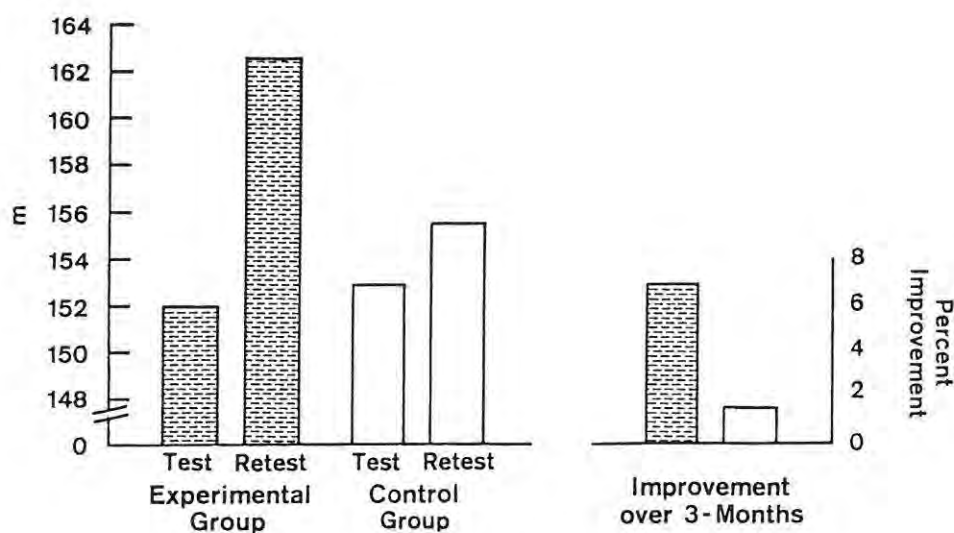


FIGURE 19: Results of Standing Long Jump Test.

No significant differences were noticed over the three-month period between the experimental and control groups. There was, however, a difference of 6.8cm (4.3%) between the groups after the three months. The fact that the experimental group indicated a significant increase over the training period can be attributed to the enrichment programme they were subjected to.

The results obtained for the Xhosa-speaking boys were similar to those of Australian children (Pyke, 1986) and American children (Haubenstricker and Seefeldt) in Malina and Bouchard (1991), Standing Long Jump performance.

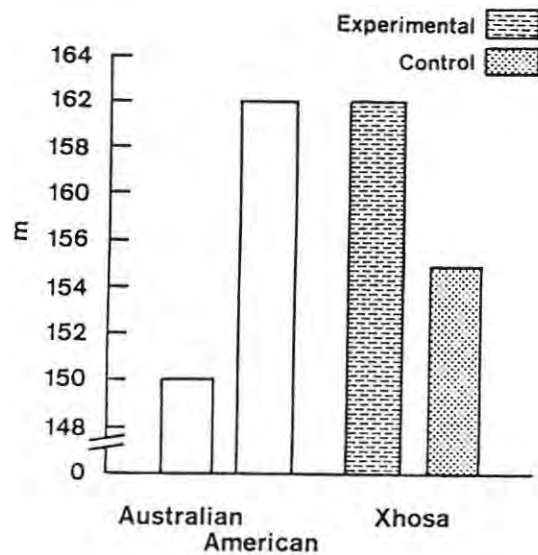


FIGURE 20: Comparison of Standing Long Jump Performances.

Running speed increased significantly in the experimental group over a distance of 50m. The experimental group experienced a drop of 0.5s (5.7%) as opposed to the no change in the control group. The difference between the groups after the three-month period was 0.65s (6.8%). The fact that the experimental group had gained in lean body mass and had significantly lost 4.6% absolute body fat, is one reason why the experimental group experienced a drop in time required to run 50m. Another reason was that the experimental group's performance increased because of the positive response to an enrichment training programme.

When the results of the Xhosa group were compared to other ethnic groups (Komadel, 1988; Pyke, 1986), they proved similar to Australian children, but rated low in comparison to Slovakian children.

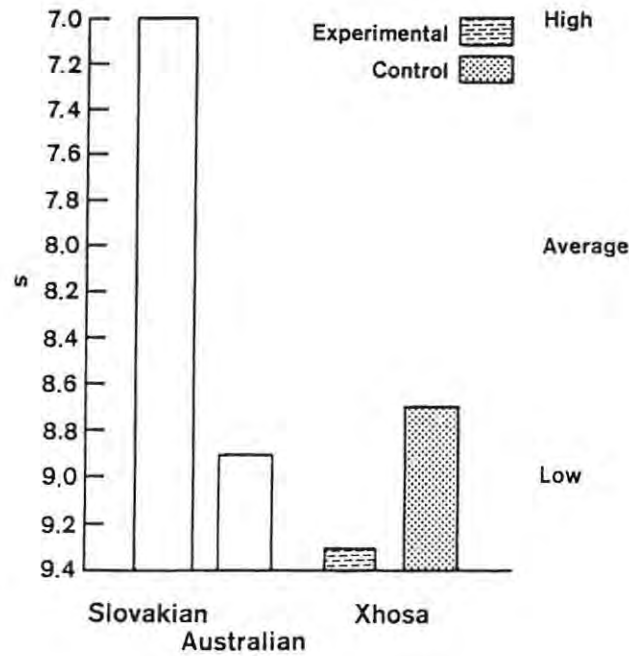


FIGURE 21: Comparison of 50m Performance Results.

Sloan (1966), in a comparative study on adolescent South African children, found White and Coloured boys to be superior to Black boys in the 50m sprint. The findings of Sloan, as well as the fact that there was an improvement in the present study, not only in speed, but also in power, strength, agility and flexibility, corroborates the claim that the reason for the poor performance by "Blacks" is because of a lack of organised coaching and training programmes.

Endurance

Figure 12 shows that both experimental and control groups experienced significant increases in the Illinois 18-Item Motor Fitness Test of endurance. The experimental group recorded an increase of 26% as opposed to 29% in the control

group. The experimental group's initial pass rate was 51.6% as opposed to 47% for the control group. After the three-month period the experimental group had a pass-rate of 65%, as opposed to 61% experienced by the control group. From the above results it can be seen that the increases experienced by both groups were similar. The endurance hops presented no problems to any of the subjects. However, when the subjects had to breath-hold, or to hold the V-sit position for a time, it was easy to succumb to "acting". A test that prevented this type of situation was the CAHPER 300m run.

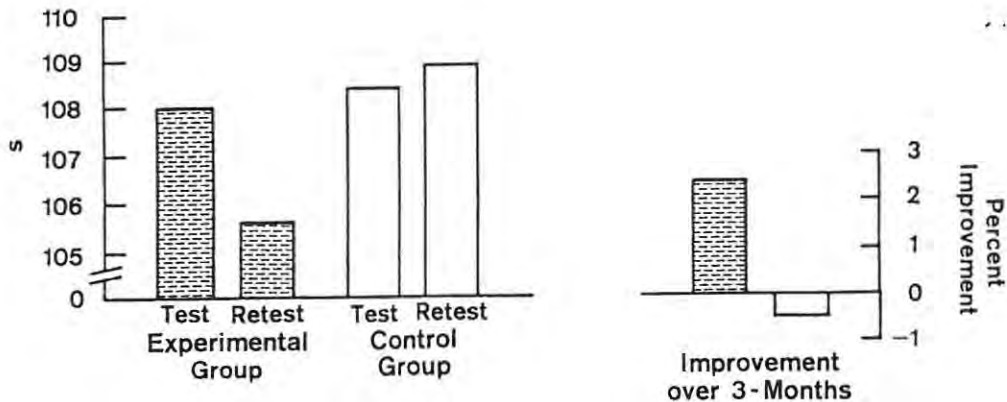


FIGURE 22: Results of the 300m run.

The experimental group indicated a significant drop in the time required to cover the 300m. There was no noticeable change in the control group over the duration of the study. The experimental group experienced a drop of 2.3% (2.4s), whereas the control group experienced an increase of

0.5% (0.65s) over the same period. This brought about a significant re-test difference of 3.1% (3.3s) between the groups.

The distance covered in the 12 min run also shows a significant increase of 188m (7.6%) for the experimental group, as opposed to only a 10m increase (0.4%) from the control group. This suggests that there was an improvement not only in mechanical running efficiency, but also in the functioning of cardio-respiratory systems. The fact that the experimental group increased its aerobic capacity and lean body mass, and experienced a significant drop in body fat because of the positive effect of the training programme, gave them the added advantage over the control group.

AUTHOR'S SKILL EVALUATION

The author's expertise regarding subjective skill and match play assessment is based on years of experience as player (Provincial level) and coach, and his credentials as a qualified physical educator with primary, secondary and tertiary level teaching experience. The author has been involved in coaching of senior amateur and semi-professional teams, while being personally involved in playing soccer. From knowledge gained through study and experience over 20 years of competitive soccer, the author was able to assess, albeit subjectively, qualities of good match play as well as virtuosity and skill. Being able to control a ball with your feet, while concentrating solely on the specific task reflects adroitness, but skill alone does not constitute good

match play. This, in many cases, is the downfall of many Black soccer teams. It must be said, however, that a high skill level in conjunction with the ability to "read" a soccer game constitutes the basis for good match play. To be unselfish and "allow the ball to do most of the work" will ensure a good match performance.

Many "Black" senior soccer players have to show-off their personal ball skill during a game, which rubs off on the youth which in most instances, either disregard or have never learned the basics of good match play. This was most evident in the early stages of the training programme in the present study. Ball-control skill ranged from "adequate" to "superb". This presented the problem of individuals with superb skill keeping the ball among themselves and of neglecting to pass the ball to "average" players. A soccer team is comprised of eleven players, all fulfilling an important role for effective and good match play. Over the training period the twenty subjects learned that the basic pattern of running into space and passing the ball comes first, before trying to out-dribble the whole opposing team. This solved the problem of "bunching" over the ball. The type of soccer played by Xhosa youth encompasses both above mentioned problems because of large numbers and little space. It is seldom that children of this age get to play in organised soccer matches that would obviously prevent problems of this nature.

This was evident when the type of soccer played by the training group was compared to that of the control group,

after the enrichment programme. Irrespective of the various skill levels, the experimental (training) group played a more structured and disciplined game than did the control group. They did not rely only on skill, but also on the basics necessary to effective match play. Positional play and creating opportunities were improved, which directly affected match performance.

It is therefore possible to assert, even although the assertion defies measurement, that an effective training programme not only produced improvements in personal performance but also in match performance.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Aims of the Study

This study sought to examine the anthropometric, physiological and motor performance characteristics of a selected group of pre-pubescent Xhosa-speaking children as well as to determine the effects, if any, of a soccer enrichment programme over a period of three months. In addition to this, the aim was to subjectively determine improvements in match skill, if any, over the training period.

The tested hypothesis was, therefore, that there would be no difference between pre- and post-test results obtained prior to and following the enrichment period.

METHOD

A group of 50 Xhosa-speaking children, 11 years of age, was selected from two local township schools in Grahamstown. The control group represented 30 randomly selected pupils, 15 pupils from either school, while the experimental group comprised 20 pupils. Both groups participated in a pre- and post-test session, while only the experimental group participated in a 3-month soccer programme.

The training programme consisted of anaerobic, aerobic, muscle strengthening exercise as well as skill and match

practice. Each session lasted for an hour, three times a week, starting with a warm-up.

Data collection involved anthropometric measurement of stature, body mass, femoral epicondylar and humeral condylar diameters, calf girths and various skinfolds. Aerobic measurements of predicted VO_2 max and resting and working heart rates. Aerobic power and work were assessed and Motor Fitness tests, including the Illinois 18-Item and CAHPER Motor Fitness tests, were conducted.

RESULTS

1. Somatotype

Somatotype ratings showed no change over the three-month period. However, there was a difference between the ratings of the two groups. The experimental group classified as balanced mesomorphs, whereas the control group was, on average, ectomorphic-mesomorph. The different ratings could be accounted for through the large variation within the sample group.

2. Body Composition

While there was no significant group difference in mass before or after the programme, it must be mentioned that the control group experienced a larger mass increase than did the experimental group. The reason for this was that the experimental group experienced a marked drop in relative body fat together with an increase in lean body mass, whereas the control group gained more in body fat and less in lean body

mass, allowing the groups to become more comparable following a difference of 2.1% before the programme.

3. Aerobic Response

Subjects who participated in the training programme experienced higher predicted VO_2 max mean values, as well as, a mean further running distance than the subjects of the control group. Improvements were also noted in resting and recovery heart rates of the experimental group after the three-month programme, indicating an overall improvement of the cardio-respiratory system.

4. Anaerobic Response

Even though both groups reflected significant increases in anaerobic power over the three-month period, the experimental group experienced larger gains in relative power, absolute power and velocity. Anaerobic power therefore increased not only with age, but also as a result of an effective soccer training programme.

5. Motor Fitness

In both the 18-Item Motor Fitness Test and CAHPER Motor Fitness Test the experimental group, which had undergone a soccer training programme, performed better than the control group after the period of study.

Significant improvements in all six fitness components of the 18-Item Motor Fitness Test were experienced by the experimental group, as opposed to the improvements in only two fitness components (endurance and flexibility), by the control group. Before the programme both groups were classified as "average", when their performance was compared

against the American norms for the 18-Item Motor Fitness Test. Following the enrichment programme, however, an "average" rating was achieved by the control group, whereas the experimental group had improved to an "above average" classification.

Regarding the CAHPER Motor Fitness Test, pre-testing showed no significant inter-group difference. However, post-testing results reflected significant differences in the shuttle run, flexed arm hand, sit-ups, 50m dash and the 300m run. In the standing long jump the experimental group reflected a marked increase in distance as compared to the control group.

6. Adroitness in skill and match-play improved considerably over the three-month training programme, allowing for a more structured and disciplined performance for the experimental group (personal observation).

CONCLUSION

No increase in the growth-rate tempo was observed during the experimental period in either the experimental or control groups. Similarly the somatotype rating of both groups, was consistent over the three-month period. Body composition, however, indicated significant results and differences between groups over the training period. This indicated a positive response to the additional physical activity by the selected experimental group.

Increases in predicted anaerobic as well as aerobic power and running economy were experienced by the experimental group, as a result of the enrichment programme.

In most of the motor fitness components, improvements were noticed in the group subjected to additional training. The motor fitness components that favoured both groups were flexibility and endurance in the 18-Item Motor Fitness Test and standing long jump in the CAHPER Motor Fitness Test.

One can conclude that, irrespective of improvements due to growth, a well organised and executed soccer training programme contributes to improvements in body composition, anaerobic and aerobic power, motor fitness, general skill and match performance.

Hypothesis 1

Hypothesis 1 was rejected in the case of all physiological and motor performance variables and for all but one of the anthropometric characteristics. Only somatotype remained unchanged by the experimental treatment.

Hypothesis 2

Hypothesis 2, likewise, was rejected in respect of all physiological and motor performance parameters, and for all but one of the anthropometric characteristics, for again, only somatotype, matched prior to the experiment, remained the same in experimental and control groups after the experiment.

RECOMMENDATIONS

The keen interest taken by the selected group in their enrichment programme can be attributed to the sport with which they could associate themselves, this contributing to the positive results. Soccer per se, is a sport which demands anaerobic and aerobic power and various motor fitness components. These constitute attributes which therefore can contribute to a generalisable improvement in physical work capacity.

A more scientific approach is needed in determining nutritional status. Though there were no overt signs of malnutrition, nutrient deficiencies could not be determined.

When working with individuals who are not accustomed to motor tests it would be advisable to introduce these skills at an earlier stage to allow subjects to become accustomed.

For comparative purposes the CAHPER Test battery proved to be more informative regarding motor skills.

Incentives and rival competition proved to be sound factors which contributed to maximal performance in the 12-min run.

Psychological factors regarding individual performance in the enrichment programme need to be carefully studied, especially when working with pre-pubescent underprivileged children.

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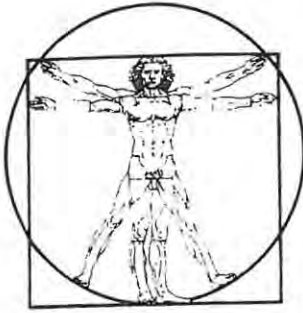
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HUMAN MOVEMENT STUDIES

APPENDIX 1

February, 1991

The Headmaster,
Makana Primary School,
Rini Township,
GRAHAMSTOWN

Dear Sir,

I would like to begin a study on underprivileged children and the effects a well organised physical activity enrichment programme will have on them. I am therefore in need of your assistance and would appreciate if you would allow me to use 25 pupils of your school for the enrichment programme.

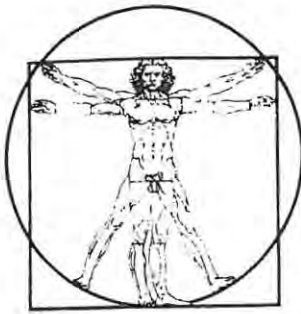
The programme will be executed during the afternoon so as not to interfere with the academic programme of the school. This will be an ideal opportunity for the elected to participate in a constructive form of exercise after school.

I look forward to your reply at your earliest convenience.

Yours faithfully,

Mr F. van Rooyen.





HUMAN MOVEMENT STUDIES

APPENDIX 2

February, 1991

The Headmaster,
Archie Mbolekwa Primary School,
Rini Township,
GRAHAMSTOWN

Dear Sir,

I would like to begin a study on underprivileged children and the effects a well organised physical activity enrichment programme will have on them. I am therefore in need of your assistance and would appreciate if you would allow me to use 25 pupils of your school for the enrichment programme.

The programme will be executed during the afternoon so as not to interfere with the academic programme of the school. This will be an ideal opportunity for the elected to participate in a constructive form of exercise after school.

I look forward to your reply at your earliest convenience.

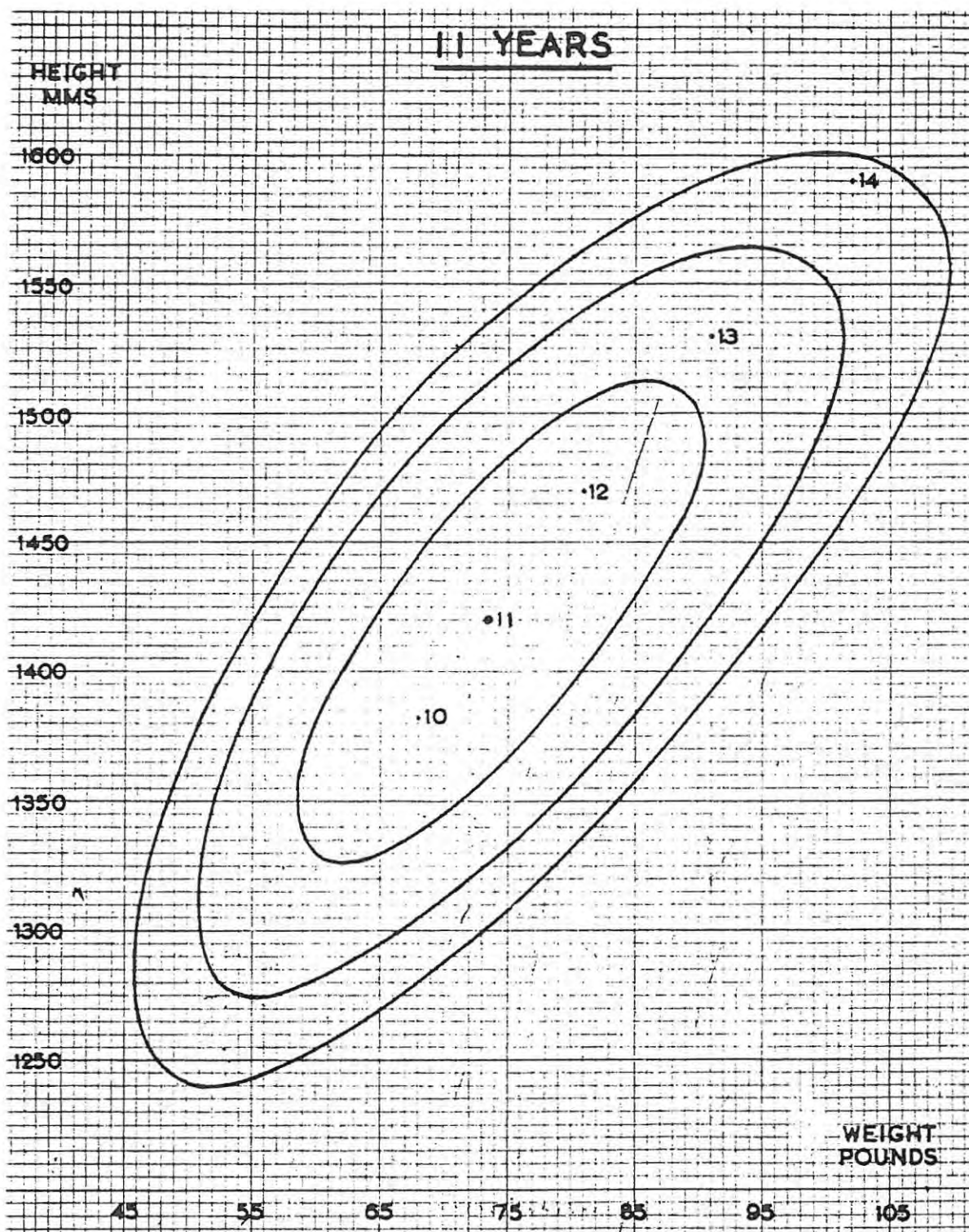
Yours faithfully,

A handwritten signature in cursive script, appearing to read 'F. van Rooyen'.

Mr F. van Rooyen.



Grobbelaar's weight-height and distribution chart and general growth curve for White South Africans.
 (Grobbelaar, 1964)



APPENDIX 5

Protocol following the guidelines of Charteris and Walker (1971)

THE CURETON "ILLINOIS" 18 - ITEM MOTOR FITNESS TEST

COMPONENT	ITEM	(CHECK)	
		PASS	FAIL
Balance	1. <u>Diver's Stance</u> , heels raised, eyes closed, 20 seconds.		
	2. <u>Squat Stand</u> , 10 seconds, balance.		
	3. <u>Dizziness Recovery</u> , walk 10 foot line, 5 seconds after 10 turns around with finger on floor.		
Flexibility	4. <u>Floor Touch</u> , knees straight (Women touch palms flat).		
	5. <u>Trunk Flexion Forward</u> , sitting position, knees held down, forehead slowly to within 8" of floor (2 fists, 1 on top of other).		
	6. <u>Trunk Extension - Backward</u> , lying on front, (buttocks held down), hands behind neck; raise chin 18" from floor.		
Agility	7. <u>Kneeling Jump</u> , spring to feet; hold balance 3 seconds.		
	8. <u>Jack Spring</u> , touching hands to toes at least waist high; 5 times in succession.		
	9. <u>Agility 6 - Count Exercise</u> , squat, extend legs backward, shoot through hands, extend legs forward, flip over, return to squat-rest position, return to standing position. (6 times in 20 seconds).		
Strength	10. <u>Man Lift</u> , pick up partner of own weight and place on shoulder for carry; in 10 seconds.		
	11. <u>Stick Body</u> , hold 30 seconds, head on partners knee, own hands on hips.		
	12. <u>Extended Press-ups</u> , from hands and toes without using elbows. (Women do forearm press-ups, 20 seconds).		
Power	13. <u>Standing Long Jump</u> , Height + 1 foot.		
	14. <u>Floor Push-Ups</u> , 15 times (Women do 30 from knees).		
	15. <u>Straddle Chinning</u> , 20 times (Women do 10).		
Endurance	16. <u>V-Sit</u> , 60 seconds.		
	17. <u>Breath Holding</u> , 30 seconds after running in place 120 seconds at 180 steps per minute.		
	18. <u>Endurance Hops</u> , in succession 200 up and down, 200 straddle jumps, 200 alternate strides, 50 hops on left foot, 50 hops on right foot and as many full squat jumps as possible.		