DEVELOPMENT OF A NUTRITIONAL SUPPLEMENT FROM LOCAL FOODS AND DETERMINATION OF ITS EFFICACY IN IMPROVING NUTRITIONAL STATUS AND PHYSICAL ENDURANCE IN LONG-DISTANCE ATHLETES AT NGONG TRAINING CAMP, KENYA

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A THESIS SUBMITTEDIN FULFILLMENT OF THE REQUIREMENTS FOR THEAWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY INAPPLIED HUMAN NUTRITION

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DECLARATION

This thesis is my original work and has not been presented for award of a degree in any other university:

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ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
SPSS	Statistical Package for the Social Sciences
BMI	Body Mass Index
Hb	Hemoglobin
FFM	Free Fat Mass
% FM	Percentage of Fat Mass
TBF	Total Body Fat
ATP	Adenosine Triphosphate
IAAF	International Association of Athletics Federations
WADA	World Anti-Doping Agency
AK	Athletics Kenya
RDA	Recommended Dietary Allowances
FFA	Free Fatty Acids
CHO	Carbohydrate
AOAC	Association of Official Analytical Chemists.

DEFINITION OF TERMS

Intervention	Nutritional supplementation
Pre-intervention	Period before supplementation
Post-intervention	Period after supplementation
Participants	Athletes randomly selected for the study
Intervention group	supplementation group
Control group	Participants not on supplementation.
Control	Unsupplemented Group
Physical endurance	Both muscular and cardio-respiratory endurance.
Product	The nutritional supplement
Athle-food	The Food supplement developed under this Research study
Group I	Women Athletes' Group
Group II	Men Athletes' Group

ABSTRACT

The present study was conducted on long distance athletes training in selected private training camps in Ngong area, Kenya. The objective of the study was to develop a nutritional supplement from local foods and determine its efficacy in improving nutritional status and physical endurance of long distance athletes at Ngong Camp, Kenya. Food Frequency and 24-hour food recall methods were used to determine food and nutrient intake. The study was designed to comprise food and nutrient intake assessment, Dietary supplement development and supplementation intervention to determine its' efficacy in improving nutritional status and physical endurance in long distance athletes. This study included 11 women and 13 men who were selected purposively from a population 0f 36 athletes. Assessment done included both anthropometric and body composition. Food frequency analysis showed that cereal and cereal products were consumed daily by 95.8% of all the respondents, followed by dairy products whose daily intake was at 95.8%. Daily consumption of vegetables was at 87.5% whereas meat intake was at 62.5%. Pulses and legumes were poorly consumed with daily intake at only 16.7% with fruits being the least consumed at 8.3%.According to the 24 hour food recall results, the mean daily calorie intake of women was 1072.45 Kcal representing 40% of the Recommended Dietary Allowance (RDA), whereas calorie intake for men was 1266.76 Kcal which represented 46.6% of the RDA. Results of t-test revealed that there was a significant difference between calorie intake by men and women *(P=0.032)*.The mean daily carbohydrate intake for women and men was 150g and 195g, respectively. This represented 37.4% and 47.9% of the RDA for the groups, respectively. This level was inadequate to maintain muscle glycogen at normal levels and prevent muscle glycogen depletion for the endurance athletes which require to be maintained at adequate levels. Statistical analysis showed that there was a significant difference between carbohydrate intake by men and women *(P<0.002).* Average daily fat intake for women and men was 29g (39% of RDA) and 27g (37 % of RDA) respectively. Mean daily protein intake for women and men was 54.81g and 59.53g which represented 54.6% and 58.9% of the RDA respectively. Analysis of the results also showed no significant difference between protein intake by men and women *(P<0.286*). The mean daily iron intake for the groups I and II was 9.56mg and 11.98mg which represented 53.1% and 79.8% of the RDA respectively. The iron intake by men and women was found to have significant difference (*P<0.001*). The average calcium intake for the two groups was 708.9mg and 827.23mg which represented 59% and 68.8% of the RDA respectively. Calcium intake by both men and women had no significant difference *(P<0.229*).
The food supplement developed for this study constituted of Soya, Pearl millet and Skimmed milk powder as ingredients. According to the proximate composition analysis done on the most acceptable product, the results showed that the product developed contained 228.2mg of calcium, 3.95mg of iron, 71.97g carbohydrate, 8.72g fat, 17.37g protein, 435.84 Kcal, 8.22g moisture and 1.42g of total ash content per 100g of the product. On sensory evaluation results, the study formulation was rated highest with 50% of the respondents rating Overall acceptability of the formulation as Liked very much. Body composition results showed a significant increase in the mean body weight in the supplemented male group as compared to the unsupplemented/control group *(P< 0.001).*The results showed similarly, there was a corresponding significant increase of the mean Body mass Index for the same group as compared with the control group (*P< 0.001*). The same results also indicated a significant increase in the mean Fat Free Mass in the supplemented group as compared with the control group (*P< 0.008*). In the women supplemented group, the mean percentage body fat significantly reduced from 19.79 to 19.72 %

(*P=.0.049*) as opposed to the unsupplemented group. In both men and women however, there was insignificant change in percentage bone mass. In conclusion the findings indicate that there was inadequate food and nutrient intake according to recommended Dietary Allowance values. it is therefore recommended that sports' nutrition education be incorporated of in training camps to sensitize athletes about good dietary habits for improved performance. These research results should be used to justify and avail Dietary supplement developed in line with the findings to the athletes, to enhance their nutritional status and physical endurance even as more research in this area need to be done.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

Athlete's nutrition is a crucial factor in performance enhancement and several studies have showed that adequate nourishment enhances athletic performance.. Research carried out in this area have found out that when compared to healthy sedentary persons, iron deficiency anemia is more prevalent in athletes, also referred to as sports' anemia. In addition, their energy, protein and calcium needs are increased and many of them become deficient (Pramukova, 2011).

The local foods are well endowed with the various nutrients and if formulated would supply the required intake of the nutrients. The present study investigated the efficacy of a calorie, protein, calcium and iron rich dietary supplement on nutritional status and body composition of long distance-athletes. Nutritional counseling and support is very important in order to equip the athletes with adequate knowledge to help them make right choices of food. Athletes have special nutritional needs and meal timing to enhance/optimal sports performance and achieve adequate hydration (Pramukova, 2011).

As the duration of physical exercise lengthens, however, protein is used through the process of gluconeogenesis in the liver to produce glucose so as to maintain glucose level in the blood(Kato et al., 2016). The athletes also need to take in adequate protein to meet the Recommended Dietary Allowances (RDA) in order to maintain positive nitrogen balance, help in repair of worn out tissues as well as maintain healthy muscle mass(Knuiman et al., 2018).

Adequate calorie intake is very crucial for the endurance athletes in order to spare protein and prevent muscle wasting(Vitale &Getzin, 2019). Fat intake should be just enough to meet the RDA in order to provide alternative source of energy during the longdistance competition as well as enhance absorption of fat soluble vitamins. Apart from adequate energy and macronutrient intake, long distance endurance athletes also need to ensure adequate intake of iron to meet the RDA in order to prevent sports' anemia which is common in long distance runners(Hinton, 2014).Calcium intake is also needed in adequate amount in order to meet the RDA for maintenance of strong bones and prevention of osteoporosis, and also enhance healthy muscular activity during competition (DellaValle, 2013)..

In this study, supplementation intervention was guided by nutritional requirements for athletes as per the Recommended Dietary Allowances for Energy, Protein, Calcium and Iron because these are the nutrients that have been found to be very important for Athletes (Jeukendrup, 2011). Recommended energy intake should be at the level of 45-50 Kcal per kilogram of ideal body weight per day in order to meet the increased energy demands. The protein requirements for an endurance athlete is approximately 1.2 to 1.4 grams per kilogram of body weight per day, equivalent to about 15% of the total daily energy requirement. Fat is a major source of fuel for exercise, but the fat intake should be moderate to avoid overload through accumulation as adipose tissue and gain in weight. Recommended energy intake as fat is 20% of the total daily calorie intake. Recommended daily intake of Calcium and Iron for athletes is 1,000mg and 8mg respectively. Female athletes however require a higher daily iron intake (15mg) in order to avoid sports' anemia(Vitale &Getzin, 2019).

The aim of the study was to formulate from local foods an appropriate supplement which in addition to the regular foods eaten would help to supply adequate amounts of Calorie, protein, calcium and iron. It was envisaged that this supplement would be better affordable than the available international supplements, which were currently out of the affordable price range by athletes and would therefore provide a good alternative. Different types of supplements were available in the market viz. carbohydrate supplements, protein supplements, minerals and vitamin supplements, iron supplements, antioxidants, carbohydrate-protein mix and creatine supplements (Vitale &Getzin, 2019).

1.2 Statement of the Problem

In some instances, Kenyan athletes have resorted to use of foreign formulations whose effects, merits and demerits they do not understand very well, with some unknowingly using already banned supplements leading to their ban from sports. Moreover, most of the athletes training in the private camps in Kenya have no financial support from the government and therefore can't even afford imported supplements though may be legally acceptable (Reardon & Creado, 2014). Currently, there is no single locally formulated affordable nutritional supplement in Kenya that athletes can use to enhance their competitiveness. Kenyan athletes have sometimes experienced serious injuries during the competitions, a setback that is very often traced to poor nutrition and deficiency of some crucial nutrients, such as iron and calcium. Sports nutrition is also poor, and often the athletes are not even able to take adequate nutrients from the commonly eaten diets. There are, however, no systematic study results that show intervention in athletics camps that can guide nutritional education and interventions.

1.3 Justification of the Study

This research was driven by understanding of increased nutritional requirements and physiological effects of exercise. Kenyan athletes though highly performing lack an organized support in nutrition and practice before international competitions. Most of the success was own initiative. Increase in nutritional knowledge and availability of affordable and working nutritional supplements with performance enhancement capability will go a long way in improving the performance of the athletes. The local foods are well endowed with the various nutrients and if carefully selected and intermixed in formulation will supply the required intake of the nutrients. If these food supplements are proven to work like the imported ones, then they will give confidence to the Kenyan athletes.

Secondly, sports have become lucrative occupation with some countries getting good revenue from sporting events. Performance enhancing food supplements will therefore enhance revenue generation in the countries that invest in them. Regarding choice of ingredients for the nutritional supplement, pulses are a key source of quality protein important for adequate tissue repair and recovery from strenuous exercise. The grains (cereals) contain high calorie necessary to replenish the glycogen stores and provide energy needed for competition. The cereals also contain high levels of phosphorus, vital for energy generation in form of ATP, for synthesis of nucleic acids including the DNA as well as synthesis and maintenance of bones. Then calcium is needed e.g. from milk and dairy products, Omena, bone soup etc., for bone synthesis and prevention of osteoporosis, for stamina and performance (Editor, Journals And Conferences, 2022).

Pulses and legumes are also rich in Zinc which is very vital for body cell synthesis and strong immune system. Soybean also supplies high levels of iron, needed for synthesis of erythrocytes /red blood cells and prevention of anemia/sports anemia and fatigue. Other nutrients important in sports and high in soybean are folic acid and selenium (Chen et al., 2021).Pulses can be very well complemented with pearl millet because this is high in protein, available carbohydrates, energy, iron and Zinc. The study findings will also be of benefit to coaches and investors/team managers because they would use the information to improve nutritional status of their athletes and enhance their physical endurance and competitiveness.

1.4 Objectives of the Study

1.4.1 Overall objective

To develop a nutritional supplement from local foods, and determine its efficacy in improving nutritional status and physical endurance of long distance athletes at Ngong Camp, Kenya.

1.4.2 Specific objectives

i) To determine food consumption and intake of protein, energy, iron and calcium by long distance athletes at Ngong training camp.

ii) To develop a nutritional supplement for long distance athletes from local foods that is high in protein, calcium and iron.

iii) To establish efficacy of the nutritional supplement in improving the nutritional status of the long distance athletes.

iv) To establish efficacy of the nutritional supplement in improving the physical endurance of the long distance athletes.

1.4.3 Research Hypotheses

i) Food consumption and intake of protein, energy, iron and calcium by long distance athletes is inadequate.

ii) An acceptable nutritional supplement that is high in protein, calcium and iron cannot be developed from local foods.

iii) Long distance athletes' nutritional status cannot be improved by consumption of a nutritional supplement which is high in protein, calcium and iron.

iv) Long distance athletes' physical endurance cannot be improved by consumption of a nutritional supplement which is high in protein, calcium and iron.

CHAPTER TWO: LITERATURE REVIEW

2.1 Athletics – Global Perspective

At the international level, Athletics is a sport that is managed by the body called International Association of Athletics Federations (IAAF). At the beginning, the body was founded in 1912 and named International Amateur Athletics federation at its' first congress held in Sweden, with attendance of representatives from seventeen national athletics federations(Hurst et al., 2020).. The headquarters of this organization has been Monaco since 1993.The word Amateur was retained by the organization in its' name until the congress held in 2001, at which the name was changed to International Association of Athletics Federations.

World Anti-Doping Agency (WADA) is another organization that complements the work of International Association of Athletics Federations in management of athletic activities(Vorona & Nieschlag, 2018).The body was established through an initiative spearheaded by the International Olympic Committee (IOC).Establishment of this organization was necessitated by the desire of promotion, coordination and monitoring the fight against abuse of drugs in sports (Legg et al., 2015).

2.2 Athletics in Kenya

Kenya is a great sporting country, which is best known for winning awards in athletics with its' athletes winning several awards at Olympics and other World International competitions(Byron & Chepyator-Thomson, 2015). However, although Kenya is mainly known as a giant in athletics in the world of sports, there are many more games that Kenyan sports men and women can explore and do well.

Other sporting activities open for competitions in Kenya include; Rugby, Golf, Water sports, motor sports, mountain climbing, cricket and Football. Although Kenya is highly successful in athletics, it is important to note that the success is limited to only middle and long distance races. From the series of victorious events at marathon, field and track competitions, Kenya has several great sporting legends, who include; Catherine Ndereba, Paul Tergat, Joseph Ngugi, Tecla Lorupe, Moses Tanui and Kipchoge Keino among others. In Kenya, competitions in field and track events are usually held at the national sports stadiums which include; Nairobi Gymkana, Nyayo stadium, Nairobi city stadium and Moi International Sports Centre-Kasarani (Simiyu Njororai, 2012).

Athletics events/ competitions in Kenya (both field and track) are governed by the body called Athletics Kenya (AK).This body is a member of the Confederation of African athletics and International Association of Athletics Federations (IAAF).All athletic competitions held in Kenya are organized by Athletics Kenya and this body is also in charge of Kenyan teams that are sent to international competitions. Athletics Kenya has been headquartered in Riadha house, opposite Nyayo National Stadium, in Nairobi (Murray, 2023).

Since November 2006, Athletics Kenya has also been operating an athletics Museum in Riadha house. This body has also won awards such as Kenyan Sports Federation of the year awards in 2006, 2009 and 2010. Some of the government organizations most Kenyan athletes affiliate themselves with include; The Kenya Police Service, Kenya Defense Forces, Public Universities, Colleges and Kenya Prisons Service. Private athletics clubs in Kenya include Kiptenden and MFAE clubs in Kericho and Nyahururu Counties respectively (Njororai, 2016). Field and track events that are held all over the country are coordinated by several associations. The events include the following:

2.2.1 Lewa marathon

This Marathon was started in the year 2000 with the purpose to raise funds for support of conservation and projects in North-Eastern Kenya. The Marathon is held annually at the Lewa Wildlife Conservancy. Participants from all over the world are invited to join the race which has been ranked among the top ten toughest marathon races in the world. It is a unique marathon where athletes run at an altitude of 1,650m above sea level and the only marathon in the world that takes place in a game reserve(Bale & Sang, 2013).

2.2.2 Mombasa marathon

This marathon is an important way to attract and promote sports tourism in Kenya, since Mombasa is a reputed tourist's destination. The marathon is held annually in May and since it is at sea level altitude, it is a key tourists' attraction and among the world's elite marathon races (Finn, 2013).

2.2.3 Nairobi marathon

This marathon is held annually and was started by the Standard with purpose of raising funds to support various community programmes in Kenya. The second purpose of the marathon was to promote the race in the country and provide a platform for local athletes to compete in preparation for international competitions, as well as give an opportunity for upcoming athletes to test their competence(Finn, 2013).

2.2.4 Kericho tea run

The marathon was started in 2010 by the Tea Board of Kenya and has now been upgraded to a 42 Km International Marathon, where participants get unique experience of running through beautiful sceneries of tea plantations in the Kenyan Rift valley. It also provides an opportunity for upcoming athletes to test their competency. Athletics Kenya is a body established by the Kenya government and works in collaboration with the Ministry of youth affairs and sports and Nike is its' major events sponsor (Simiyu Njororai, 2012). There are corporate institutions that also sponsor different sporting and track events and they include; Safaricom Kenya which sponsors relays, Kenya Commercial Bank which sponsors cross country and National Bank of Kenya which sponsors field and track events and the New KCC among others. The great support of the Athletics Kenya by the sponsors has contributed immensely to the recent tremendous achievements the body has enjoyed (Garthe & Maughan, 2018).

2.3 Nutrition and Athletics

2.3.1 Importance of nutrition in athletics

Immune system strengthening also require generous intake of micronutrients and treat nutrient deficiencies. Therefore in order to meet the increased nutrient and calories requirements, athletes should consume balanced diets (Gastrich et al., 2020). Nutrient supplementation is an essential strategy which can be used to correct dietary inadequacies though cautiously so as not to over supplement. Following supplementation guidelines and engaging in moderate training maintenance of immune system can be achieved and risk of contracting upper respiratory tract infections can be minimized (Peeling et al., 2019).

2.3.2 Carbohydrate requirement for athletes

Another study also confirmed that intake of high glycemic index carbohydrate foods resulted in elevated muscle glycogen levels one day following endurance physical activity compared with consumption of equal amounts of low glycemic index carbohydrate foods. (Burke, 1997).High carbohydrate, non-greasy, limited fat and readily digested diet is recommended before an event. 3-4 hours to an event, 200 to 300g of carbohydrates (4g/kgbwt) should be provided, and 1hour before the event 1g/kgbwt carbohydrate should be given. Sports drinks should have 6-8% carbohydrate. Carbohydrate content above 10% in sports drink is associated with abdominal cramps, nausea and diarrhea, whereas concentrations below 5% may not help performance.

One study was done to investigate changes ontherate of perceived exertion, hormonal and metabolic responses to carbohydrate supplementation both during and following sessions of endurance physical exercise. The study involved 15 long distance runners aged between 21 and 31 years who were engaged in 2 sessions of following carbohydrate and placebo consumption(Kanter, 2018).The 2 sessions were run covering a distance of 10 Km with the

2nd session starting after 1min 30 sec and both sessions were completed within 28 minutes The results reported elevated blood glucose in both sessions with significantly higher average blood lactate among the participants supplemented with carbohydrate as compared to those on placebo. Confirmation of the metabolic stress which was induced by the physical activity was achieved by interpretation of the increased heart rate. However, there was no significant difference observed between the two group trials during the physical activity in regard to plasma free fatty acids, insulin and Cortisol (Mata et al., 2019). . It was found out that among the participants who were on carbohydrate supplementation, insulin and free fatty acid concentrations were significantly lower following recovery after the physical exercise.

In a similar research study was conducted to establish relationship between consumption of high carbohydrate diet and capacity of recovery following endurance treadmill running to exhaustion. In this study, normal diets of two groups of participants were supplemented one with complex carbohydrate and the other group supplemented with simple carbohydrate. The runners were 30 in total and were in two groups i.e. 15 men and 15 women with all of them completing weighed food intake diaries between 2 to 3 wks prior to commencement of the study.

Following the end of 1st trial, the participants were grouped into 3 equal groups i.e. complex carbohydrate group, simple carbohydrate group and control group(Burke et al., 2011). The two groups on carbohydrate supplementation (complex and simple carbohydrate) raised their carbohydrate consumption by 70% for a 3 days period before commencement of trial 2, whereas boosted their energy with more fat and protein to achieve energy intake equivalent to the other two groups.

The study findings reported a significant enhancement of running time to exhaustion in both groups 1(with complex carbohydrate) and 2(with simple carbohydrate) whereby group 1 improve their performance by 26% and group 2 with 23%. There was however insignificant improvement in performance of the control group. It is important to note that blood glucose and lactate concentrations had no significant difference during trials 1 & 2 free fatty acid plasma concentrations were lower before the 2^{nd} trial for the simple carbohydrate group and complex carbohydrate group. During the 2^{nd} trial, the two carbohydrate groups showed significantly higher ratios of respiratory exchange as compared with ratios recorded during the 1^{st} trial. These study findings therefore provide evidence that capacity of recovery from strenuous physical activity is improved by raising the level of carbohydrate intake which may be achieved by using complex or simple carbohydrate to supplement normal diet.

A study carried out to investigate efficacy of carbohydrate supplementation on replenishment of glycogen stores and utilization during cycling by elite participants, reported that with increase in dietary carbohydrate consumption by the participants for a period of 3 days (from 6-9gkg^{-1} body mass, there was only slight increase in glycogen stores. Moreover, there was insignificant enhancement of performance in cycle time trial (Aandahl et al., 2021).From the study findings therefore, there was no significant improvement in cycle time trial and so it was concluded that supplementation with carbohydrate does not enhance athletic performance in athletes competing in continuous intense events lasting up to 1 hour. Moreover, significant levels of glycogen were still observed in the muscles by the end of exercise indicating that fatigue is not determined by depletion of glycogen stores in this duration of endurance exercise.

2.3.3 Athletes' protein requirement for athletes

One study reported that too much intake of protein, can lead to excessive urea production (Uremia) increasing dehydration risk which also may cause loss of calcium (Witard et al., 2019). A different study done to test the efficacy of carbohydrate loading on boosting athletic performance, the study findings established that the six men involved in the study ran 30 kilometers on a treadmill faster with carbohydrate supplementation (Knuiman et al., 2018).

However, many studies have recommended a slightly higher intake for athletes. As long as there is adequate intake of energy, a broad range of protein consumption would ensure maintenance of Fat Free Mass. For those athletes whose goal is to achieve hypertrophy of muscles, it would be of benefit to consume higher amount of protein within his/her dietary protein requirement since metabolically there is rationale on efficacy of higher protein intake and evidence on harmful consequences of increased protein intake is limited. There are however, few research study reports that convincingly show necessity of consuming high protein (2-3g kg bwt^{-1} day^{-1}).

A study was conducted to investigate relationship between protein supplementation and endurance training versus sex hormones and body composition. For a period of 3 months, twenty participants were each supplemented with 50 g/day of one of the 4 different sources of protein (i.e. soy isolate, soy concentrate, soy isolate plus whey blend and whey blend only) coupled with a program of physical endurance training(Pittman et al., 2018).According to the research findings, regardless of the source of protein, supplementation with protein led to significant improvement in fat free mass. For the % body fat, body weight or BMI, total and free testosterone, there was no significant difference observed between groups. However, elevated ratio of testosterone/estradiol was observed in all groups with reduction of estradiol. Analysis within groups a significant elevation of testosterone/estradiol ration in the group that received soy isolate plus whey blend. Those on whey blend only showed significantly lower estradiol.

A comparative study was conducted to the efficacy of whey protein versus soy protein supplementation in enhancement of physical activity, improvement of fat free mass and antioxidant activity. Fat free mass gain was evaluated in university male students who were engaged in body building training and supplemented with micronutrient fortified protein bars containing either whey or soy protein(Witard et al., 2019). The trainings were done in sets with few repetitive numbers. The control group did similar training but did not consume either of the protein bars. The results showed that both groups supplemented with soy and whey protein gained fat free mass whereas the control group did not. However, both whey protein and control groups reported low potential against oxidative damage. Following the findings, it was concluded that both whey and soy protein bar supplements enhanced physical performance, resulted to more increase in fat free mass but only soy had the extra benefit of promoting antioxidant activity.

2.3.4 Iron and Calcium requirement in athletics

Calcium is a vital minral in building strong bones and enhancing effective muscle contraction in sport. Calcium deficiency can lead to osteoporosis and weakening of bones. This would greatly compromise athletic perfomance (Desbrow et al., 2019). Although wrong dietary choices greatly contribute to deficiency of minerals especially in athletics, exercise intensity could also be a cause of the deficiency (Córdova et al., 2019).It is important to note that few studies have demonstrated efficacy of supplementation with minerals on physical performance, although for optimal health mineral supplementation is beneficial.

A separate study found out that physicians, coaches and nutritionists are greatly concerned about high prevalence of iron deficiency in athletes engaged in physical endurance. In a related study, hepcidin which is an iron metabolism regulator, was found to be elevated after physical exercise and this was discovered to correlate with elevation of interleukin-6 (DellaValle, 2013).The same study result findings showed that the level of hepcidin concentrations in well trained athletes of good iron status remained high in line with iron signals and inflammation inspite of supplementation with vitamin E (400 IU/day) and vitamin C (500 mg/day) for a period of 1 month.

It is easy for one to criticize the sports anemia concept. This is simply because the concept only takes into account blood levels without due consideration to haemodilution that results from training by athletes. Absence of this assessment complicates diagnosis of anemia and evaluation of any treatment becomes difficulty(Bass & McClung, 2011).. Consumption of balance diet or intake of iron supplement is the two keyways of preventing or treating anemia.

In another study, Daily 24 hour food recall done in 3 consecutive days showed that on average daily energy intake was 41 Kcal/Kg bwt and energy contribution of carbohydrate, fat and protein was 58.3, 29.2 and 12.5% respectively(Smith et al., 2015). The study found out that generally athletes' intake of vitamins was higher that recommended dietary allowance for each of the vitamins, whereas iron and calcium intake was lower than 100% of the recommended dietary allowance.

2.4 Nutritional Supplements

All sports and most competition levels have been affected by abuse of drugs. Drug abuse in athletics could be a result of a number of factors such as; to withstand high expectation to perform, heal physical injuries and pain, manage stress of retirement from sports, enhance performance as well as treatment of mental illness. Advancement in use of physical performance enhancement substances has been in progress with development of new strategies of doping characterized by scientific research for development and use of ergogenic substances which have similar effects as the banned substances, in response to advancing technologies and methods on detection of use of banned substances(Reardon & Creado, 2014). Use of sports' performance enhancers has been banned by most of the organizations that govern sports in the world which have developed strict punitive measures for their users. Some of the ways by which substance abuse in athletics should be addressed include counseling, motivational interviews and prescribed pharmacological interventions.

One study has reported a significant association between nutrient intake and damage of muscles, immunity, oxidative stress and markers of inflammation. These findings show that supplementation with certain nutrients especially vitamin C could enhance physical performance by reducing oxidative stress (Kantor et al., 2016).

One study reported that athletic teams have started employing and depending on team nutritionists for nutritional counseling and support of their elite athletes and this provides proof that there has been a realization that to achieve optimal athletic practice and performance, proper nutrition is very important. To avoid injuries due to sports, improve performance, hasten recovery after competition and prolong time of practice adequate intake of specific nutrients is very important(Tawfik et al., 2016).

In one of the research findings it was reported use of banned substances especially anabolic steroids and stimulants was on the rise. A number of other substances found in some of these supplements are responsible for high morbidity and mortality(Aljaloud & Ibrahim, 2013). All partners in sport should join hands in handling this issue, especially by providing them with the education that they need in order to be well informed of the harmful effects of using such substances.

2.5 Nutritional Supplements for Sports

Among the latest studies, a study on the effects of supplementation with peptide of silk on physical performance by mice was conducted with all the mice being trained on trend mill. Assessment was done 2 weeks before and after training by measuring VO2 max. Energy metabolism was also assessed following the period of training, during a 1 hour training exercise. Apart from taking blood samples for assessment, hepatic glycogen, gastrocnemius red and gastrocnemius white muscle were obtained at 3 different time intervals i.e. before exercise, immediately post-exercise and 1 hr. after the physical activity (Martínez-Sanz et al., 2017). The research findings reported an improvement in the physical performance following supplementation with silk peptide(Kannan et al., 2020). It is therefore believed that supplementation with silk peptide would offer effective benefits to athletes as it would in the same way boost their performance.

Several studies involving supplementation with carbohydrate and protein at pre- and post-supplementation have reported increase in Fat Free Mass following endurance training. More research in this area would be of great importance as it would benefit competing athletes. Research has shown that athletes require more protein to maintain +ve nitrogen balance when compared with sedentary people, though there is no proof yet whether the extra protein would boost one's athletic performance (Alcantara et al., 2019).In another study which involved men in two separate groups, it was reported that suppllementation with both protein and carbohydrate at the same time restores physical performance capacity and imroves glycogen stores after a prolonged exercise.

A different study to investigate benefits of the polysaccharide extracts of sweet cassava, on strenuous physical activity in rats reported that supplementation with polysaccharides of sweet cassava can improve physical endurance in rats. It increased levels of muscle glycogen, blood glucose and concentrations of free fatty acids in the blood which ultimately increased time taken to exhaustion (Maughan et al., 2018). Various research studies have provided evidence that show that carbohydrate supplementation at pre- and during physical activity boost performance in prolonged activities that go beyond 1 hour, by increasing glucose oxidation rate, maintenance of blood glucose level and sparing both hepatic and muscular glycogen reserves. This was confirmed in a study where Raisins and chews were found to increase glucose oxidation and also boosted performance in running as compared with intake of water only.

A study was done where two groups of elite male basketball players were supplemented, with one group receiving both carbohydrate and protein supplement and the second group received carbohydrate only one and half hour before engaging in a vigorous competition which was to last 87 minutes. There was an increase in creatine kinase witnessed among the participants who received both carbohydrate and protein supplement as compared to those who received carbohydrate only(Oliveira et al., 2022).. Those on both carbohydrate and protein supplement had higher blood glucose level during and post physical activity. Cortisol level rose after the exercise whereas nausea increased during and after the exercise following supplementation with both carbohydrate and protein. The study results indicated that both carbohydrate and protein supplementation pre-exercise for the elite basketball players, increased Creatine kinase hence lowering damage on muscles during the physical activity. Apart from this benefit, nausea may have been increased during the physical activity by the body not being used to the higher amount of protein given and this may have overshadowed subsequent benefits of other measurements. Another study done to investigate importance of carbohydrate supplementation on physical performance of athletes, reported that carbohydrate supplementation boosts performance of both moderate and high intensity endurance athletics.

In yet another separate study involving carbohydrate and protein supplementation of rugby players, it was established that increased supplementation resulted in enhance performance and higher fat free mass(Barrack et al., 2022). The study further recommended that athletes raise their intake of fruits, vegetables, milk and dairy products in order to better their vitamin and mineral intake. The participants showed atherogenic lipid profile as compared to the control group. This indicated that excessive carbohydrate supplementation may end up forming more of atherogenic factors including triglycerides. So the supplementation should be guided by recommended dietary allowance for each nutrient as well as energy. Moreover, according to the study none of the participants developed anemia or iron deficiency. Regardless of contradicting information regarding safety of protein in sports by 'experts', none should be worried by this since there is a huge amount of scientific evidence on its' safety profile, and also availability of universally known dietary protein benefits to health.

Recently a study was done to assess efficacy of carbohydrate and caffeine supplement improvement of female athletes' agility performance and sprint cycling. The findings showed that intake of caffeine only or carbohydrate plus caffeine do not raise total work output, power output or increase agility during strenuous exercise, as compared to intake of placebo plus placebo(Burke, 2019). As opposed to intake of caffeine plus placebo, caffeine plus carbohydrate and placebo plus placebo, intake of placebo plus carbohydrate raised sprint performance. It was also found that intake of carbohydrate plus placebo did not alter hormone levels or agility. The findings therefore reported that female athletes supplemented with carbohydrate before physical activity with no caffeine would improve subsequent sprint competitions.

Carbohydrate is stored mainly in the liver and muscles and is the nutrient mostly used as a source of energy during physical activity. Any exercise whose duration is more than one hour, one needs to consume carbohydrate before starting the event (Peteva& Ivanov, 2016).

Glucose is the main source of energy during strenuous physical activity though oxidation of a number of amino acids occurs, but only to a low of 1-6% of overall calorie expenditure. Some of the amino acids most studied for their efficacy in boosting of physical activity include the branched chain amino acids, especially Leucine(Burke, 2019). The enzyme that oxidizes Leucine is usually inactive at rest but is always activated at the beginning of physical activity through dephosphorylation. Following the end of the strenuous exercise, activation of the enzyme and oxidation of the amino acids is reduced. It is important to note however, that reduced intake of carbohydrate or energy increases oxidation of amino acids and overall protein requirement. Strenous physical activity has insignificant effect on requirement of dietary protein as long as there is adequate intake of carbohydrate and energy and therefore an intake of 1g of protein/ Kg bwt will still be adequate. Only in situation of top endurance athletes do requirement of protein increase beyond normal requirement i.e. to about 1.6g/Kg bwt/day. Athletes consuming low carbohydrate and energy would require to be counseled on how to increase dietary protein in order to meet their requirement, although most of the athletes engaged in endurance training are able to meet their increased requirement as long as their carbohydrate intake is adequate. A study done on commercial supplements has shown that maltodextrin fructose which is a commercially sold beverage boosts fluid and carbohydrate intake which is believed to be of benefit to the athletes especially those on prolonged moderate physical activity.

In one of the studies, it was established that in endurance training, up to one third of a day’s average energy expenditure of an individual may be expended. This high energy expenditure significantly increases requirements for both water and energy source nutrients(Barrack et al., 2022). In yet another similar study on carbohydrate supplementation for athletes, it was established that in comparison to the control (without supplement) group, individuals in the group that was supplemented with carbohydrate had higher concentrations of glucose in the blood following recovery(Garthe & Maughan, 2018). The study concluded that supplementation with carbohydrate, most likely reduced the catabolic stress by attenuating suppression of hypothalamic pituitary gonadal axis and hence improving performance in the race.

Another research study was done to investigate efficacy of supplementation with a carbohydrate plus electrolyte drink on improving sports performance(Smith et al., 2015). The participants were supplemented with 5 percent carbohydrate-electrolyte drink, and in this study positive changes were noted in responses in heart rate, total time of endurance and lactate in blood during the physical activity at 70% VO_2 Max.

The most inadequate source of energy in the body in carbohydrate (glycogen) and during moderately intense physical activity, it is the most highly metabolized(Veasey et al., 2015). Consequently, consumption of a diet high in carbohydrate (8-10g of carbohydrate/ kg bwt/day) is recommended to improve physical training and sport performance.

Protein is not used by the body as a source of fuel to power moderate or short period physical exercises(Maughan et al., 2018). As the duration of physical exercise lengthens however, protein is used through the process of gluconeogenesis in the liver to produce glucose so as to maintain glucose level in the blood.

There exists strong evidence showing that supplementation with protein, has effective benefits on promotion of exercise in sports persons(Escobar et al., 2015). Amino acid transport in the body to the muscles has a positive relationship with synthesis of muscle protein and this transport is usually facilitated by amino acid intake.

2.6 Available nutritional Supplements for Sports in the Market

A number of supplements are available in the world market most of which are chemicals or hormones e.g. steroids and not foods. They are industrially manufactured with commercial purpose and most of them are not healthy for the athletes as they interfere with the normal body metabolic processes. The following are some of the commonly abused supplements by sports persons.

2.6.1 Use of creatine monohydrate in sport

Supplementation of creatine is not directly linked to physical endurance performance. However, consumption of creatine corresponds directly with improved speed, strength and power which is essential in boosting physical performance(Hall & Trojian, 2013). Many research findings published have reported importance of creatine use as an ergogenic aid for enhancement of strength and size of muscles. With the high number of research findings in support of its' use for endurance performance, we hereby differ with those of opposite opinion.

Creatine supplementation has been found to provide huge boost to cyclists, triathletes and runners and elevate their training competitiveness by inducing its' positive effects on increase of creatine status, elevation of phosphocreatine stores, fast rise in production of ATP and increased anaerobic output. Therefore, it is true to say that creatine supplementation is effective in increasing physical endurance.

One study has reported that engaging in hill training, workouts at intervals of lactate threshold though often and commonly dreaded techniques which are used to increase efficiency of running and running times, the better the quality of the training events, the better the physical endurance and performance(Jagim et al., 2018). Supplementation with creatine has been reported to raise lactate threshold and power output as well as reduce time of recovery following repeated exercise intervals. Increase in economy of running, power output and speed of running during one's training events, corresponds to better sport performance during the completion day (Recommended Dose: 3-5g/day). Initially, increase in Total Body Water leads to weight gain which may then lower physical performance.

2.6.2 Effect of caffeine in athletics

Coffee is one of the main sources of caffeine which for a long time now has been used for improvement of physical performance by athletes. This sounds ridiculous as many Kenyans drink coffee and by this way take in caffeine. Apart from enhancing concentration and focus on the event's activity and delaying fatigue which can greatly ease the long runs, caffeine does provide quick stimulation especially for those athletes engaged in morning sessions of endurance training. It is however important to note that drinking the regular coffee can effectively replace consumption of the commercial caffeine.

Several studies have reported the importance of caffeine intake in boosting physical performance of endurance athletes in events such as cross country, cycling etc. Other than these benefits, caffeine has also been reported to accelerate fat oxidation hence very helpful in facilitating weight loss for those on weight management.

It is recommended that those who are using caffeine to boost their physical endurance performance, approximately 60 minutes before racing because caffeine's optimal blood concentration is reached after around one hour(Mielgo-Ayuso et al., 2019).. Another separate study has provided evidence showing that despite caffeine being a diuretic (by increasing urine production), consumption of caffeine doesn't lead to fluid-electrolyte imbalances or by any way lower tolerance of heat due to exercise. (**The recommended; Dose:** 1.3-2.7 mg/lbbwt. 60 minutes before the exercise).

2.6.3 Benefit of β-Alanine use in sports

This is a single chemical sold to sports persons to enhance performance. Although supplementation with β-Alanine has been found to enhance physical performance and result in delayed fatigue in strenuous activities, we need to ask ourselves whether the supplementation is really necessary for endurance athletes. Having one as an endurance athlete doesn't mean that he/she trains exclusively at high intensity or vice versa.

Other aspects of one's training that are meant to better running outcome e.g. race pacing, tempo runs and weight lifting would all benefit from supplementation with β-Alanine. A number of research studies have reported improved performance on physical endurance in sports such as cycling and rowing time following supplementation with β-Alanine. Large amount of hydrogen ions, build up in the body following highly intensive sessions of training(Kelly, 2018). The buildup of hydrogen ions leads to lowered blood PH hence inducing fatigue. β-Alanine supplementation has been found to boost the ability of the body to neutralize hydrogen ions by increasing intramuscular carnosine content in the body. This has been found to immensely enhance physical performance, delay fatigue as well as lower perceptions on fatigue and increase training capacity. **(Recom. Dose:** 3-6 g/day, taking 800 mg doses throughout the day).

2.6.4 Effect of sodium phosphate in sport

This is single chemical substance that is sold as supplement for commercial purposes with no significant importance in sports performance. Apart from being used for preservation of many foods including meat, sodium phosphate is nowadays also used as a physical performance booster(Buck et al., 2013). Supplementation with sodium phosphate has been reported to raise physical endurance capacity and also lengthen time to exhaustion by increasing the red blood cells' ability to transport oxygen to the actively respiring muscles. Moreover, a number of studies have reported improved physical endurance and performance with sodium phosphate supplementation due to increased oxygen uptake and ventilation. (**Recom. Dose:** 3-5 g/day , taken as single gram doses for between 3-6 days before a strenuous exercise).

2.6.5 Benefits of branched chain amino acids (BCAA) in exercise

Increased intake of branched chain amino acids (Valine, Leucine and Iso-leucine), can greatly lower tryptophan amount that crosses the brain blood barrier (BBB) hence delayed fatigue. In addition, lactate production has been shown to be reduced by BCAA's metabolism greatly leading to increased physical endurance capacity (Master & Macedo, 2021). Further research findings in this area have given evidence that show that BCAA to a substantial extent lower muscle protein breakdown, boosts immunity and enhances fast recovery following strenuous exercise. (**Recom. Dose:** 3-6 grams before or during exercise, in the ratio of 2:1:1 leucine,iso-leucine, valine is the most effective.).

2.6.6 Use of glutamine in sports

This is a single amino acid that is sold as a supplement in the world market. It is believed that the body's glutamine reserves are depleted more quickly than the body can replace them during strenuous physical activity which may unfortunately lead to muscle breakdown causing the individual to go into catabolic state. The reduction in glutamine level can immensely reduce one's immunity raising susceptibility to infections.

Research has shown that supplementation with glutamine facilitates quick recovery other than enhancing immune response after intensive physical activity. This was confirmed by a study conducted with 200 runners which established that very high proportion (81%) of the participating athletes who were supplemented with glutamine did not report any infections following strenuous training compared to placebo group whose high number (49%) experience various infections (Aljaloud & Ibrahim, 2013). In summary, the study findings revealed that glutamine supplementation lowers an individual's susceptibility to infections following intense physical activity hence helping him/her to engage in strenuous exercise and have faster recovery(**Recommended Dose:** 20g/day).

One study conducted on harmful effects and benefits of commercial supplements, it was found that apart from creatine, all the supplements studied had potential harmful effects. Among them, it was revealed that a number of them showed serious harmful effects and therefore their use should be cautioned strongly. Moreover, the study strongly recommended banning of ephedra from the market.

2.7 Use of Mineral water in Sports

Study done on use of sports drink in maintenance of physical performance has showed that with sufficient hydration and intake of balanced diet between events, no significant reduction in physical performance was witnessed n tennis players even in consecutive competition events.

A separate study was conducted to investigate the effect of moderate mineralization together with mineral water on status of physical performance after a long dehydrating exercise in the sun heat. The study involved nine, active healthy women aged between 20 and 28 years. Moderate mineralization coupled with mineral water had positive effect on promotion of physical activity recovery and endurance as compared with effect of plain water after a long strenuous running event (Brink-Elfegoun et al., 2014).

A research study done to investigate efficacy of supplementation with minerals on enhancement of physical performance showed the importance of minerals in many physiologic and metabolic processes in the body (Okanović et al., 2014). Minerals support a number of physiologic processes in athletics and these processes include; maintenance of normal heart rhythm, muscle contraction, oxygen transport, conduction of nerve impulses, immunity, activation of enzymes, oxidative phosphorylation, health of bone, blood acid-base balance and antioxidant activity in the body. The minerals are classified into two broad classes i.e. macro minerals and micro minerals. Since most of the processes are more active during physical activity, intake of sufficient amount of minerals is essential in order to achieve optimal performance. Deficiency of minerals in athletes their health and this impairment may greatly affect their physical performance and therefore all athletes should consume diets that are rich in minerals to enable them meet the recommended dietary allowance.

A similar study on adequacy of minerals in regular diet, it was revealed that the two minerals that are mainly insufficient in diets especially for young athletes are calcium and iron. These findings were confirmed by another study conducted on female skaters which showed inadequate dietary calcium and iron intake among female skaters in one of the competition seasons.

A related study was done in the same year to investigate the effect of endurance training for a period of 10 weeks on urinary and serum levels of minerals(Al-Qurashi et al., 2022).. After the high-intensity training phase, the results showed that serum calcium level dropped below normal whereas urinary calcium level was elevated. These results show that excretion of calcium is increased during events of high intensity training which may predispose the athletes to osteoporosis more so for women who experience the athlete triad i.e. disordered eating, osteoporosis and amenorrhea.

2.8 Product Ingredients and their Nutritional Value

2.8.1 Millet

One research study was done with complementary variations prepared from formulations of soybean and unmalted or malted millet (Amadoubr & Le, 2013). In formulation of these variations, raw or malted millet was thereby fortified with raw or malted soybean at the ratio of 7:3 or 1:1. The formulations were extruded and then subjected to analysis for nutritional composition and organoleptic properties. Crude protein was lowest (18.3%) in the unmalted formulation whose ratio of millet to soybean was 7:3, the malted formulation whose ratio of millet to soybean was 1:1 had a significant value of protein (28.9%. Extruded formulations whose ratio of raw millet to raw soybean was 1:1 had a higher value of energy i.e. 1,819 kJ/100g as compared to other formulations. Significant differences were observed in phosphorus, Calcium, zinc, sodium and magnesium levels and the formulations were rich in all minerals. The formulation whose ratio of millet to soybean was 1:1 had higher protein content than the formulation whose ratio of millet to soybean was 7:3. Organoleptic evaluation reported an increase in flavour, taste and texture in most of the malted ingredients, although the colour rating was unacceptable. Whereas chemical values improved with increase in proportion of soybean, formulations with lower proportion of soybean seemed to be accepted more.

As indicated in Table 1 below, millet has relatively higher levels of protein and calorie as well as calcium and iron content as compared to other cereals.

Table 1: Target minerals and protein content of Pearl millet per 100g.

Food type	Protein[a](g)	Energy (kcal)	Ca (mg)	Fe (mg)
Pearl millet	11.8	363	42	11.0

[a]Protein =N x 6.25.

Source: Hulse. Laing and Pearson. 1980

2.8.2 Energy and target nutrients in Soy bean

Soybean calorie and nutrient content be demonstrated by the research findings in table 2.

Table 2: Energy and target nutrient value of Soybean, per 100g

Nut/Seed	Protein	Minerals				Energy
Soy Beans	35.22 grams	Calcium	-	138	mg	471 calories
		Iron	-	3.9	mg	
		Zinc	-	3.14	mg	

Source: Food & Nutrition Center, United States Department of Agriculture (USDA). .

Scientific evidence in nutrition and sports performance has provided crucial information on efficacy of various nutrients in enhancement of sports performance and also created a growing and dynamic market for nutritional supplements as well as help identify new market opportunities in this field. Today a number of institutions including Solae Company have been in the forefront in conducting research especially providing scientific evidence on the numerous nutritional benefits of soy protein(Shenoy et al., 2016). There is a currently a large number of research studies, showing scientific findings in support of the special nutritional benefits of Soy protein in relation to athletic performance and body health.

Currently the recommended method of evaluating protein quality is by use of the WHO/FAO Protein Digestibility Corrected Amino Acid Score (PDCAAS). This is despite the fact that some may still talk of earlier methods like Net Protein Utilization (NPU), Biological value (BV) and Protein Efficiency Ratio (PER) (Kostrakiewicz-Gierałt, 2020). The WHO/FAO method was developed on the basis of the actual amino acid requirement of the human body and is now used for labeling of protein content in foods and nutritional supplements by the Food and Drug Administration (FDA).

In a separate research done on performance of active athletic American with soy, it was found out that endurance athletes' protein requirement ranges between 1.2 to1.4g/kg bwt/day whereas protein requirement for the strength athletes range between 1.2 to 1.7g/Kg bwt/day(Cintineo et al., 2018).. On average, research findings show that a protein intake of between 1.2 and 1.7g/kg bwt/day would therefore be sufficient to meet daily protein requirements of all athletes. Soy protein provide the best source of all amino acids especially essential amino acids and therefore most suitable above all plant proteins.

Athletes require adequate carbohydrate and energy in order to replenish muscle glycogen stores as well as sufficient protein to build and repair worn out tissues(Messina, 2016). Furthermore, right selection of type and amount of fat taken is important to nourish the body with essential fatty acids, enhance absorption of fat soluble vitamins and provide energy without elevating blood cholesterol level.

2.8.3 Skim milk powder

One of the richest sources of calcium is skim milk powder(Roy, 2008). For that reason, therefore, it was considered as one of the key sources of calcium in product development for this study. One study done on nutritional composition of skim milk powder reported the levels of target minerals, protein and energy shown in Table 3 (Rankin et al., 2018).

Table 3: Energy and target nutrients' proportions, in milk powder per 100g.

Calorie/ Nutrient	Amount per 100g
Energy	500 kcal
Protein	34.0–37.0%
Iron	0.32 mg
Calcium	1,257 mg

Source: Reference Manual for U.S. Milk Powders. Arlington, VA: U.S. Dairy Export Council, 2005. p41.

2.9 Industrial Processes used to Manufacture Supplements

2.9.1 Soft gel technology

In a single operation, soft gel capsules' formation occurs, and then they are filled and sealed. The process starts by melting gelatin with water and plasticizer forming a molten gel mass (Sekhar et al., 2021). The molten gel is then cooled on the encapsulation machine forming two ribbons which are used to form the outer coating of the capsule. Then the suspension, liquid or semi-solid with the API (fill), enters through the top of the encapsulation machine with the two ribbons fed into each side. The gelatin ribbons then encapsulate the fill, forming the capsule. After formation of the soft gel capsules, they are dried in drying tunnels spread on drying trays.

Timeline: Upon commencement of production for a particular product, the manufacturing process proceeds continuously until the lot is completed. Immediately production of another lot begins and this results in a continuous manufacturing process that runs around the clock.

Additional Innovation: Great innovation on in line gel ribbon printing is a is a technology that enables printing to be done directly on the wet gelatin ribbons, to have differentiating features on the product such as product name, logo or dosage(Khoa Huynh et al., 2022). This process would be important for compliance, differentiation and regulatory requirements. Soft Gel Technologies companies usually offer contract manufacturing of soft gelatin capsules either for dietary supplement industry or drugs.

2.9.2 Liquid supplements technology

Standard Procedure

In production of beverages, components with high volumes e.g.water; syrup base or sugar solution external pumps are mostly used to convey them to the blending station. Container vessels should be located near the unit in order to minimize product losses particularly where production involves expensive concentrates and base components. It is most preferable that the ingredients flow downwards to the plant by gravity(Khoa Huynh et al., 2022). The ingredients are first de aerated before they enter blending pipe and then pumped by centrifugal pumps or alternatively by positive displacement pumps which is integrated into the unit. De-aeration vessels are essential for de aeration of any ingredients that may have a risk of air being trapped in them.

2.9.3 Dry flour mix supplements technology

Development of this type of supplement involves careful selection of ingredients, sorting, washing and drying them to get rid of any contaminants. Except the liquid ingredients, all the solid ingredients are then milled into flour and roasted before blending and mixing them thoroughly to produce a homogenous pre-cooked mixture. Spray-drying technology may be used in order to achieve uniformity in the mixture (Hanif Mughal, 2019).

2.10 Conceptual Framework

The study involved three independent variables i.e. routine regular food intake, routine training and intake of a food supplement rich in energy, protein, calcium and iron. The dependent variable was Athletic performance which was directly dependent on the intervening variables which were nutritional status and physical endurance. Determining effect of independent variables on intervening factors was key in establishing their overall impact on athletic performance.

2.10.1 Study Variables

Figure 1 illustrates conceptual framework of the study, showing independent variables that affect nutritional status and physical endurance of athletes and consequently their athletic performance.

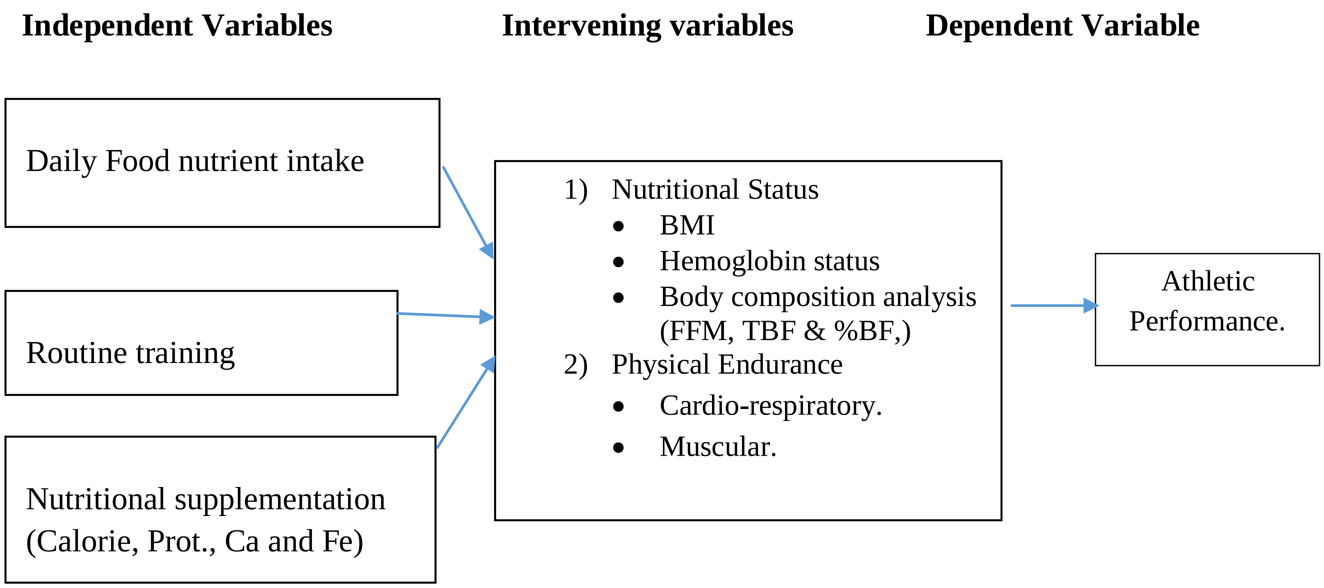

Figure 1: Conceptual Framework

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study Setting

The main Athletic training camps in Kenya are located in Ngong area which has an altitude of 1961 meters above sea level. It is located on the outskirts of the capital city of Nairobi and other camps are located in Kapsabet, which is in the Rift valley region. The camps at the Ngong area which is near Ngong hills were chosen for this study because they serve as grounds for recruiting, training and also for their close proximity to the National stadia which are all in Nairobi. This place is situated in Rift Valley, Kenya, its geographical coordinates are 1° 22' 0" South, 36° 39' 0" East.

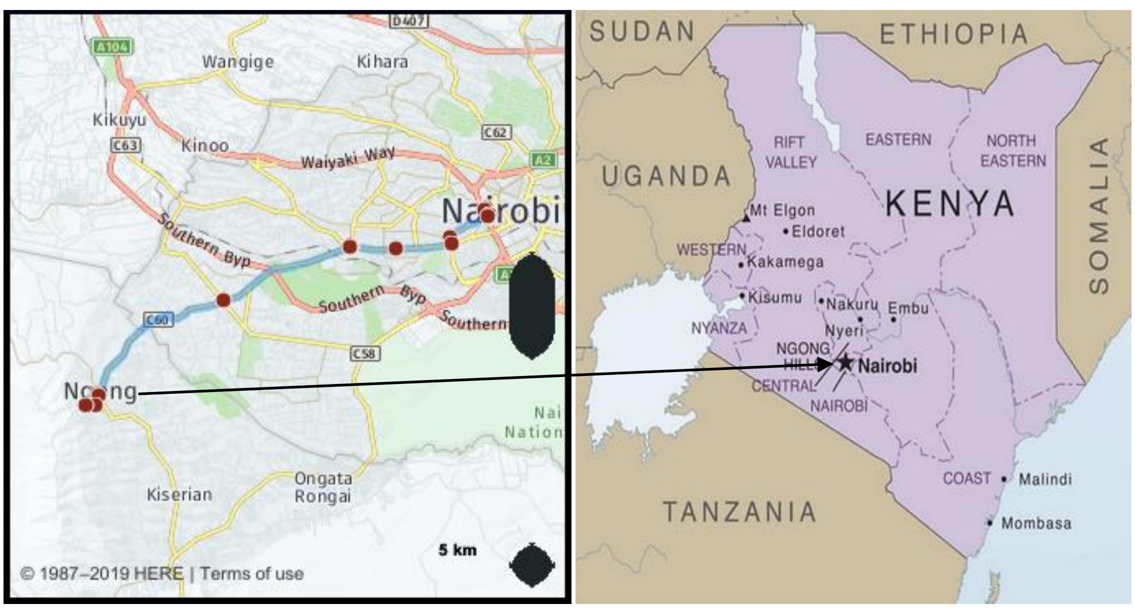

Figure 2: A Map of Kenya showing the Ngong area. ©www.bestourism.com

3.2 Research Design

The present study entitled "**Development of a nutritional supplement from local foods and determination of its efficacy in improving nutritional status and physical endurance in long distance athletes "**was carried out in three phases as follows: Phase I was product (nutritional supplement) development, phase II Study control and phase III was the intervention study. The study was done to assess efficacy of calorie, protein, calcium and iron rich supplement on physical endurance and nutritional status of athletes. The study was an experimental cohort study where a stratified random sampling was used to get participants from training camps (at Ngong). Dietary intake assessment was done on the participants by use of the 24-hour food recall and food frequency methods (Bytomski, 2018). Then socio-demographic information (age, gender, Religion, level of education & Marital status) was also gathered from the participants. This was followed by development of a nutritional supplement (exposure) for administration to the participants to provide approximately 25% of the targeted calorie and nutrients i.e. protein, calcium and iron requirements. Proximate composition analysis was then done for protein, Starch, crude fat, ash, iron and calcium. However, before start of both supplementation and control periods all the participants dewormed and then underwent nutritional status (BMI, Hb, FFM, % FM, TBF, % BM and % BW) and physical endurance (cardio-respiratory and muscular) assessments. All the participants except during the control period were then supplemented for a period of two months after which all the study variables were reassessed. Finally, data from both pre-intervention and post-intervention was analyzed by use of SPSS including paired-sample t-test to make inferences on difference between sample means and hence, enabled the researcher to make judgment on the efficacy of the supplement on enhancement of the study variables.

The Study Design consisted of a Food supplement development, cross sectional baseline survey, and longitudinal study components as follows: A food supplement was developed and Laboratory work done to determine proximate composition of the food supplement, and a Cross-sectional baseline study was done to establish athletes' food and nutrient intake, nutritional status and physical endurance. This was then followed by longitudinal study where repeated measures at Pre- and post-intervention were taken to establish efficacy of the supplement on enhancement of nutritional status and physical endurance.

3.3 Study Implementation

The study was conducted at Ngong athletic training camp. At Ngong there are several private training camps. With permission from Athletics Kenya, two camps were randomly selected for the purpose of this study. After camps were selected, then the study participants were randomly selected from the two camps following the set inclusion and exclusion criteria.

3.3.1 Data collection tools

Method of data collection used was the questionnaire method. Detailed structured questionnaires were used to collect the necessary data i.e. socio-demographic (Age, Gender, marital status, level of education and Religion), dietary intake (by use of the 24-hour food recall) and Foods consumed (by use of Food frequency). Data collection here focused to capture information on several factors that could have influence on the key variables which the study was targeting on from pre-intervention to post-intervention. The questionnaire was used to collect information on Socio-demographic, food intake and dietary intake of protein, energy, calcium and iron.

3.3.2 Study population

The study targeted long distance (Marathon) athletes at Ngong training camps. The population was 36 athletes in the two selected training camps, out of which three were private and the other three were public.

3.3.3 Sample size determination

Fisher's formula was used to determine the sample size. Since variability in the proportion that would adopt the practice, it was assumed that p=.5 (maximum variability). Using a desired 95% confidence level and ±5% precision, the resulting sample size would be demonstrated as follows;

$$n_o = \frac{Z^2pq}{e^2} = \frac{(1.96)^2(.5)(.5)}{(.05)^2} = 385 \text{ participants}$$

However, the population was36 athletes and since it was less than 10,000 corrected formula for small populations was used whereby the sample size was adjusted by use of the following corrected formula;

$$n = \frac{n_o}{1 + \frac{(n_o - 1)}{N}} = \frac{385}{1 + \frac{(385- 1)}{36}} = 33$$

A representative sample could also have been obtained by using the following simplified formula for proportions by Yamane for calculating the sample size from the target population

i.e. $n = \frac{N}{1 + N(e)^2}$

Where n= Sample size

N=Total estimated population

e=Level of precision at 95% confidence level and P=0.05

However, for the purpose of this study a convenient sub-sample of 13 men and 11 women were selected through simple random sampling to serve as both control and supplementation/intervention groups respectively. The target was to enroll all the women into the study since their number was small but two out of the 13 were not available at the time of the study. However, the number sampled for both gender was statistically representative of the target population. This is because for clinical controlled studies the sample size was statistically sufficient, and also due to the fact that the calculated value is so high and costly. Initially, two weeks prior all the participants were given dewormers to eliminate any possible interference by worm infestation. Then baseline nutritional status and physical endurance assessments were done on all the participants and were then followed up for a period of two months with only sports 'nutrition education offered to them, and then after the two months the assessments were repeated in order to determine any change in the variables assessed. In this period, the participants served as control groups for the study. After these assessments, the nutritional supplement was introduced and all the participants followed again for a further period of two months after which final assessments were done to determine effects of the supplement on nutritional status and physical endurance of the athletes. In the last two months' period, the participants served as study/intervention groups. The participantswere those aged 18-25yrs from the two camps.

3.3.4 Sampling procedure

The Study participants were randomly selected from the sporting athletes at Ngong training Camps and included both male and female athletes. With permission from Athletics Kenya, two camps were selected for the purpose of the study. Consent was sought from the couches as appropriate. Out of a total population of 36 athletes (23 men and 13 women), 24 participants (13 men and 11 women) participated in this study. Consent was sought from all the participants (18-30 years old) and they were given consent forms to fill and sign as evidence of agreement to participate in the study.

3.3.5 Inclusion and exclusion criteria avoid bulleting at all times

Inclusion criteria

i) Long distance athletes training at Ngong camp, who were between 18-35 years of age,

ii) Athletes with routine training and engaged in long distance races (Marathon and half marathon)

Exclusion criteria

i) Athletes who failed to give consent for participating in the study were left out.

ii) Athletes who agreed to be using other supplements were excluded in this study.

3.4 Nutrient intake and types of foods consumed

Dietary intake assessment was done on the participants to investigate their nutrient intake. .Information on foods commonly consumed was collected using a structured, pre-tested food frequency table. Food frequency method of assessment was also used in order to establish whether there were food omissions or excesses in the diet, which would lead to deficiencies or excesses of some nutrient intake. Nutrient intake was assessed by 24-hour food recall method, using standardized utensils (cups and spoons) and nutrient adequacy for various nutrients was calculated based on their recommended dietary allowances (RDA). A 24 hour food Recall questionnaire was used for the period of three days to estimate nutrient and calorie intake. Percentage adequacy of carbohydrate, protein, fat calcium and iron were computed, based on the recommendations for sports persons, i.e. 60%, 15% and 25% of the total daily calorie requirement respectively (Pramukova, 2011). Percentage calorie adequacy was determined based on the recommended daily calorie intake of 50 kcal per kg body weight for endurance athletes. Average calcium and iron intake was established from the dietary intake Bytomski, (2018), compared with their Recommended Dietary Allowance (RDA) which is 1200mg and 15mg, respectively.

In Food frequency, food groups formed basis of the questions so as to collect comprehensive data i.e. cereals, meats and meat substitutes (Legumes and Pulses), Dairy products, Vegetables and fruits (Naderi et al., 2018). The food groups included were key in delivery of energy, protein, calcium and iron which are the main requirements for enhanced athletic performance. In 24-hour food recall, estimated food intake was worked out with the help of the participants to enable calculations on estimated Calorie, Protein, Calcium and Iron intake.

3.5 Phase I- Product Development

This phase focused on developing a product that would be able to deliver at least 25% of RDA of the four (4) nutritional components targeted i.e. Energy, Protein, Calcium and Iron. Energy mainly is derived from cereals whereas Protein is mainly abundant in animal products, legumes or pulses. Foods rich in calcium included milk and dairy products and fish (especially Omena). Athletes' RDA for Calorie, Protein, Calcium and Iron for endurance athletes is 50Kcal/kgbwt/day, 1.2-1.4g/kgbwt/day, 1,000 mg/day and 18mg/day respectively.

To begin with, four (4) formulations were prepared using different combinations of the following ingredients; pearl millet, as main source of energy, Soy bean as rich source of protein and iron and Skimmed Milk powder as a rich source of calcium**.**

For the purpose of this study, the form of nutritional supplement was pre-cooked flour, for easy preparation and consumption. Preparation of the food supplement formulations was done based on the selected nutrients i.e. energy, protein, calcium and iron. Clean ingredients were procured, sorted and washed to remove any physical contaminants. The millet was milled into flour and roasted. Soya bean was first roasted and then milled into flour due to its' high fat content. The milk powder was also roasted and the three mixed thoroughly to produce a pre-cooked homogenous product. The four (4) formulations were then subjected to sensory evaluation with a panel selected from the participants.

3.5.1 Product Formulations

Different formulations were prepared first after determination of their ability to deliver at least 25% of the Recommended Dietary Allowances (RDA) for the target nutrients. That is because different proportions of the component ingredients affect both organoleptic properties of the product as well as cost of it.

The variations were constituted as follows;

Formulation I- Millet (50%), Soy bean (30%) and Milk powder (20%).

Formulation II- Millet (60%), Soy bean (20%) and Milk powder (20%).

Formulation III-Millet (60%), Soy bean (10%) and Milk powder (30%).

Formulation IV-Millet (70%), Soy bean (10%) and Milk powder (20%).

3.5.2 Acceptability of the nutritional supplement

Acceptability of the supplement variations was assessed by conducting sensory evaluation with the participants as follows; Sensory evaluation of the 4 variations of the products helped to decide on which one of them was acceptable and could therefore be used in the intervention. The evaluation was done by giving the variation samples to the study participants(13 men and 11 women). A sensory evaluation score card was developed and administered to the participants to get their responses. The supplement was reconstituted with hot water, followed by a brief (5-10 minutes) boiling period in order to ensure safety of the ready to drink porridge.

The participants were then asked to rate the product using the sensory attributes; colour, appearance, taste, aroma and overall acceptability. The hedonic rating scale was then used to determine acceptability of the different variations. The rating scale had 7 rating levels i.e. Dislike strongly-1, dislike moderately-2, dislike slightly-3, neither like nor dislike-4, like slightly-5, Like moderately-6, Like strongly-7.The variation which scored the highest in terms of sensory attributes and cost-effectiveness was chosen for the supplementation intervention.

3.5.3 Shelf-life Evaluation

Shelf-life study was done on the acceptable product to establish its shelf-life in order to protect consumers against intake of spoilt product in case of large scale production. The product was stored in three different types of packaging materials i.e. Plastic bag, Gunny bag and Kraft paper bag. It was stored at three different temperatures of18˚C, 25˚C and 38˚C and after every two (2) weeks product from each of the three packages were subjected to sensory evaluation to establish the time at which changes in organoleptic characteristics (taste, odor, or appearance) would be perceived. The time at which the change(s) occur was then used to determine the shelf-life of the product. Chemical changes were also evaluated by analyzing for peroxide value due to high fat content of soy bean.

3.5.4 Proximate Analysis

Standard AOAC methods were used to determine the proximate composition of the supplement. The analysis included; Protein, Crude fat, starch (Total, Available and Resistant), Ash, Iron and Calcium. The analysis of these target nutrients were carried out as follows:

Protein Analysis by Kjeldahl method

The total nitrogen content of the product was estimated by Kjeldahl method (Kirk, 1950). Then the protein content was calculated by multiplying the total nitrogen value with factor 6.25 and expressed as a percentage.

The steps followed were as illustrated by the flow – diagram below (Figures 3a, 3b and 3c).

Put 2g of the product sample into a 100ml kjeldahl flask

↓

Add 30ml of concentrated sulphuric acid (H_2SO_4)

↓

Add a catalyst mixture (1 spatula)

↓

Digest on the micro-digestion unit until the solution is colourless and clear

↓

After cooling, make-up the volume to 100ml with distilled water.

↓

Test for completion of digestion by adding 1 drop of perchloric acid. (If digestion is complete it does not turn yellow).

Figure 3a: Protein digestion stage

Put 10ml of digest into the sample flask (C) through the funnel

↓

Then add 10ml of 40% NaOH through the funnel.

↓

Keep a receiver flask with 10ml boric acid solution + indicator at delivery end of the condenser with tip just beneath the surface of the liquid.

↓

Heat the round-bottomed flask (A) with water to produce steam

↓

The steam passes through contents in sample flask (C) and the NH_3 formed by the alkaline treatment of the protein digest is carried with it through the

↓

NH_3 is trapped by boric acid as ammonium borate, changing the colour from greenish yellow to blue.

↓

Steam distill till about 30ml distillate is collected in the receive flask

↓

Stop heating the round bottomed flask A & take the distillate for titration.

Figure 3b: Distillation of the protein digest

The distillate in receiver flask was titrated against 0.01 N Hcl, till colour changed from blue to green colour.

↓

The volume of the acid used was noted and used to calculate the percentage nitrogen of the sample.

↓

Similarly, ammonium sulphate [$(NH_4)_2SO_4$] and distilled water were used in place of the sample for the distillation and titration steps to obtain both the standard and blank value respectively.

Figure 3c: Titration of the protein distillate

The % nitrogen and % protein content of the product sample was calculated as follows:

$$\% \text{ Nitrogen} = \frac{\text{Titrevalue-Blank}}{\text{Standard value} - \text{Blank}} \times \frac{100}{\text{wt of sample}} \times \frac{1}{1000}$$

Then % protein = % Nitrogen x 6.25

2 Determination of Crude fat

3g of moisture free sample of the product was weighed into moisture free thimble and crude fat was extracted by refluxing in soxhlet apparatus using petroleum ether as solvent, for a period of 14-16 hours (Soxhlet, 1879). Further details are shown in Figure4.

Weigh 3g of moisture free sample into a thimble & plug with cotton.

↓

Weigh and record weight of an empty, dry and clean round-bottomed soxhlet flask.

↓

Put petroleum ether in the dry, clean round bottomed flask and fix it into the set-up for extraction process.

↓

Place the thimble in the soxhlet apparatus and extract fat with anhydrous ether for about 16 hours

↓

The ether was then removed from the round bottomed flask by evaporation and the flask with the residue dried in an over at 100^0C, cooled in a desiccator and weighed. The weight of fat residue will then be calculated by subtracting the

Figure 4: Determination of crude fat

The percentage crude fat content of the product sample was calculated using the formula:

$$\% \text{ crude fat} = \frac{\text{Weight of fat residue (g)}}{\text{Weight of sample (g)}} \times 100$$

3. Starch (Total starch, available starch and resistant starch):

Starch was estimated by enzymatic digestion with amylases(Zhu et al., 2016).

a) Determination of Available starch

This component was analyzed by use of the enzymes α-amylase, Gluco-amylase and sodium acetate buffer (2M) (Marshall, 1978). The steps were as shown in Figure 5a.

Put 250mg fat free sample into clean beaker

↓ Add 15 ml distilled water

Incubate with 100mg α-amylase in boiling water for 15 min.

↓

Exactly dilute the mixture to 25ml with distilled water

↓

Add 250 mg gluco-amylase + 2 ml buffer.

↓

Mix well and incubate at 60^0C for 30 min.

↓

Filter and then dilute to 100ml with distilled water

↓

Take an aliquot of the solution i.e. 20µl and estimate liberated glucose.

↓

Then % available starch was calculated using the formula

Figure 5a: Determination of available starch

$$\textbf{\% available starch} = \frac{\textbf{Mg of glucose x 100 x 0.9 x dilution factor}}{\textbf{250}}$$

Where **0.9** was the correction factor.

Determination of Total starch

Total starch was estimated by the same amylase digestion method (Chow and Landhausser, 2004). The reagents were the enzyme α- amylase and gluco-amylase, sodium acetate buffer (2m), potassium hydroxide (4N) and hydrochloric acid (5N). The steps followed were as shown in Figure 5b.

Suspend 250mg of sample in 2ml of distilled water and 10ml of freshly prepared 4N KOH solution at room temperature for 30 min.

↓

Neutralize with 5N HCl to a pH of 6.5 to 7.

↓

Then followed the steps used to analyze available starch to estimate the total starch in the sample, by using α-amylase and gluco-amylase as described

Figure 5b: Determination of total starch

Similarly, % total starch was also calculated using the same formula,i.e.

$$\textbf{\% total starch} = \frac{\textbf{Mg of glucose x 100 x 0.9 x dilution factor}}{\textbf{250}}$$

c) Resistant starch

% resistant starch was calculated by subtracting % available starch from the % total starch.

4. Determination ofAsh Content

The ash content of the product was estimated by subtracting the weight of empty crucible from the final weight of crucible + ash. The steps followed in the analysis wereas Shown in Figure 6.

Empty crucible was cleaned, dried at 100^0C weighed, and the empty weight recorded.

↓

10g of accurately weighed sample was put into the crucible (which was previously heated at 600^0C and cooled).

↓

The sample was then completely charred over a heated wire mess.

↓

The charred sample was then transferred to a muffle furnace in the same crucible and further heated at about 600^0C for 5 hours.

↓

It was then cooled in a dedicator and weighed.

↓

Heating was repeated for another ½ hour and re-weighed to ensure complete ashing was achieved.

↓

This was repeated until 2 consecutive weights were obtained and the ash was almost white or greish white in colour.

↓

The difference between the final weight of crucible +sample and the weight of the empty dry crucible previously weighed was used to determine the weight of ash in grammes.

6: Determination of ash content

% ash content of the sample was then calculated using the formula.

$$\textbf{\% ash content (g/100g sample} = \frac{\textbf{Weight of the ash (g)}}{\textbf{Weight of the sample taken (g)}} \textbf{ x100}$$

5. Determination of Iron

Iron content of the product was analyzed by the use of α-α- bipyridyl method (Moss, 1942). Before the analysis, ash solution of the sample was prepared for mineral estimations using the steps in Figure 7.

Ash of 10g sample + 1ml of double-distilled water + 5ml of concentrated Hcl (in a crucible)

↓

Evaporate to dryness on boiling water bath

↓

Add 5ml of concentrated Hcl and Evaporate

↓

Again add 4ml of concentrated Hcl + 1 ml of double-distilled water (warm it)

↓

Filter it into 100ml volumetric flask using watman no. 40/42.

↓

Make-up the volume to 100ml with double –distilled H_2O

↓

Then this solution was used for mineral estimations.

Figure 7: Preparation of mineral solution

Iron was determined as shown in Figure 8 below

Iron estimation was done by α-α- bipyridyl method, as per the following steps.

↓

1ml of the mineral solution was put into a test-tube

↓

Then 1 ml of hydroxylamine hydrochloride was added

↓

Incubation at room temperature for 5 min

↓

Addition 5ml acetate buffer

↓

Then addition of 2 ml of α-α- bipyridyl

↓

Volume topped up to 25 ml with double distilled water (16ml)

↓

Absorbance of the colour developed was then read at 510 nm within 20min. The concentration of iron was calculated from the standard curve, and the iron content calculated in mg/100g.

Figure 8: Determination of iron

6. Determination of Calcium

Calcium content of the product was analyzed by titrimetric method(Harvey, 2012). The steps were as shown in Figure 9.

Put 2ml of sample mineral solution into 15 ml centrifuge tube

↓

Add 2ml of distilled water + 1ml ammonium oxalate

↓

Mix thoroughly and keep overnight

↓

Again mix contents and centrifuge for 5 min at 2000 rpm

↓

Carefully pour off supernatant liquid

↓

Drain centrifuge tube by inverting it for 5 min on a rack (taking care not to disturb the ppt)

↓

Wipe the mouth of centrifuge tube with filter paper

↓

Stir the ppt and wash sides of the tube with 3ml of dilute NH_3

↓

Centrifuge it again and drain as before

↓

Wash the ppt once more with dilute NH_3 (3ml) to ensure complete removal of ammonium oxalate.

↓

Dissolve the ppt into 2ml of 1N H_2SO_4

↓

Heat the tube by placing it on boiling water bath for 1min and titrate against 0.01 $KMnO_4$ solution till pink colour persist for at least 1 min.

↓

Using 0.2004 mg of Ca to correspond to 1ml of 0.01N $KMnO_4$, the amount of calcium in the sample was calculated in mg/100g.

Figure 9: Determination of calcium

3.6 Nutritional status and Body Composition assessment

3.6.1 Nutritional status

One of the variables that were assessed before and after intervention (supplementation) was nutritional status of all participants, both in the groups' supplementation period and in the control period. The following assessments were done on the participants to assess their nutritional status; all the participants in both the study/supplementation and control periods had their weights, Body Mass Index (BMI) and hemoglobin (Hb) levels determined at Pre-intervention/before supplementation and pre-counseling respectively. A Medical doctor was included in supervision of the research and a Medical Laboratory technologist was involved in the drawing of blood and Hb status analysis.

3.6.2 Body Composition Analysis

In addition to this, Body composition analysis was done by use of a body composition Analyzer (BCA)to support the findings of the Body Mass Index (BMI), as body fat is also a determinant of BMI(Gibson-Smith et al., 2020).This provided information on Free Fat Mass (FFM), Total Body Fat (TBF), % body water, bone mass as well as percentage (%) body fat. The assessment is done by pre-setting the BCA and having the athlete stand on it bare footed for a short period of time to allow analysis by the machine. Then after the analysis was done, the individual would step down and the readings read and recorded at the point in time. Nutritional status and physical endurance assessments were done both before and after the supplementation intervention in order to determine efficacy of the nutritional supplement on nutritional status and physical endurance of the athletes.

3.7 Physical Endurance Assessment

Both cardio-respiratory and muscular endurance tests were conducted on both the study and control groups. The two tests provided important information on overall physical endurance level of the participants before intervention. For comparison, the tests were done both at pre-intervention (before supplementation) Mid-intervention and post-intervention (after supplementation).

3.7.1 Cardio-respiratory endurance assessment.

Cardiorespiratory endurance is very important in determining competitiveness of endurance athletes (Shikany et al., 2013). In Both the study and control periods, participants were assessed on the treadmill at Pre- and Post-intervention by allowing each of them to run on the treadmill at a speed of 15km/hr and then his/her time to exhaustion, distance covered and amount of calories spent/burnt were determined from the treadmill readings and recorded for analysis by end of the study(Cuenca-García et al., 2012).

3.7.2 Muscular endurance assessment

This assessment was done by counting the number of *Press-ups/push-ups* to exhaustion for each participant at the beginning and at the end of both the supplementation and the control periods (Quinn, 2016). As stated earlier, to establish efficacy of the supplementation this assessment was done both at pre-intervention (before supplementation) and post-intervention (after supplementation). The participants were asked to do three press-up sessions on three subsequent days, same time in the morning and then the average was determined and considered as the result at the time.

3.8 Supplementation Intervention

This phase included both control and supplementation periods. The participants were followed up for two months after baseline assessments, with only sports' nutrition education being offered. After the two months, all the assessments were repeated for comparative analysis. Finally, this was followed by a two months supplementation period with same assessments done at the end of the supplementation period, so as to determine efficacy of the supplementation in improving nutritional status and physical endurance of the athletes.

The supplement was packaged into 100g sachets and delivered to each of the participants for reconstitution with hot water, boiled it for a short time (5-10minutes) to make porridge and consume at the scheduled times. The intervention was nutritional supplementation of the study participants for a period of two (2) months with each participant consuming 100g of the supplement daily before the exercise and then followed by mid and post-intervention assessments (Nutritional status, Body composition and physical endurance assessments).They were educated on the importance of adherence to consistent intake as well as importance of the study. In addition, for follow up the deputy coach was charged with the responsibility of reminding them to take the supplement daily about 30 minutes before exercise.

The efficacy of the supplement was assessed by studying the effect on nutritional status, body composition and physical endurance of the study participants (Athletes).This was established by analysis of the data on nutritional status, body composition and physical endurance assessments on the participants at Post-intervention. During the control period, the participants also underwent same assessments at the start and at the end for comparative analysis to be done. The participants were given a form to report perceived benefits of the food supplement as well as any kind of effect on the sport performance.

3.9 Data Analysis

By use of SPSS, Inferential statistics were done by use of t-test, to establish the difference between calorie intake by men and women as well as difference in intake of protein, fat, calcium and iron by the two groups. Means of both calorie and the target nutrients' intake were also calculated and compared with Recommended Dietary Allowances to determine levels of intake for each. Then percentage intake was calculated for calorie, protein, calcium and iron and the findings reported in graphical presentation. Findings on food frequency were determined by calculating the percentage of respondents consuming each of the foods enlisted and presented in tabular form. Paired sample t-test was used to determine significance in difference between the two means of both men and women at pre and post intervention, whereas two samples t-test was also used to compare means of both the intervention/supplementation and control groups at pre- and post-intervention.

3.10 Ethical consideration

Ethical clearance was sought from the KNH-UoN Ethical Review Committee before commencement of the research **(Ref. No. KNH-ERC/A/113).** The study participants were also well sensitized on the details of the study and the steps that would be taken.

CHAPTER FOUR: RESULTS

4.1 Demographic Characteristics of the Respondents

Out of the thirteen (13) men who participated in the study, 77 percent were aged between 30 and 35 years whereas the remaining 23% were aged between 20 and 29 years. Most of those age above 30 years (80%) had participated in the long distance races for a period of 10 to 15 years, whereas those whose age was below 30 years had a sporting experience of between 5 to 10 years. All the ladies in the study were aged between 20 and 27 years. Eighty-two percent (82%) of the female athletes had sporting experience of between 2 to 5 years whereas eighteen percent (18%) had sporting experience of between 5 to 10 years. For the level of education, 54% of the men (7) reported to had completed secondary level education, 31% (4) had completed primary level education and 15% (2) had gone through college education. Eight- two (82%) of the women athletes reported to have secondary level education with the remaining 18% (2) indicating having primary level education. On marital status, 62% (8) of the male athletes were married and the remaining 38% (5) were single. Eighty-two percent of the female athletes were single and 18% (2) were married.

Table 4: Demographic Characteristics of the Athletes

Gender	Proportion by Age (%).		Proportion by sporting Experience (%).			Proportion by Education level (%)			Proportion by Marital Status (%).	
	18-29 yrs.	30-40 yrs.	0-5 yrs.	5-10 yrs.	10-15 yrs.	Pry	Sec.	Tertiary	Married	Single
Men	23	77	-	38	62	31	54	15	62	38
Women	100	-	82	18	-	18	82	-	82	18

4.2 Food and nutrient intake

4.2.1 Food Frequency of the participants

Daily food intake frequency was as illustrated in Figure 10.Food frequency analysis showed that cereal and cereal products were consumed daily by 95.8% of all the respondents, indication that they formed the main proportion of the respondents' diet (Table 5). Pulses and legumes were poorly consumed with only 16.7% consuming them daily, 25% once weekly, 25% occasionally and 20.8% didn't consume them at all. This food group is important because an endurance athlete needs carbohydrate to fuel muscles and protein to build and repair the muscles (Kanter, 2018).

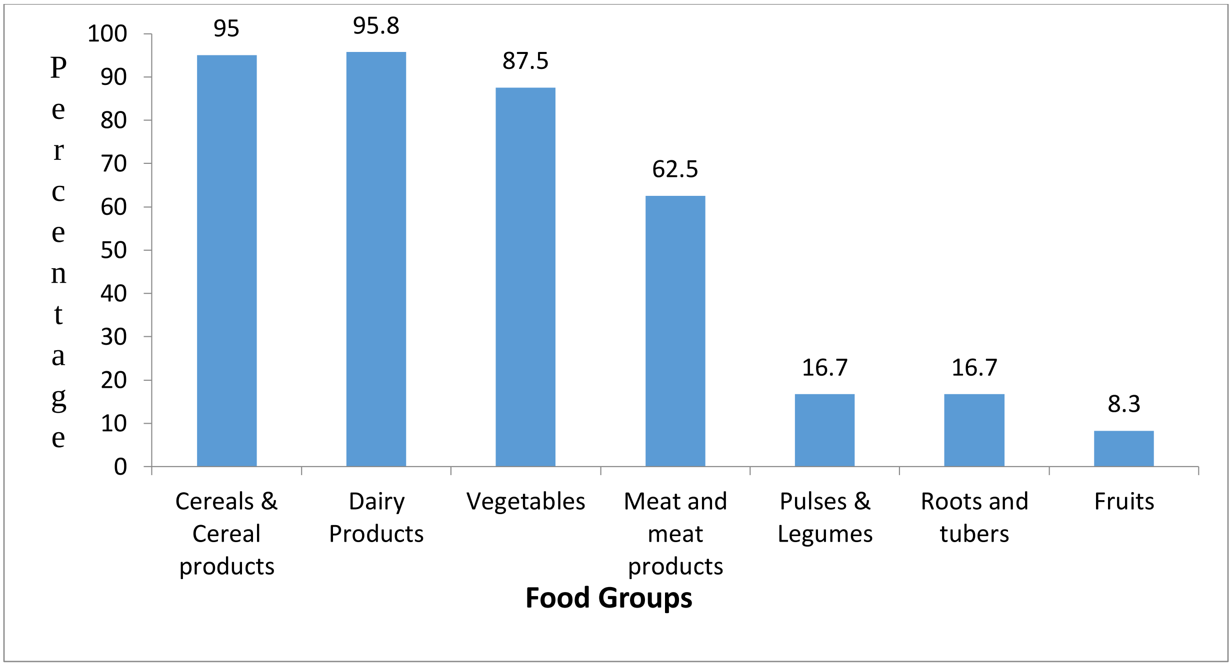

Figure 10: Daily food intake frequency

According to the results, Green leafy vegetables were very well consumed with 87.5% of the respondents consuming them daily with only 12.5% consuming them occasionally. Other vegetables such as carrots and green peas were poorly consumed with only 8.3% of the respondents consuming them daily, 45.8% occasionally and 25% never consumed them at all. Fruit intake was also poor with only 8.3% consuming them daily, 33.3% once weekly and 33.3% occasionally.

Consumption of roots and tubers was also low with only 16.7% consuming them daily, 33.3% once weekly, 29.2% occasionally and 12.5% never taking them at all. Milk and milk products intake was excellent with 95.8% of the respondents consuming them daily and only 4.2% taking them occasionally. Consumption of meat and meat products was good with 62.5% of the respondents taking them daily, 16.7% once in a week, 16.7% monthly and only 4.2% occasionally. However, the amounts consumed were lower than recommended in order to meet the RDA for protein.(Meyer et al., 2020).

Table 5: Food Intake Frequency (Number of respondents, % of respondents in brackets)

S. No	Food Group	Daily	Frequency weekly				Monthly	Occasionally	Never
			Once	Twice	Thrice	4 Times			
1	Cereal & Cereal products (Maize, Rice, Wheat)	23 (95.8)	0	1 (4.2)	0	0	0	0	0
2	Pulses & Legumes (Beans & Peas)	4 (16.7	6 (25)	1 (4.2)	0	0	2 (8.3)	6 (25)	5 (20.8)
3	Green leafy vegetables	21 (87.5)	0	0	0	0	0	3 (12.5)	0
4	Other vegetables (Carrots, Green peas)	2 (8.3)	2 (8.3)	0	0	0	3 (12.5)	11 (45.8%)	6 (25)
5	Fruits	2 (8.3)	8 (33.3)	2 (8.3)	0	0	4 (16.7)	8 (33.3)	0
6	Roots & Tubers (Sweet and Irish Potatoes)	4 (16.7)	8 (33.3)	0	0	0	2 (8.3)	7 (29.2)	3 (12.5)
7	Milk & Milk products	23 (95.8)	0	0	0	0	0	1 (4.2)	0
8	Meat & Meat products	15 (62.5)	4 (16.7)	0	0	0	4 (16.7)	1 (4.2)	0

4.2.2 Calorie and Nutrient Needs of the Respondents

The mean daily calorie intake of women was 1072.45 Kcal representing 40.09% of the Recommended Dietary Allowance (RDA), whereas calorie intake for men was 1266.76 Kcal which represented 46.6% of the RDA (Figure 10). Results of t-test revealed that there was a significant difference between calorie intake by men and women (*P-= 0.032).*

The mean daily carbohydrate intake for women and men was 150.09g and 195.53g respectively. This represented 37.4% and 47.9% of the RDA for the groups, respectively. This level was inadequate to maintain muscle glycogen at normal levels and prevent muscle glycogen depletion for the endurance athletes which require to be maintained at adequate levels. Statistical analysis showed that there was a significant difference between carbohydrate intake by men and women (*P=0.002*).

Average daily fat intake for women and men was 29g (39% of RDA) and 27.38g (36.6% of RDA) respectively. This further contributed to the general inadequate calorie intake by the respondents. Fat intake therefore needed to be increased to meet the RDA in order to spare protein during the long distance endurance race. Investigation on association between fat intake by gender established that there was no significant difference between fat intake by the two groups (*P= 0.610*).

Mean daily protein intake for the groups I and II was 54.81g and 59.53g which represented 54.6% and 58.9% of the RDA respectively. Analysis of the results also showed no significant difference between protein intake by men and women (*P= 1.094*). Following the inadequate intake, the respondents were advised to increase intake of protein foods like meat, pulses and legumes in order to meet the RDA and safeguard against tissue breakdown and muscle wasting. This is crucial also to maintain positive nitrogen balance.

The mean daily iron intake for the groups I and II was 9.56mg and 11.98mg which represented 53.1% and 79.8% of the RDA respectively. The iron intake by men and women was found to have significant difference (*P= 0.001).*These results indicate a level of iron intake which was inadequate to prevent sports anemia in the two groups of the athletes, and therefore the reason for the anemia established by the Hemoglobin (Hb) levels of the two groups. Consequently, the participants were educated on iron rich foods and the importance of increasing consumption of those foods in order to boost hemoglobin levels and prevent sports' anemia.

The average calcium intake for the two groups was 708.9mg and 827.23mg which represented 59% and 68.8% of the RDA respectively. According to the findings, Calcium intake by both men and women had no significant difference (*P= 0.229).*

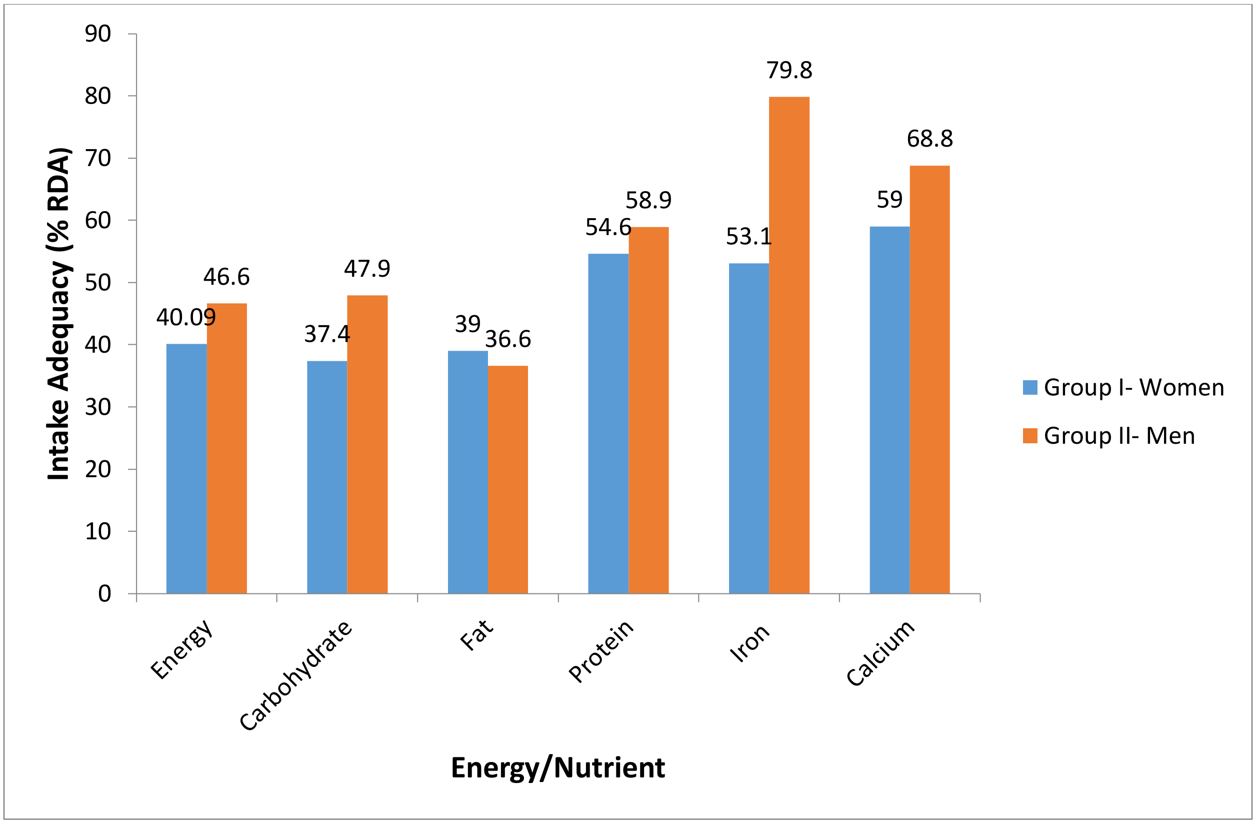

Figure 11: Daily Calorie and Nutrient Intake

Therefore, in summary, daily calorie and nutrient intake for group I (women) was as follows; Calorie 40.09 %, Carbohydrate 37.4 %, Fat 39 %, protein 54.6 %, iron 53.1 % and Calcium 59 % of the daily requirement (**Table 6**). Adequacy daily calorie and nutrient intake for group II (Men) was as follows; Calorie 46.6 %, Carbohydrate 47.9 %, Fat 36.6 %, protein 58.9 %, iron 79.8 % and Calcium 68.8 %.

Table 6: Daily Calorie and Nutrient Intake

Calorie/Nutrient	MEN Target RDA	Mean Intake	Percent Intake (%)	WOMEN Target RDA	Mean Intake	Percent Intake (%)	*P-Value*
Calorie	2716.5Kcal	1266.76± 221.53 Kcal	46.6	2675 Kcal	1072.45 ±189.3 Kcal	40.09	0.032
Protein	101.8g	59.53±9.78 g	58.47	100.3g	54.81±11.35 g	54.6	0.286
Carbohydrate	407.47g	195.53±37.26 g	48	401.25g	150.09 ±24.34 g	37.4	0.002
Fat	75.4g	27.38±7.04 g	36.6	74.3g	29 ±8.25 g	39.0	0.61
Calcium	1200mg	827.23±277.09 mg	68.9	1200mg	708.9 ±166.1 mg	59	0.229
Iron	15mg	11.98±1.39 mg	79.8	18mg	9.56 ±1.74 mg	53.1	0.001

Research has established that for optimal performance in long distance athletics, the ideal Body Mass Index (BMI) should be between 17.5 and 20.7. The mean BMI for women and men was 20.63 and 20.57 respectively(Sedeaud et al., 2014).

4.3. Development and Acceptability of the Dietary Supplement.

4.3.1 Sensory Evaluation Results

Table 7 shows sensory evaluation results of the developed Food Supplement as provided by the selected sensory evaluation participants. The rating scale provided for evaluation was as follows; Like very much-5, Like moderately-4, neither like nor dislike-3, Dislike moderately-2 and Dislike very much-1.

According to the responses, 50% of the respondents rated Overall acceptability of formulation II of the product as liked very much and 33.3 % rated overall acceptability of formulation I as liked very much. 25% of the participants Liked overall acceptability of formulation IV very much and only 16.6% of the respondents rated overall acceptability of formulation III as liked very much. Generally, rating of the organoleptic properties (Colour, appearance, taste, texture, flavor and overall acceptability) indicated that variation II was the most appealing to the respondents and therefore it was selected for the supplementation intervention.

Table 7: Sensory Analysis

Means of Responses by panelists who rated each of the attributes as "most liked"

Formulation	Colour	Appearance	Taste	Flavor	Texture	Overall Acceptability
I	2±1.82	3±1.63	2±1.82	2±1.29	3±1.41	4±1.41
II	3±1.41	4±1.82	5±2.16	4±1.41	3±1.41	6±2.44
III	1±1.82	2±0.81	1±2.44	2±1.41	1±2.16	2±1.41
IV	3±0.81	2±1.15	1±1.82	3±1.41	3±1.63	3±1.41

4.3.2 Proximate composition analysis results

Proximate Composition of the product

The formulation was computed based on ability to deliver at least 25% of the Recommended Dietary Allowance (RDA) for energy, protein, calcium and iron.

According to the proximate composition analysis done on the most acceptable product, the results showed that the product developed contained 228.2mg of calcium, 3.95mg of iron, 71.97g carbohydrate, 8.72g fat, 17.37g protein, 435.84 Kcal, 8.22g moisture and 1.42g of total ash content per 100g of the product. This therefore represented daily supplementation level for individual athlete, because each athlete was given a 100g of the food supplement for each day. Shelf-life analysis results reported that the product would remain safe in the market for a period of 3-4 months depending on the prevailing conditions of storage.

4.4 Nutritional Status and Body Composition of the Study Participants

4.4.1 Nutritional Status of the participants

4.4.1.1 Body Mass Index status

In Group I (Women) the percentage of the participants who were underweight with a Body Mass Index less than 18.5 was 9% at pre-intervention whereas all the participants had their BMI within the normal range (18.5-22.9) post-supplementation intervention. On the other hand, 15.38% of men (group II) participants were underweight with their Body mass index less than 18.5 at pre-supplementation intervention and all of them had their BMI within the normal range (18.5-22.9) post the intervention. Mean weight improved significantly in women, post-supplementation intervention, as compared to the control group ($P < 0.001$).

4.4.1.2 Hemoglobin results

Group I (women) –intervention group hemoglobin results

Initial Hemoglobin assessment indicated that all (100 %) the participants in group I (women) had sports' anemia with Hb levels below 12mg/dl (Figure 16). The assessment was done by use of the Hemoque machine for all the participants. Hemoglobin assessment in group I (women) showed a remarkable improvement in the mean hemoglobin levels from pre-intervention, Mid-intervention and post intervention assessments. The mean hemoglobin increased from 9.78 mg/dl at pre-intervention to 12.32 mg/dl at Mid-intervention and finally to 14.6 mg/dl at post-intervention (Figure 12).

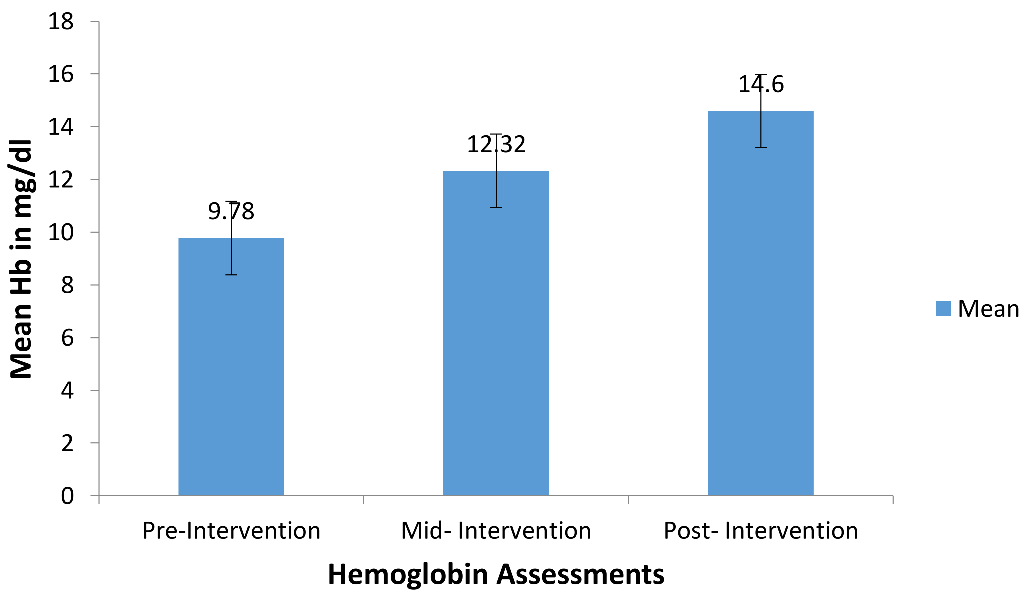

Figure 12: Women Intervention Group's mean Hemoglobin levels

Group 1 (women) - control group: hemoglobin (Hb) test results

For the Group I Control/ unsupplemented group however, hemoglobin assessment showed minimal changes in the mean Hb level. On the contrary, the mean hemoglobin level reduced slightly from 9.61mg/dl to 9.52mg/dl. This was a clear indication that the food supplement administered in group 1-intervention group, had a positive impact in improving Hemoglobin status of the participants. **Table 8** illustrates hemoglobin levels of both women intervention and control groups.

Table 8: Women Intervention and Control Mean Hemoglobin Levels

Measurement	**Group I-Intervention**	**Group I- Control Group**
At the Start-Mean Hb (mg/dl)	9.78 ±1.28	9.61 ±1.23
At the End-Mean Hb (mg/dl)	14.6 ±1.37	9.52 ±0.91

Group 2 (men) - intervention group: hemoglobin results-summary

Pre-intervention hemoglobin assessment indicated that 84.61 % of the participants in group II (**men**) had sports' anemia with Hb levels below 14mg/dl(Figure 17). However, hemoglobin assessment in group II (men) showed a remarkable improvement in the mean hemoglobin levels from pre-intervention, Mid-intervention and post intervention assessments respectively. The mean hemoglobin levels increased progressively from 11.8mg/dl at pre-intervention to 13.64mg/dl at Mid-intervention and finally to 15.85 mg/dl at post-intervention as indicated in Figure 13).

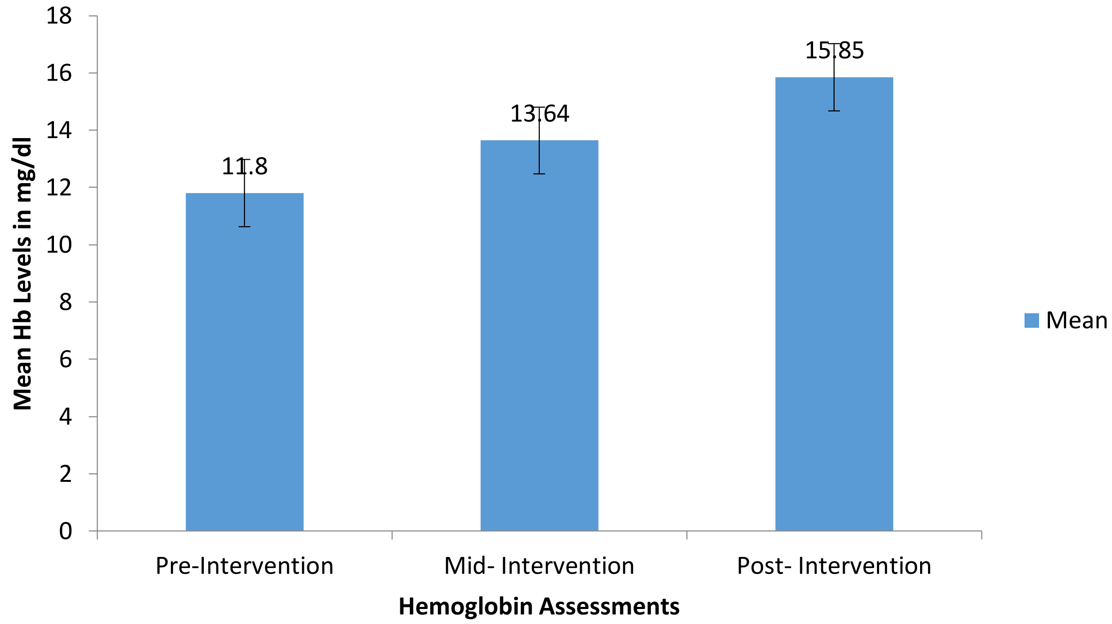

Figure 13: Men Intervention Group's mean Hemoglobin levels

Group 2 (men) - control group: hemoglobin results

Like in women, hemoglobin assessment for Control/ unsupplemented male group showed minimal changes in the mean Hb levels. The mean hemoglobin levels for this group increased slightly from 11.80 mg/dl to 11.86 mg/dl (Table 10). This was a clear indication that the food supplement administered to the male- intervention group, had a positive impact in improving Hemoglobin status of the participants, further supporting observation made in group I-intervention/ supplemented group. **Table 9** illustrates hemoglobin levels of both men intervention and control groups.

Table 9: Men Intervention and Control Mean Hemoglobin Levels

Measurement	Group II- Intervention Group.	Group II- Control Group
At the Start Mean Hb (mg/dl)	11.8 ±1.68	11.80 ±1.68
At the End Mean Hb (mg/dl)	15.85 ±1.08	11.86 ±1.66

4.4.2 Body composition of the study participants

Group 1 (women)-intervention group body composition analysis results

Body Composition Analysis was done using a BCA machine called Diagnostic Scale. According to the Body Composition Analysis results, there was an increase in the mean fat free mass in women (group I) from 19.18 Kg to 19.40 though the change was not significant (*P=0.144*). There was also an insignificant increase in the mean body mass index in the same group, from 20.63 to 20.90 (*P=0.144*).The mean percentage body fat significantly reduced from 19.79 to 19.72 % (*P=.0.049*). The mean Basal metabolic rate (BMR) in the same group also increased from 1353.09 to 1364.63. The mean bone mass percentage remained unchanged in group I, whereas the mean total body water percentage also increased from 58.48 to 59.11 % at the end of the intervention period (Figure 14). The percentage body water increment was however insignificant compared to the control group (*P=0.134*).

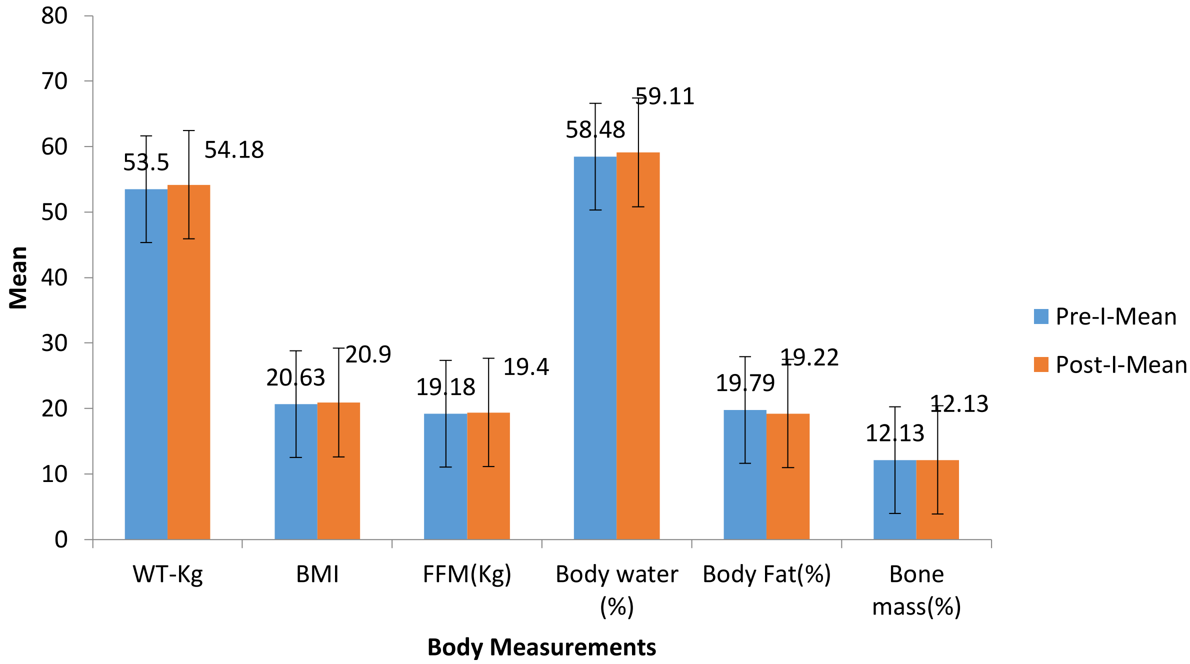

Figure 14: Women Intervention Group's mean body composition

Group1 (women): Control group's body composition analysis results

Body composition results for Group 1 (Women) control/ unsupplemented group showed minimal or insignificant changes (Figure 15). The results for the women control group were as follows; there was a slight increase in the mean fat free mass from 19.15 Kg to 19.18. There was also slight improvement in the mean body weight and body mass index in the same group, from 53.32 to 53.50 Kg and 20.57 to 20.63 Kg/m^2 respectively. The mean Basal metabolic rate (BMR) in the same group increased slightly from 1353.02 to 1353.09. Changes observed in mean body weight, BMI, FFM and BMR were however insignificant. The mean bone mass percentage showed very slight reduction in women from 12.14% to 12.13%, whereas the mean total body water percentage increased significantly from 58.42 to 58.48 % at the end of the intervention period ($P < 0.011$).

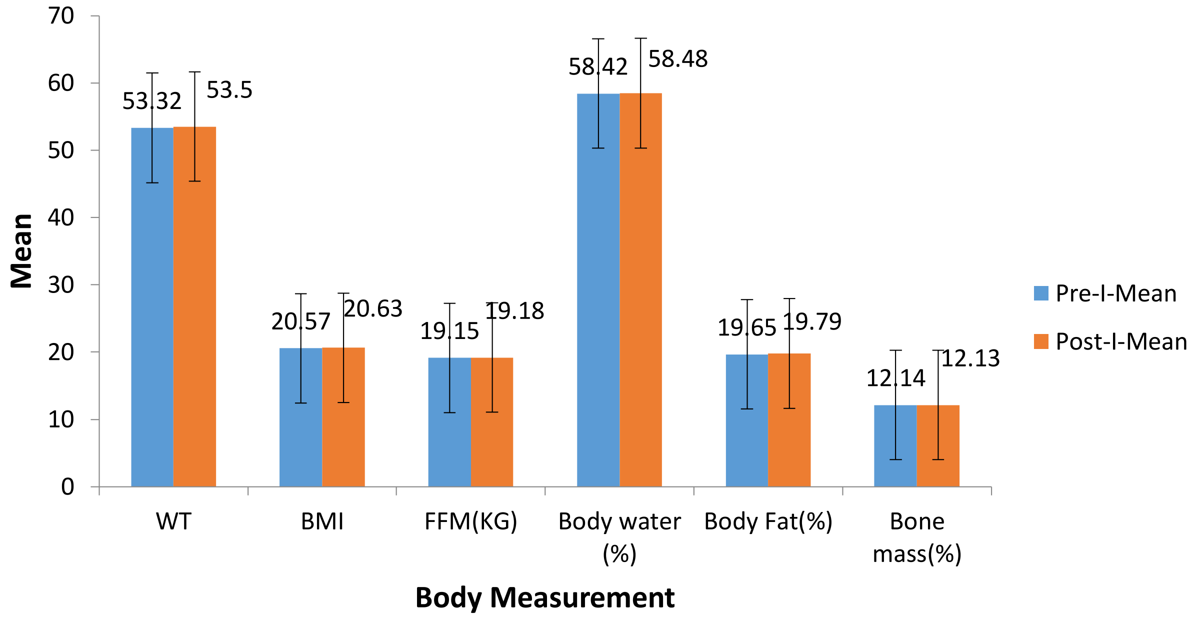

Figure 15: Women Control Group's mean body composition

Difference in body composition between the intervention/supplemented and unsupplemented/control clusters in group I (women) can be better explained by interrogating the summary of results in Table 10. The table summarizes results of body composition for both Group I (women) intervention and control clusters for easier comparison of the difference between the two sub-groups. This therefore provides a clear picture of the level of significance in improvement of body composition between the intervention and control clusters.

Table 10: Group 1(women) combined results for body composition

Measurement	WT (Kg) I.Gp	WT (Kg) C.Gp	BMI I.Gp	BMI C. Gp	FFM(KG) I.Gp	FFM(KG) C.Gp	Body water (%) I.Gp	Body water (%) C.Gp	Body Fat(%) I.Gp	Body Fat(%) C.Gp	Bone mass(%) I.Gp	Bone mass (%) C.Gp
Pre-I-Mean	53.5 ±6.79	53.32 ±6.83	20.63 ±1.22	20.57 ±1.29	19.18 ±2.01	19.15 ±2.06	58.48 ±2.25	58.42 ±2.23	19.79 ±2.99	19.65 ±2.75	12.13 ±0.51	12.14 ±0.52
Post-I-Mean	54.18 ±6.86	53.5 ±6.79	20.90 ±1.12	20.63 ±1.22	19.4± 2.33	19.18 ±2.01	59.11 ±3.03	58.48 ±2.25	19.22 ±3.17	19.79 ±2.99	12.13 ±0.55	12.13 ±0.51
%age improvement	2.21	0.34	1.31	0.29	1.15	0.15	1.08	0.1	-2.88	0.71	0	0.08
P-Value	0.050	0.260	0.117	0.117	0.144	0.277	0.134	0.011	0.049	0.340	0.923	0.588

I.Gp represents Intervention/supplemented group&

C.Gp represents Control/unsupplemented group

Group II (men)-intervention group body composition analysis results

According to the results, there was an increase in the mean fat free mass in men (group II) from 26.78kg to 26.99 kg (Figure 13). There was an increase in the mean body weight and body mass index in the same group, from 54.33 kgto55.35 kgand19.71to 20.08 kg respectively. The mean Basal metabolic rate (BMR) in the same group also increased from 1458.46to 1474.23. The mean bone mass percentage increased slightly in group II from 15.69% to 15.78%, whereas the mean total body water percentage reduced slightly from65.15 to 65.01 % at the end of the intervention period.

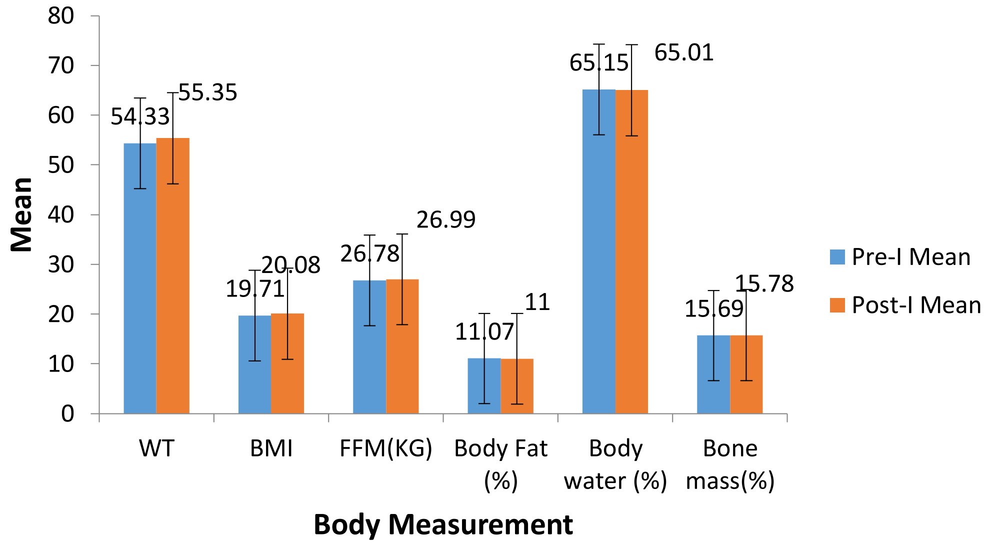

Figure 16: Men Intervention group's mean body composition

Group II:Control group body composition

Like in group I, body composition results for the control/ unsupplemented male group showed minimal or insignificant changes (Figure 17). The results for the men control group were as follows; there was a slight increase in the mean fat free mass from 26.74 Kg to 26.78Kg. There was also slight improvement in the mean body weight and body mass index in the same group, from 54.30 to 54.33 and 19.70 to 19.71 respectively. The mean Basal metabolic rate (BMR) in the same group reduced slightly from 1495.07 to 1458.46. The mean bone mass percentage showed very slight increment in group II control results from 15.68 % to 15.69 %, whereas the mean total body water percentage also reduced slightly from 65.17 % to65.15 % at the end of the control period.

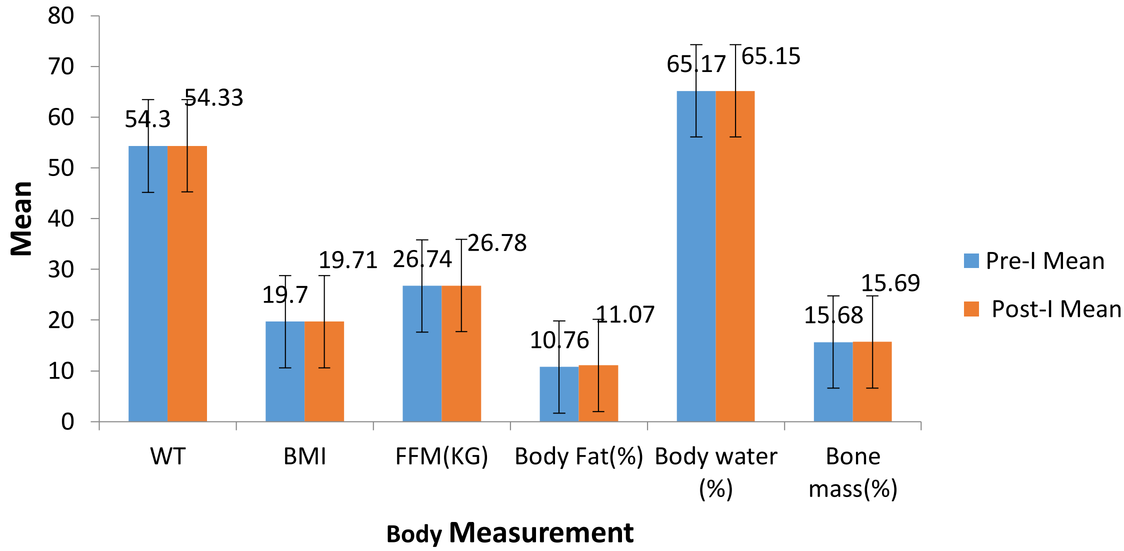

Figure 17: The Men Control mean body composition

The difference in body composition between the intervention/supplemented and unsupplemented/control clusters in group II (Men) can be better explained by interrogating the summary of results in the Table 11.The table summarizes results of body composition for both Group II (men) intervention and control clusters for easier comparison of the difference between the two sub-groups. This therefore provides a clear picture of the level of significance in improvement of body composition between the intervention and control sub-groups.

Table 11: Group II (Men)'s combined results for body composition analysis

Measurement	WT (Kg) I.G	WT (Kg) C.G	BMI I.G	BMI C.G	FFM (KG) I.Gp	FFM (KG) C.Gp	Body water (%) I.G	Body water (%) C.G	Body Fat (%) I.G	Body Fat (%) C.G	Bone mass (%) I.G	Bone mass (%) C.G
Pre-I-Mean	54.33 ±5.84	54.3 ±5.83	19.71 ±1.41	19.70 ±1.33	26.78 ±1.85	26.74 ±1.84	65.15 ±2.58	65.17 ±2.57	11.07 ±4.03	10.76 ±3.52	15.69 ±0.90	15.68 ±0.91
Post-I-Mean	55.35 ±6.34	54.33 ±5.84	20.08 ±1.44	19.71 ±1.41	26.99 ±1.95	26.78 ±1.85	65.01 ±2.32	65.15 ±2.58	11 ±3.32	11.07 ±4.03	15.78 ±0.89	15.69 ±0.90
%age improvement	1.88	0.05	1.87	0.05	0.78	0.15	-0.21	-0.03	-0.63	2.88	0.09	0.06
P-Value	0.001	0.104	0.001	0.226	0.008	0.018	0.338	0.656	0.838	0.325	0.376	0.584

I.G represents Intervention/supplemented group &

C.G represents Control/unsupplemented group

The results showed a significant increase of the mean body weight in the supplemented male group as compared to the unsupplemented/control group *(P< 0.001).*Similarly, there was a corresponding significant increase of the mean Body mass Index for the same group as compared with the control group (*P< 0.001*). The same results also indicated a significant increase in the mean Fat Free Mass in the supplemented group as compared with the control group (*P< 0.008*).

4.5 Physical Endurance of the Participants

4.5.1 Cardio-respiratory Endurance Results

Physical endurance tests were also done for all the groups at pre-intervention, mid- intervention and post-intervention i.e. for both cardio-respiratory and muscular endurance. Cardio-respiratory endurance assessment was done by use of a treadmill. The subjects were instructed to run on the treadmill with the speed set at 15 $kmhr^{-1}$. The parameters recorded for each run were; time taken (in minutes) to exhaustion, calories burnt and distance covered in km. The assessments were done three times i.e. pre-intervention, mid-intervention (after 1month) and post-intervention.

Group 1 (women)-Intervention group's cardio-respiratory endurance results

According to the cardiorespiratory assessment done for group I (women) intervention / supplemented group, the mean time taken to exhaustion for the pre-intervention, mid-intervention and post-intervention assessments was 10.87, 17.72 and 21.83 minutes respectively. This showed a significant improvement in time taken to exhaustion in the subsequent assessments (*P=0.001*). Similarly, there was a consistent increase in the mean calories burnt and distance covered to exhaustion. Mean calories burnt by the subjects for the three consecutive assessments were 160.71, 284.91 and 342.45 respectively. This represented a significant improvement in calories burnt to exhaustion (*P=0.003*). The mean distance covered for the three assessments were 1.92, 3.16 and 3.84kKm respectively, which was also a significant improvement in the mean distance covered to exhaustion (*P=0.013*). **Table 12** shows Cardiorespiratory Endurance results for women (Group I) intervention cluster.

Table 12: Group I (Women): Intervention Cardiorespiratory Endurance Results

Mean time, calories burnt and distance covered on treadmill

Parameter measured	**Pre-intervention**	**After one month**	**Post-intervention**
Time to Exhaustion (Minutes)	10.87 ±7.03	17.72 ±4.88	21.83 ±5.01
Calories Burnt/Expended (Kcal)	160.71 ±149.98	284.91 ±73.00	342.45 ±87.68
Distance covered (Km)	1.92 ±1.88	3.16 ±0.72	3.84 ±0,92

Female control group's Cardio-respiratory endurance results

The cardiorespiratory assessment done for group (women) Control/Unsupplemented group however did not show major changes between the two assessments done, compared to the supplemented group. The mean time taken to exhaustion for the pre-intervention and post-intervention assessments was 10.58 and 11.63 minutes respectively. This however, showed a significant improvement in the meantime taken to exhaustion (*P=0.018*). There was a slight increase in the mean calories burnt and distance covered to exhaustion. Mean calories burnt to exhaustion by the subjects for the two consecutive assessments were 174.39, and 183.72 respectively. The results showed that there was no significant improvement in the mean calories burnt to exhaustion (*P=0.296*).The mean distance covered to exhaustion for the assessments were 1.928, and 2.09 Km respectively. That also showed no significant improvement in the mean distance covered to exhaustion by the group (*P=0.123*). The slight improvement in the three parameters could be attributed to the nutritional counseling sessions done, which were offered to all the groups. **Table 13** illustrates Cardiorespiratory Endurance results for women (Group I) Control cluster.

Table 13: Women control group's Cardio-respiratory endurance

Parameter measured	Starting Mean	Ending Mean
Mean Time to Exhaustion (Minutes)	10.58 ±7.19	11.63 ±7.06
Mean Calories Burnt/ Expended (Kcal)	174.39 ±155.65	183.72 ±147.18
Mean Distance covered (Km)	1.98 ±1.9	2.09 ±1.79

Male Intervention group's Cardio-respiratory endurance results

Cardiorespiratory assessment done for group II (men) intervention/supplemented group, showed an improvement in the three parameters assessed for cardiorespiratory endurance i.e. mean time taken to exhaustion, distance covered and calories burnt. The mean time taken to exhaustion for the pre-intervention, mid-intervention and post-intervention assessments was 13.26, 18.34 and 22.99 minutes respectively. These findings showed a significant improvement I the mean time taken to exhaustion (*P=0.014*). Similarly, there was a consistent increase in the mean calories burnt and distance covered to exhaustion. Mean calories burnt by the subjects for the three consecutive assessments were 217.8, 335.07 and 615.61 respectively. However, the results did not represent significant improvement in the mean calories burnt to exhaustion by the group (*P=0.075*). The mean distance covered to exhaustion by the group for the assessments was2.66, 3.91 and 4.87 Km respectively. These findings showed a significant improvement in the mean distance covered to exhaustion (*P=0.025*).**Table 14** illustrates Cardiorespiratory Endurance results for men (Group II) Intervention cluster.

Table 14: Men Intervention group's Cardio-respiratory endurance

Parameter measured	Pre-intervention	After one month	Post-intervention
Mean Time to Exhaustion (Minutes)	13.26 ±5.61	18.34 ±9.14	22.99 ±11.27
Mean calories Burnt/Expended (Kcal)	217.8 ±112.8	335.07 ±180.27	615.61 ±708.02
Mean Distance covered (Km)	2.66 ±1.6	3.91 ±2.31	4.87 ±2.76

Male control Group's, cardiorespiratory endurance results

The three parameters were also assessed for the group II (Men) Control/Unsupplemented group. However, the results did not present major changes between the two assessments done, compared to the supplemented group. The mean time taken to exhaustion for the pre-intervention and post-intervention assessments increased slightly from13.26 and 13.49 minutes respectively. The results showed that there was no significant improvement in the meantime taken to exhaustion by the group (*P=0.762*). Likewise, there was a slight increase in the mean calories burnt and distance covered to exhaustion. Mean calories burnt to exhaustion by the subjects for the two consecutive assessments was217.8, and 227.42 respectively. These results also did not represent significant improvement in the mean calories burnt to exhaustion (*P=0.527*). The mean distance covered to exhaustion also showed insignificant improvement for the consecutive assessments done, whose results were 2.61, and 2.66 Km respectively (*P=0.803*).**Table 15**shows Cardiorespiratory Endurance results for men (Group II) Control cluster.

Table 15: Men control Group's, cardiorespiratory endurance

Mean time taken, calories burnt and distance covered on treadmill

Parameter measured	Starting Mean	Ending Mean
Time to Exhaustion (Minutes)	13.26 ±4.81	13.49 ±5.61
Calories Burnt/Expended (Kcal)	217.8 ±88.76	227.42 ±112.8
Distance covered (Km)	2.61 ±1.48	2.66 ±1.6

The group members also received nutritional education together with the other groups which could have enabled them to achieve the slight improvement observed in the three parameters assessed. However, there was a more tremendous improvement in all the three parameters assessed for Group II (men) supplemented group, which indicated that the supplementation played a key role in improving their cardiorespiratory endurance.**Table 16** shows a summary of Cardiorespiratory Endurance results for both men (Group II) and women (Group I) intervention cluster.

Table16: Groups I &II Pre- and Post-Intervention Treadmill Summary Results

Parameter measured	Group I Intervention Group		Group I- Control Group		Group II Intervention Group		Group II- Control Group	
	Pre-I	**Post-I**	Pre-I	**Post-I**	Pre-I	**Post-I**	Pre-I	**Post-I**
Mean Time to Exhaustion (Minutes)	10.87 ±7.03	21.83 ±5.01	10.58 ±7.19	11.63 ±7.06	13.26 ±5.61	22.99 ±11.27	13.26 ±4.81	13.49 ±5.61
Mean Calories Burnt/Expended (Kcal)	160.71 ±149.98	342.45 ±87.68	174.39±155.65	183.72±147.18	217.8 ±112.8	615.61±708.02	217.8 ±88.76	227.42 ±112.8
Mean Distance covered (Km)	1.92 ±1.88	3.84 ±0,92	1.98 ±1.9	2.09 ±1.79	2.66 ±1.6	4.87 ±2.76	2.61 ±1.48	2.66 ±1.6

4.5.2 Muscular endurance

Female Intervention Group's muscular endurance results

Muscular endurance of the participants was assessed by use of complete push-ups to exhaustion. This assessment was also conducted three times i.e. at pre-intervention, mid-intervention (after 1 month) and post-intervention. The push-ups were done by one participant at a time, in order to observe complete push-ups. Then for each participant, the number of complete push-ups to exhaustion were counted and recorded for each assessment.

In order to improve accuracy of the results, the participants were asked to perform the push-ups two times for each assessment and the push-ups performance repeated after a day and done at the same time of the day (morning 8.30-9.30). Then the mean of the two push-up exercises were calculated and recorded. According to the results, there was a consistent increase in the mean number of push-ups done in the three assessments.

The mean push-ups for pre-intervention, mid-intervention and post-intervention assessments for group I (women) supplemented group were 10, 12.7 and 16.8respectively (Figure 18). These results showed a significant improvement in muscular endurance of the participants (*P=0.003*).

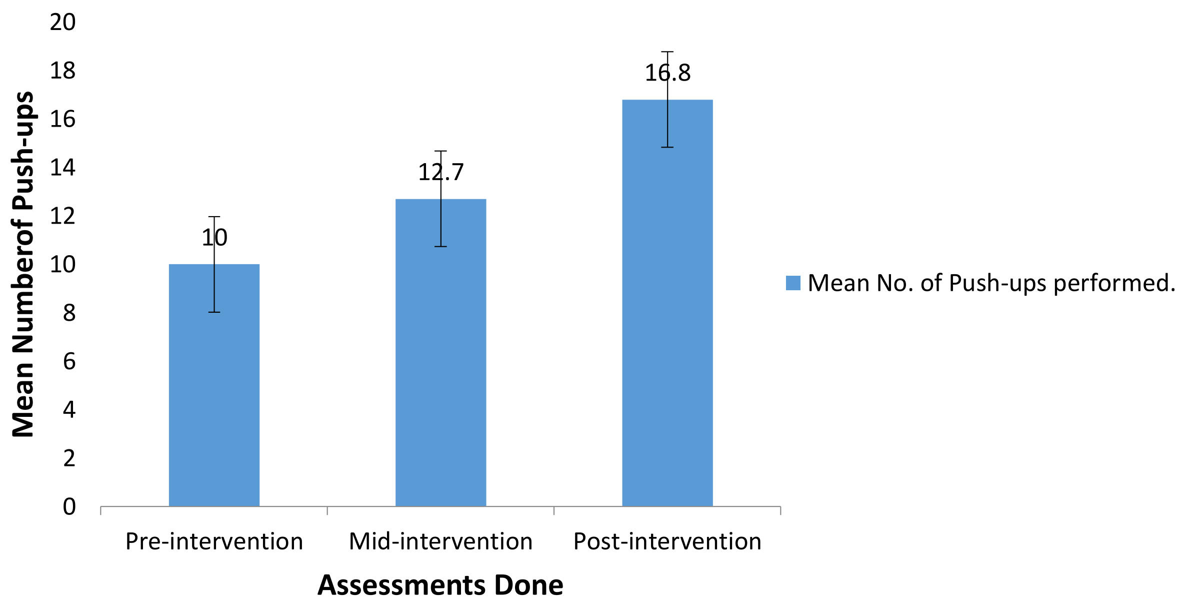

Figure 18: Women Intervention Group's muscular endurance

Female Control Group's muscular endurance Results

Muscular endurance assessment for the group I control/unsupplemented group showed only a slight improvement compared to the supplemented group. The mean push-ups for pre-intervention, and post-intervention assessments for group I (women) Control group was9.5 and 10 respectively. This however, did not represent significant improvement in the mean push-ups performed to exhaustion (*P=0.296*). This indicated a major improvement was observed in the supplemented group as compared with the control group. This further proved that the food supplement had not only positive effect in improvement of cardiorespiratory endurance but muscular endurance as well.

Male Intervention Group's Muscular Endurance Results

Muscular endurance assessment was done also for group II (men) supplemented group and the mean push-ups for pre-intervention, mid-intervention and post-intervention assessments were 10.23, 12.46 and 15.76 respectively **(Figure 19)**. The results showed a significant improvement in the mean push-ups performed to exhaustion (*P=0.000*). These results similarly showed a consistent improvement in muscular endurance of the participants.

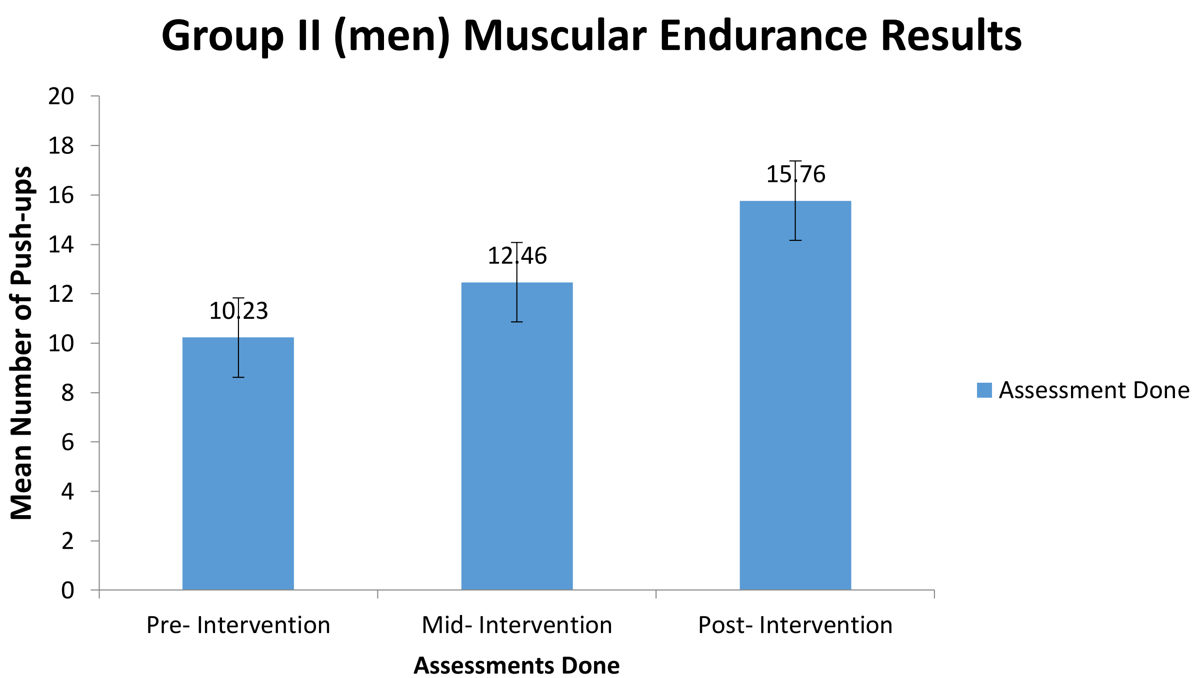

Figure 19: Men Intervention Group's Muscular Endurance

Male control group's muscular endurance results

Muscular endurance assessment for the group II (Men) control/unsupplemented group showed a slight decline in the mean push-ups contrary to the supplemented group in which the participants showed improvement. The mean push-ups for pre-intervention and post-intervention assessments for group II (men) Control group were 10.15 and 9.92 respectively. The results did not represent significant improvement in the mean push-ups performed to exhaustion by the group (*P=0.387*). This showed that a major improvement was observed in the supplemented group as compared with the control group. Therefore, the findings were in line with findings for group I which indicated that the food supplement had a major positive effect in improving muscular endurance of the participants. **Table 17** shows a Summary of Muscular Endurance results for both men and women Groups.

Table 17: Groups I & II Muscular Endurance Results-Summary

Parameter measured	Group I Intervention Group		Group I- Control Group		Group II Intervention Group		Group II- Control Group	
	Pre-I	**Post-I**	Pre-I	**Post-I**	Pre-I	**Post-I**	Pre-I	**Post-I**
Mean number of push-ups to exhaustion	10 ±3.39	16.8 ±7.6	9.5 ±3.47	10 ±3.34	10.23 ±1.3	15.76 ±4.24	10.15 ±1.4	9.92 ±0.95

Pre-I: means Pre-Intervention

Post-I: means Post-Intervention

CHAPTER FIVE: DISCUSSION

5.1 Food and Nutrient Intake of the athletes

Food frequency and nutrient intake questionnaire was administered to collect data on foods regularly consumed and the frequency of intake, as well as calorie and key target nutrients' intake. Roots and tubers contain bioactive constituents such as phenolic compounds, saponins, bioactive proteins, glycoalkaloids, and phytic acids. This makes roots and tubers an important part of diet, offering numerous desirable nutritional and health benefits such as antioxidative, hypoglycemic, hypocholesterolemic, antimicrobial, and immunomodulatory effects in the body (Chandrasekara & Josheph Kumar, 2016b). However, according to the results on calcium intake, the amounts consumed could have been lower and so the RDA for calcium was not met. So the participants were encouraged to increase their milk and milk products intake in order to boost their calcium and other minerals intake. Dairy products are thought to improve recovery after both resistance and endurance exercises due to their nutritional proprieties(Purcell et al., 2013). The main nutrients targeted in the assessment were carbohydrate, protein, fat, calcium and iron. Carbohydrate intake was assessed because it is the main source of energy for the athletes. Protein intake was also of special interest because of its' higher requirement for tissue repair for the wear and tear that occur during the training and competition. Being the next alternative source of energy, fat intake assessment was also crucial as it contributes to the overall daily calorie intake and hence the reason why it was targeted in the current study.

Calcium is also very important for the long distance athletes as it is required for healthy muscular function as well as maintenance of healthy strong bones that is vital to support the intense physical activity and prevent osteoporosis. Therefore, calcium intake was also an important factor to be evaluated in this study. There was a need therefore, to increase calcium intake to enhance strength of the bones and maintain normal calcium metabolism. This gap was covered during the education sessions and all the participants were enlightened on the importance of adequate calcium intake in promoting healthy muscles contraction as well as in maintenance of optimal bone health and strength.

Sports' anemia is very common in athletes due to increased iron losses through sweat during the long distance training. The anemia reduces oxygen transport due to low hemoglobin levels which consequently reduce oxidation of glucose and fatty acids to supply the much needed energy during the training sessions. That leads to early fatigue, reduced cardiorespiratory and muscular endurance and compromised physical performance. For this reason, iron intake was a key factor assessed in this study.

To determine calorie and all the target nutrients' intake, standard food exchanges and measuring equipment were used. Standard cup (250 ml) and standard food portions (exchanges) were used in diet calculations to determine the intake.

Due to the low intake of pulses, there was need therefore to encourage the participants who consumed the pulses and legumes occasionally as well as those who never ate them to take them more frequently as they offer a good source of protein-carbohydrate combination which is very important for optimal performance. Green leafy vegetables were very well consumed and these provide a good source of antioxidants to counteract oxidative damage of the cells which could result from free radicals generated by the prolonged periods of endurance exercise. Meat intake was also good which indicates a good intake of amino acids. Milk and milk products intake by both gender was excellent and that is why data analysis on calcium intake by both men and women showed no significant difference. However, 24-hour food recall revealed that the intake was not adequate to meet the RDA for calcium.

The general low intake of fruits could have further compromised their vitamin and mineral intake. Low intake of fruits could be partly attributed to high prices and most of them being out of season but mainly due to inadequate knowledge of their importance in the diet. Many athletes the world over experience the same problem and that’s why sports’ nutrition education and support is vital for the athletes. Therefore during the sports nutrition education sessions they were encouraged to eat more fruit in order to help prevent mineral and vitamin deficiencies which would predispose them to oxidative stress (Burkhart & Pelly, 2016)..

The 24-hour food recall also showed that RDA for energy, protein, carbohydrate, fat and iron was not met. Similar to many other research publications, calorie intake by men and women was found to have significant difference, since men require more energy than women due to higher muscle mass. The difference however, does not apply on fat intake by both gender since women tend to consume higher proportions of fat in diet than men and hence no significant difference on fat intake by both gender. As reported in other research findings, carbohydrate intake levels showed there was a significant difference between men and women. This was mainly because higher energy needs in men drive then to consume much more food especially carbohydrate since it is the main source of energy for the body. Results on iron intake by both men and women showed a significant difference. This compares very well with several other studies done on iron intake as it is related to higher dietary intake by men as compared to women. The results reveal a gap in sports’ nutrition that need to be addressed be athletics management bodies both locally and internationally. In addition to food, calorie and nutrient intake, we established that both women and men had their mean BMI within the recommended range for long distance athletes.

5.2 Dietary Supplement development and Proximate Composition

Product development was informed by the Key target nutritional components, vital for optimal athletic performance. One of the key components is energy which according to research findings is a challenge for many athletes more so due to glycogen depletion and underweight as a result of inadequate dietary intake.

The Food supplement was formulated with a target of providing at least 20% RDA of the four key nutritional components which formed the basis of this study. To ensure acceptability of the food supplement, four variations were formulated and subjected to sensory evaluation. The variation which scored the highest was then chosen for the supplementation intervention.

Athle-food also had high acceptability ratings in terms of colour, appearance, Texture, flavor and overall acceptability as shown by the sensory evaluation results. Since this supplementation only met approximately 20% of the RDA for energy, protein, calcium and iron, the participants were encouraged to maintain their normal dietary intake to ensure adequate calorie and nutrient intake.

The recommended Dietary Allowance (RDA) for energy in athletes is 45-50Kcal/Kg bwt/day which by far higher than non-exercising individuals which is usually around 30-35Kcal/Kg bwt/day. The other major nutritional component of interest is protein, whose RDA is elevated to 1.2 to1.4g/Kg bwt/day to help in repair of worn out tissues and recovery in between competitions. Apart from these two, iron is also another key nutritional component because sports' anemia is very common in athletes. This is because there is usually increased iron loss from the body through sweat. The RDA for Iron in athletes is elevated to 15-18mg/day which is far above the normal average for non-exercising individuals' of 8mg/day. The other nutrient very critical for athletes and targeted by the present study is calcium, which is essential for maintenance of healthy bones and muscular activity. The RDA for calcium in athletics is 1200 to

1500 mg/day which by far exceeds the RDA for non-exercising persons which is 800 to 1,000 mg/day.

According to the proximate composition results, the daily supplementation provided the athletes with approximately 20% of the RDA for energy (435.84), 20% of the RDA for calcium (228.2mg) and 20% of the RDA for Iron (3.95mg). In addition, the supplementation also provided approximately 20% of the RDA for protein (17.37g). This level of supplementation was quite significant considering that during the nutrition education sessions; the athletes were advised to prioritize foods that were rich in these sports performance enhancing foods.

5.3 Efficacy of the Dietary Supplement in improving Nutritional Status of the Athletes.

During the first two (2) months of baseline assessment (Phase I), all the participants were offered sports' nutrition education only after which same assessments were repeated. The same participants were then given dietary supplement using the food product that was developed and followed up farther for the next two month period. So the entire study period on the participants was four (4) months. At the end of the supplementation period, the same assessments were repeated in order to determine efficacy of the Food Supplement in improving nutritional status and body composition of the athletes. This is supported by another study previously done in this area (DellaValle, 2013).

The research found out that, with use of the high calorie, protein, calcium and iron supplementation there was a greater improvement in the mean Body Mass Index (BMI) in men as compared to women. The mean BMI in group I (women) supplemented cluster increased by 1.31% whereas in the unsupplemented cluster the mean BMI increased slightly by 0.29%.However, there was no significant change in BMI post-supplementation intervention phase as compared to pre/post counseling phase in women *(P=0.117*). This could be partly attributed to some level of sharing the porridge with other members of the family especially children. The mean BMI in Group II (Men) supplemented cluster increased by 1.87% whereas in the unsupplemented cluster, the mean BMI increased only slightly by 0.05%.This showed that there was a significant change in BMI in the male supplemented group as compared to the control/unsupplemented group (*P=0.001*). This means that there is a significant change in weight after treatment was administered in the pre/post intervention phase as compared to pre/post counseling phase.

The findings revealed however, that there was no significant improvement in the mean BMI for the male control group (*P=0.226*). This shows that the male supplemented group utilized the supplementation very well with minimal sharing.

Body composition in women showed slight improvement in Fat Free Mass with the supplemented cluster having 1.15% increment in Fat Free Mass (FFM) compared to an increase by 0.15% in the unsupplemented cluster. However, the improvement in the mean Fat Free Mass was not statistically significant as compared to the control group (*P- =0.114*). Similarly, there was slight increase in the mean total body water at 1.08% in the supplemented cluster compared to the increment by 0.1% in the unsupplemented cluster. The increment in mean total body water was however not significant post-supplementation (*P=0.134*). On the other hand, there was a significant increase in mean percentage body water in women control group (*P=0.011*). This could be attributed to the higher percentage of body fat in the unsupplemented/control group as compared to the supplemented group as well as lower physical activity as compared to the supplemented group.

There was however a significant decrease in the mean percentage body fat for the supplemented cluster by 2.88% which shows a shift of the body weight towards Fat Free Mass which supports better competitiveness (*P=0.049*). In the women unsupplemented/control group however, there was no significant change in the percentage body fat (*P=0.340*), There was no significant change in the bone mass for both the supplemented and control groups for the period of supplementation (P= 0.923). This indicated that there was a shift in body composition from fat mass towards fat free mass and that the increase in Fat Free Mass resulted in more respiratory activity and oxidation of fats for energy.

In Group II (Men) a similar trend was observed with an increase in mean FFM for the supplemented cluster by 0.78% compared to an increment of 0.15% in the unsupplemented cluster. The increment in mean Fat Free mass (FFM) was statistically significant post-intervention in the supplemented male group (*P= 0.008*). Although the mean FFM increment in control group was lower than in the supplemented group, the increment was statistically significant, which could be attributed to the impact of sports' nutrition education offered during the period (*P=0.018*). Likewise, there was a decrease in the mean total body water for the supplemented cluster by 0.21% compared to a decrease by 0.03% in the unsupplemented cluster. However, the decrease in the mean % body water in the male groups was not statistically significant in the two groups (*P= 0.338*). The decrease in the mean total body water could be attributed to the increased physical activity and more loss through sweat.

Similarly, there was a slight decrease in mean percent body fat by 0.63% which also showed a shift in body weight towards Fat Free Mass which is good for better physical endurance. The decrease in mean % body fat for both the supplemented and unsupplemented groups was however not significant (*P= 0.838*). That was because from the beginning of the study, the mean

% body fat in men was relatively low compared to the women participants. As in Group I, there was no significant change in percent bone mass in the supplemented group as compared to the control group (*P= 0.376*). In addition, the results showed significant improvement in both the mean weight and mean Body Mass Index (BMI) in the male supplemented group as compared to the unsupplemented group (*P= 0.001*). In the control group however, there was no significant improvement in the mean Body Mass Index (BMI) (P=0.226). This indicates that the supplementation resulted in improved nutritional status of the male athletes.

Initial Hemoglobin assessment in group I (women), results indicated that all (100 %) the participants had sports' anemia with Hb levels below 12mg/dl. .The mean hemoglobin however increased for the women supplemented cluster from 9.78 mg/dl at pre-intervention to 14.6 mg/dl at post-intervention. On the contrary, the mean hemoglobin level reduced slightly from 9.61mg/dl to 9.52mg/dl in the unsupplemented cluster. The increment in the mean hemoglobin level was statistically significant as compared to the control group (*P= 0.000*). The results therefore indicate that the dietary supplementation was very effective in boosting Hemoglobin status of the female athletes.

In group II (**Men**), the baseline hemoglobin assessment indicated that 84.61 % of the participants had sports' anemia with Hb levels below 14mg/dl. The mean hemoglobin levels however increased in the Group II supplemented cluster from 11.8mg/dl at pre-intervention to 15.85 mg/dl at post-intervention. Similarly, the mean hemoglobin levels for the Group II (Male) unsupplemented cluster increased slightly from 11.80 mg/dl to 11.86 mg/dl. Improvement in the mean Hb level in the supplemented group was significant as compared to the control group (*P= 0.000*). The findings further showed that the supplementation also improved hemoglobin status in male participants.

5.4 Efficacy of the Dietary Supplement in improving Physical Endurance of the Athletes.

According to the cardiorespiratory Endurance assessment results, the mean distance covered and time taken to exhaustion improved significantly in the male supplemented group as opposed to the control group, which shows that the supplement had positive effect on the cardiorespiratory endurance of the athletes. Similarly, significant improvement was observed for the mean distance covered, time taken and calories burnt to exhaustion, in the women supplemented group as opposed to the control group. That further supported the fact evidence that the supplement was beneficial in enhancement of the athletes' cardiorespiratory endurance. Moreover, the results showed improvement in the mean push-ups to exhaustion for both male and female supplemented groups as compared to the control groups. That shows that the supplementation also improved muscular endurance of both male and female athletes.

Age and sporting experience of athletes are very key as they are closely related to muscle strength and level of physical endurance. Physical endurance develops over time and is dependent on consistent training, and for many athletes physical endurance reaches its' peak from the age of 30 to 35 years. Therefore, these results indicate that most of the men in this study were at their prime age and experience for the sport, whereas women were in their mid-stage of developing adequate endurance.

Dietary supplementation with a diet that is high in protein and energy relates very well with several other studies. For xample, in oner study which involved men in two separate groups, it was reported that suppllementation with both protein and carbohydrate at the same time restores physical performance capacity and imroves glycogen stores after a prolonged exercise (Alcantara et al., 2019).

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The study revealed that daily food and nutrient intake by the athletes is below the Recommended Dietary Allowances (RDAs) and therefore inadequate to meet their nutritional needs for optimal athletic performance. There is variety in the daily food intake. However, there is inadequate intake of the key nutrients and energy. Therefore, there is need for athletes to increase the quantities of the daily food intake to meet the RDA for energy as well as macro and micronutrients for optimal performance.

Supplementation with Athle-food results in significant improvement of nutritional status and body composition of the participants as reflected in the Mean Body Mass Index, mean Hemoglobin level and Body composition. With good nutritional support by having right formulations from natural cost-effective local foods, athletes can achieve optimal nutritional status. As a result, with this knowledge, athletes would be discouraged from doping which at times ends up ruining their career upon being banned from sport. General improvement in both cardio-respiratory and muscular endurance occurs following supplementation with the Athle-food for both men and women.

6.2 RECOMMENDATIONS

From these findings, the researcher makes the following recommendations:

i) Camp Coaches should engage qualified Nutritionist to equip the athletes with appropriate knowledge on foods and dietary habits that they need to observe to address their nutritional needs.

ii) Coaches should incorporate sports' nutrition education sessions by qualified professionals in their training programs, in order to equip athletes with Dietary and nutritional knowledge.

iii) The Coaches should also organize for routine monitoring of nutritional status of the athletes especially Hemoglobin levels, in order to prevent and manage sports anemia which was found to be a major problem among all the athletes.

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APPENDICES

APPENDIX I: RESEARCH QUESTIONNAIRE

PART I: SOCIO-DEMOGRAPHIC AND ECONOMIC INFORMATION.

1) Gender………….
2) Place of birth………
3) Place of residence………..
4) Age (Yrs)……..
5) Education level/qualification……….
6) Number of persons earning in the family…………………………
7) Amount of money spent on food per month in Ksh………………………………..

PART II: INFORMATION ON DIETARY INTAKE, PATTERN AND FOOD BAHAVIOUR.

1) Type of diet consumed (vegetarian/non-vegetarian)…………………….
2) Number of meals eaten per day…………….
3) Do you eat snacks between meals (Yes/No)……………….
4) If yes in 3 above, what type of snacks and how many?............................
5) Do you consume any "Health Foods/Supplements?" (Yes/No)……If yes, which one (s)?..
6) Estimated food and nutrient intake by 24 Hour Food Recall

Meal Timing	Foods Eaten	Ingredients used	Std. Measure (g)	Amount (g)	Est. Calorie intake	Est. Prot. intake	Est. Iron intake	Est. Calcium intake
Early Morning								
Breakfast								
Lunch								
Evening snack								
Dinner								
Bedtime								

7) Food consumption by Food Frequency method.

Food Group.	**Daily**	**Frequency weekly**				**Monthly**	**Occasionally**	**Never**
1) Cereal & Cereal products.								
2) Pulses & Legumes								
3) Green leafy vegetables								
4) Roots and Tubers								
5) Other vegetables								
6) Fruits								
7) Milk & Milk products								
8) Meats and animal products								

PART III NUTRITIONAL STATUS, BODY COMPOSITION AND PHYSICAL ENDURANCE.

1) Are you regularly engaged in the athletic sport with the rest of the team? (yes/no)…….
2) Are you training under a coach? (yes/no)…….
3) How many hours do you spend daily on training............
4) Nutritional status.

   Height (in cm)……………….

measurement	Pre-intervention	Mid-intervention	Post-intervention
Weight (in Kg)			
Body Mass Index			
Hemoglobin level (mg/dl)			

5) **Body Composition**

measurement	Pre-intervention	Mid-intervention	Post-intervention
Free Fat Mass (FFM in Kg)			
Total Body Fat (TBF in Kg)			
Percent Body Fat (%)			

6) **Physical Endurance**

Measurement	Pre-intervention	Mid-intervention	Post-intervention
Number of Push-ups/Press-ups to exhaustion.			
Time taken (in minutes & seconds) on treadmill to exhaustion.			
Distance Covered (in meters) on treadmill to exhaustion.			
Amount of energy in kilocalories burnt on treadmill to exhaustion.			

APPENDIX II: PARTICIPANT INFORMATION AND CONSENT

For enrollment in the study

Title of Study: Development of a nutritional supplement from local foods and determination of its efficacy in improving nutritional status and physical endurance in long distance athletes at Ngong training camp.

Principal Investigator\and institutional affiliation: Thiauru Lawrence Mugambi C/o University of Nairobi.

Introduction:

I would like to tell you about a study being conducted by the above listed researcher. The purpose of this consent form is to give you the information you will need to help you decide whether or not to be a participant in the study. Feel free to ask any questions about the purpose of the research, your rights as a volunteer, and anything else about the research or this form that is not clear. When we have answered all your questions to your satisfaction, you may decide to be in the study or not. This process is called 'informed consent'. Once you understand and agree to be in the study, I will request you to sign your name on this form. You should understand the general principles which apply to all participants in research:

i) Your decision to participate is entirely voluntary

ii) You may with draw from the study at anytime without necessarily giving a reason for your withdrawal

I will give you a copy of this form for your records.

May I continue? YES / NO

This study has approval by The Kenyatta National Hospital-University of Nairobi Ethics and Research Committee protocol No. __

WHAT IS THIS STUDY ABOUT

The researcher mentioned above is interviewing Athletes who participate in long distance races. The purpose of the study is to find out how intake of foods high in physical activity enhancing nutrients influences athletic performance. Participants in this research study will be asked questions about their food intake and training. Participants will also be assessed for nutritional status and body composition status. There will be approximately 40 participants in this study randomly chosen. We are asking for your consent to consider participating in this study.

WHAT WILL HAPPEN IF YOU DECIDE TO BE IN THIS RESEARCH STUDY?

If you agree to participate in this study, the following things will happen:

You will be given a questionnaire with questions on your routine food intake and training routine. The questionnaire will take approximately 20 minutes to fill in.

After filling the questionnaire, you will be assessed for hemoglobin level, body mass index and body composition for nutritional status. Then you will be required to do push-ups exercise to assess muscular endurance as well as run on a treadmill to assess cardio-respiratory endurance. After the assessment some of you will be supplied with flour made from different foods on weekly basis, which will be taken as porridge for a period of two months. After the two months then the assessments will be repeated to check on improvement.

I will ask for a telephone number where we can contact you if necessary. If you agree to provide your contact information, it will be used only by people working for this study and will never be shared with others.

ARE THERE ANY BENEFITS BEING IN THIS STUDY?

You will benefit by receiving free hemoglobin status assessment, body composition assessment and nutritional status assessment and nutritional counseling.

Also, the information you provide will help us better understand how we can appropriately use the foods we have for competitive advantage, bearing in mind that most of those who have won great races have done so with only consumption of our local foods and training without doping. This information is a contribution to science and a source of confidence for athletes to make them understand that one DOES NOT have to engage in doping to win medals.

WILL BEING IN THIS STUDY COST YOU ANYTHING?

Involvement in this study will NOT cost you anything because even the assessments will be done according to your availability so that your training routine is not interrupted.

WHAT IF YOU HAVE QUESTIONS IN FUTURE?

If you have further questions or concerns about participating in this study, please call or send a text message to the study staff at the number provided at the bottom of this page.

For more information about your rights as a research participant you may contact the Secretary/Chairperson, Kenyatta National Hospital-University of Nairobi Ethics and Research Committee Telephone No. 2726300 Ext. 44102 email uonknh_erc@uonbi.ac.ke.

WHAT ARE YOUR OTHER CHOICES?

Your decision to participate in research is voluntary. You are free to decline participation in the study and you can withdraw from the study at any time without coercion.

CONSENT FORM (STATEMENT OF CONSENT)

Participant's statement

I have read this consent form or had the information read to me. I have had the chance to discuss this research study with a study counselor. I have had my questions answered in a language that I understand. The risks and benefits have been explained to me. I understand that my participation in this study is voluntary and that I may choose to withdraw any time. I freely agree to participate in this research study.

I understand that all efforts will be made to keep information regarding my personal identity confidential.

By signing this consent form, I have not given up any of the legal rights that I have as a participant in a research study.

I agree to participate in this research study: Yes No

Participant printed name:____

Participant signature /Thumb stamp_____ Date__

Researcher's statement

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has understood and has willingly and freely given his/her consent.

Researcher's Name: Thiauru Lawrence Mugambi **Date**: _

Signature ____________________________

Role in thestudy: Principal investigator *[i.e. study staff who explained informed consentform.]*

For more information contact me on Telephone number: 0708-689777

APPENDIX III: PRODUCT FORMULATIONS

Calculated estimates of nutritional value of the four (4) variations per 100 g are as follow;

Formulation I (100g)	Pearl Millet (50%).	Soybean (30%)	Milk powder (20%).	Total	RDA	% RDA
Protein (g)	5.5	10.5	7	23	72	31.9
Energy (Kcal)	200	140	100	440	2,400	18.3
Iron (mg)	5.5	1.8	0.06	7.36	18	40.8
Calcium (mg)	17.5	41	251	309.5	1,000	30.9

Formulation II (100g)	Pearl Millet (60%).	Soybean (20%)	Milk powder (20%).	Total	RDA	% RDA
Protein (g)	6.6	7	7	20.6	72	28.61.
Energy (Kcal)	240	93	100	433	2,400	18.0
Iron (mg)	6.6	1.2	0.06	7.86	18	43.6
Calcium (mg)	21	27.3	251.4	299.7	1,000	30

Formulation III (100g)	Pearl Millet (60%)	Soybean (10%)	Milk powder (30%)	Total	RDA	% RDA
Protein (g)	6.6	3.5	10.5	20.6	72	28.6
Energy (Kcal)	240	46	150	436	2400	18.1
Iron (mg)	6.6	0.6	0.09	7.29	18	40.5
Calcium (mg)	21	14	377.1	412.1	1000	41.2

Formulation IV (100g)	Pearl Millet (70%)	Soybean (10%)	Milk powder (20%)	Total	RDA	% RDA
Protein (g)	7.7	3.5	7	18.2	72	25.2
Energy (Kcal)	280	46	100	426	2,400	17.7
Iron (mg)	7.7	0.6	0.06	8.36	18	46.4
Calcium (mg)	24.5	14	251.4	289.9	1,000	29

APPENDIX IV: SENSORY EVALUATION SCORECARD FOR THE DIETARY SUPPLEMENT.

Using the rating scale provided in the first row of the table below, rate the sensory attributes by appropriately ticking in any of the spaces provided.

	Like strongly (1)	**Like Moderately (2)**	**Like Slightly (3)**	**Neither like Nor Dislike (4)**	**Dislike Slightly (5)**	**Dislike Moderately (6)**	**Dislike strongly (7)**
	Number of responses per sensory attribute						
Colour							
Appearance							
Texture							
Taste							
Aroma							
Flavour							
Overall Acceptability							

APPENDIX V: RESEARCH AUTHORIZATION

NACOSTE Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **883847**

Date of Issue: **12/July/2021**

RESEARCH LICENSE

This is to Certify that Mr.. Thiauru Lawrence Mugambi of University of Nairobi, has been licensed to conduct research in Kajiado on the topic: DEVELOPMENT OF A NUTRITIONAL SUPPLEMENT FROM LOCAL FOODS AND DETERMINATION OF ITS EFFICACY IN IMPROVING NUTRITIONAL STATUS AND PHYSICAL ENDURANCE IN LONG DISTANCE ATHLETES AT NGONG TRAINING CAMP. for the period ending : 12/July/2022.

License No: **NACOSTI/P/21/11514**

883847

Applicant Identification Number

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THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is Guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014

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26th March 2021

Lawrence T. Mugambi
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University of Nairobi

KENYATTA NATIONAL HOSPITAL
APPROVED
26 MAR 2021
KNH/UoN-ERC

Dear Lawrence

RESEARCH PROPOSAL – DEVELOPMENT OF A NUTRITIONAL SUPPLEMENT FROM LOCAL FOODS AND DETERMINATION OF ITS EFFICACY IN IMPROVING NUTRITIONAL STATUS AND PHYSICAL ENDURANCE IN LONG DISTANCE ATHLETES AT NGONG TRAINING CAMP (P508/09/2020)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above research proposal. The approval period is 26th March 2021 – 25th March 2022.

This approval is subject to compliance with the following requirements:

a. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
c. Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
g. Submission of an *executive summary* report within 90 days upon completion of the study.

Protect to discover

This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

For more details consult the KNH- UoN ERC website**http://www.erc.uonbi.ac.ke**

Yours sincerely,

PROF. M. L. CHINDIA
SECRETARY, KNH-UoN ERC

c.c. The Principal, College of Health Sciences, UoN
The Senior Director, CS, KNH
The Chairperson, KNH- UoN ERC
The Assistant Director, Health Information Dept, KNH
The Chair, Dept. of Food Science, Nutrition and Technology, UoN
Supervisors: Prof. J.K. Imungi,Dept. of Food Science, Nutrition and Technology, UoN
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