EISSN: 2707-0425

East African Journal of Science, Technology and Innovation, Vol. 4 (Special Issue): August 2023

Effects of high calorie, protein, calcium and iron Dietary intervention on nutritional status and body composition of long distance athletes- Ngong' training Camp, Kenya

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Abstract

In recent times a number of athletes have used prohibited substances such as anabolic steroids to enhance their performance and have ended up being suspended from international competitions. This shows a growing need for foods for sports' enhancement that work and that are affordable. The objective of the study was to develop a food supplement from local foods that was high in energy, protein, calcium and iron and test its' efficacy in improving nutritional status of the athletes. It was designed to comprise of food supplement development, baseline assessment and dietary intervention with the first two months serving as control where only sports' nutrition education was offered. Consequently, pre-intervention assessment was conducted on all the study participants. This was followed by a subsequent two months' supplementation period, after which post-intervention assessment was done to determine efficacy of the product in improving nutritional and body composition status of the athletes. Athletes involved in the study included 13 men and 11 women randomly selected from a population of 36 athletes. Apart from hemoglobin levels, Anthropometric assessments included weight, height and body mass index (BMI) whereas body composition assessment included; fat free mass, percentage body fat, percentage body water and bone mass. In this study, women showed significant improvement in both % body fat and body water, whereas men had significant improvement in mean Body Mass Index and Fat Free Mass. Both men and women groups showed significant improvement in the mean hemoglobin levels at the end of the study. The study concluded that there was a need to ensure adequate nutrition for optimal nutritional status of long-distance athletes.

Keywords: *Sports' nutrition, Sports' diet, Athlete's nutrition*

Received: 27/06/23
Accepted: 06/07/23
Published: 09/08/23

Cite as: Mugambi *et al* , *(2023)* Effects of high calorie, protein, calcium and iron Dietary intervention on nutritional status and body composition of long distance athletes- Ngong' training Camp, Kenya. *East African Journal of Science, Technology and Innovation 4(special issue).*

Introduction

When food supplement is used to successfully meet a physiological/nutritional need arising in sport, it may be demonstrated to improve sports performance. The benefit of the intake of specific nutrients may contribute to preventing the undesirable physiological effects provoked by the strain of sports (Vitale and Getzin, 2019). This study was driven by the need for understanding of increased nutritional requirements and physiological effects of exercise. Research done in this area has 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. Kenyan athletes though highly performing lack an organized support in nutrition and practice before international competitions (Pramukova, 2011).

Most of the success is their 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 supplements are proven to work like the imported ones, then they will give confidence to the athletes. Athletes have special nutritional needs and meal timing to enhance optimal sports performance and achieve adequate hydration (Pramukova, 2011). The present study investigated the efficacy of a calorie, protein, calcium and iron rich supplement on nutritional status and body composition of long distance-athletes.

The study was an experimental cohort study where purposive sampling was used to get participants from training camps (at Ngong, Kenya). In this study, a food supplement was developed targeting Energy, Protein, Calcium and Iron. Supplementation intervention was then done on the participants, 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 most 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 are 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 1,200-1500mg and 15-18mg respectively (Vitale and Getzin, 2019).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 Food supplement (exposure) for administration to the participants to provide approximately 25% of the targeted calorie and nutrients i.e., protein, calcium and iron.

Studies indicate that some sportspersons do not consume adequate nutrients to meet the RDA, which would immensely affect their performance in competitive games (Smith et al., 2015). Therefore, there was a need to demonstrate this aspect through supplementation for it to be taken seriously by the sports' persons. The two private camps had a total of 36 athletes from which a sample of 24 athletes was selected for the clinical trial intervention. This number included 13 men and 11 women and all of them participated in long distance races. First, with only sports' nutrition education the participants were followed up for a period of two months where initial and end of period assessments were done. Then this was followed by a two months' supplementation period and all the participants were dewormed before the study period began. Nutritional status was assessed by use of Body Mass Index, hemoglobin assessment and body composition assessment, at pre- and post-supplementation intervention (Kannan *et al.*, 2020).

Materials and Methods

Study Setting

The main Athletic training camps in Kenya are located in Ngong area which has an altitude of 1961 meters above sea level. This is where the current study was conducted. It is located on the outskirts of the capital city of Nairobi. The choice of the region for training is informed by its' high altitude above sea level which is very conducive for building adequate endurance for athletes who can compete in any altitude. This therefore enables the athlete to withstand any environment regardless of the air oxygen concentration. 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 as shown in Figure 1.

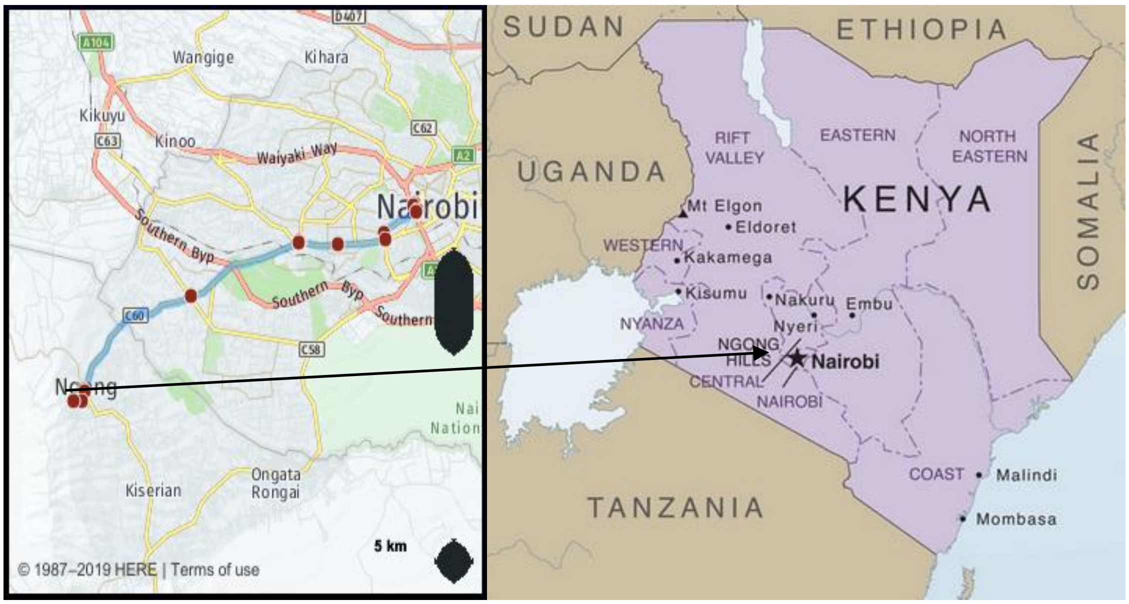

Figure 1: A Map of Kenya showing the Ngong area. ©www.bestourism.com

Training starts as early as 5.30 am daily. At the camps, all marathon athletes are usually engaged in routine daily training where on six days of the week they participate in shorter races like 10 km and other forms of aerobics and on Saturdays they participate in 42 Km Marathon and 21 km for those who run half-marathon. In the Camps there were also short distance athletes who participated in track events. During the training a high level of discipline was observed and coaches were usually present to ensure that training is done as per the schedules.

Study Design

The present study was carried out in three phases as follows: Phase I was product (Food supplement) development, phase II baseline assessment and Study control period and phase III was the supplementation intervention. The Study Design consisted of product development, a cross sectional baseline survey, and longitudinal study component as follows: Cross-sectional baseline assessment was done to establish their nutritional and body composition status. This was then followed by a longitudinal study where all participants were offered sports' nutrition education only and followed up for two months, after which the same assessments were repeated to determine whether there were any changes on nutritional and body composition status. Afterwards, supplementation was initiated immediately and the athletes followed up for the subsequent two months and same assessments repeated to determine efficacy of the food supplement in improving nutritional status and body composition of the participants.

It was designed to comprise two distinct study periods in phase III each period taking two (2) months, with the first two months serving as control with only sports' nutrition education offered. The subsequent two months involved supplementation and post-intervention assessments to determine efficacy of the product developed in improving nutritional and body composition status of the athletes. Athletes involved in the study included 13 men and 11 women purposively selected from a population of 36 athletes depending on the number of athletes and their availability. All the athletes in the camp were offered regular sports' nutrition education but only those selected for the study were assessed and supplemented for the study. Baseline anthropometric, body composition and hemoglobin status assessments were conducted on all the study participants. Anthropometric assessments included weight, height and body mass index (BMI) whereas body composition assessment included; Fat free mass, percentage body fat, percentage body water and bone mass.

Selection of participants

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 (18-36 years old) and they were given consent forms to fill and sign as evidence of agreement to participate in the study. Ethical clearance was given by the KNH-UoN ERC of the University of Nairobi, reference number KNH-ERC/A/113. Permit to collect data was given by the National Commission for Science, Technology and Innovation (NACOSTI Permit Ref No: 883847).

Anthropometric assessment

Assessment for height and weight was carried out for each athlete and the Body Mass Index determined. The height was measured using a stadiometer and recorded to the nearest 0.1 cm (Andari et al., 2021). A calibrated portable platform balance (spring) was used to measure weight in kilograms and recorded to the nearest 0.5kg with the participant standing on it without support, with light sports clothing and without shoes.

The Body Mass Index (BMI) was determined as follows:

$$BMI = \frac{\text{Weight (Kg)}}{(\text{Height in m})^2}$$

The BMI results were then interpreted against the WHO (2002) classification of BMI for adults as shown in Table 1 below;

Table 1: BMI Classification for Adults

BMI Classes	Presumptive diagnosis
<18.5	Under weight
18.5-22.9	Ideal BMI
>23.0-24.9	Mildly Overweight
25-29.9	Overweight
30-34.9	Obese grade I
35-39.9	Obese grade II
>40.0	Obese grade III

Phase I: Food Supplement (Athle-food) development

The supplement (Athle-food) was prepared by use of Pearl millet, Soybean and Milk powder. This phase focused on developing a product that would be able to deliver at least 25% of RDA for the four (4) nutritional components targeted i.e., Energy, Protein, Calcium and Iron. Dietary calculation was done to come up with variations guided by RDAs for athletes and this informed development of the final product for use in the supplementation intervention. Due to its' high fat content, soybean was first roasted before it was milled into flour together with the millet. After milling the two, all the ingredients' mixture was then roasted and then thoroughly mixed together to obtain a homogenous product (Andari et al., 2021).

Sensory Evaluation

Study participants were randomly sampled for sensory evaluation targeting seven (7) men and five (5) women to make a total of 12 respondents. They were provided with a sensory evaluation scorecard each and requested to analyze the four (4) variations of the product for sensory attributes viz. color, appearance, texture/mouth feel, taste, flavor, and overall acceptability, using the rating scale provided. The scale provided was as follows; Like very much-5, Like moderately-4, Neither like Nor dislike-3, Dislike moderately-2 and Dislike very much-1 (Lestari *et al.,* 2021).

Using their responses, the variation which was rated most acceptable was chosen for the supplementation intervention.

Clinical Trial Phase

At the beginning of both supplementation and control periods all the participants underwent nutritional status and body composition (BMI, Hb, FFM, % FM, TBF, % BM and % BW) assessments (Nepocatych, Balilionis, and O'Neal, 2017). All the participants except for the control 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 paired-sample t-test in order to make inferences on difference between sample means to enable the researchers make judgment on the efficacy of the supplement in enhancement of nutritional status and body composition of the athletes (Gibson-Smith *et al.,* 2020).

Baseline assessment & Study Control (Phase II)

This phase of the study involved the 24 participants (13 men and 11 women) who were selected for the study. The first step in this phase included deworming all the participants, providing sports' nutrition education to the participants and following them up for a period of two months where initial and end of period nutrition status assessments were done. Nutritional status was assessed by use of Body Mass Index, hemoglobin level and body composition i.e., Fat Free Mass, percent Fat Mass, percent Body Water and percent Bone Mass, at pre and post baseline/control period.

Dietary Intervention (Phase III)

Baseline/Control phase was followed by a two months' supplementation on the same athletes with the developed food supplement and a repeat of the assessments at pre-.and post supplementation intervention one. This phase included actual supplementation intervention, for all the 24 participants. The supplement was packaged into 100g sachets and delivered to each of the participants for reconstitution with hot water, boil it for a short period (5-10minutes) to make porridge and consuming it early in the morning before the training session. 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. After the intervention period, post-intervention nutritional status assessment was done using same indicators i.e. Body mass Index, Hemoglobin level and body composition assessments (Alaunyte *et al.,* 2014).

They were educated on the importance of adherence to consistent intake as well as importance of the study. In addition, for follow up the assistant 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 through its' effects on nutritional status of the study participants (Athletes). This was established by analysis of the data on nutritional status of the participants at post-intervention. The same participants underwent the similar assessments at pre and post baseline/control period (two months' pre-supplementation period) for comparative analysis to be done. BMI, Body Composition analysis parameters and Hemoglobin (Hb) levels were determined at the beginning of the baseline/control period and before supplementation (Sedeaud *et al.,* 2014).

Same assessments were done post-supplementation period to determine the efficacy of the supplementation on improving nutritional status and body composition of the athletes. A Medical doctor was included in supervision of the tests and a Medical Laboratory technologist was involved in the drawing of blood and Hb status analysis (Fujii, 2015).

Data Analysis

Data was analyzed by use of SPSS where paired sample t-test was used to determine whether there was significant difference between means of similar variables for both male and female athletes at pre and post intervention and two samples t-test to compare means of variables for intervention/supplementation and control groups at pre-and post-intervention.

Results

Phase I: Food Supplement Development

In the present study a high calorie, protein, calcium and iron supplement named Athle-food was formulated for sports personnel and tested its' efficacy on improving nutritional status and body composition of long-distance athletes. The study was conducted in three phases whereby in the first phase, the food supplement was developed and tested for sensory attributes/acceptability. It was formulated with locally available, cost-effective cereal (millet) and pulse (Soybean) along with added high calcium source namely, milk powder. Athle-food also had high acceptability ratings in terms of color, appearance, Texture, flavor and overall acceptability as shown by the sensory evaluation results.

With the ingredients having been roasted, the product was pre-cooked and therefore the participants needed to boil the porridge for a few minutes before consuming it. 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 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.

Phase II And III: Study Control and Supplementation Intervention Results

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). 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.

Hemoglobin results

Initial Hemoglobin assessment in group I (women), results indicated that all the participants had sports' anemia with Hb levels below 12mg/dl. Upon supplementation, the hemoglobin assessment showed a remarkable improvement in the mean hemoglobin level of the group participants from pre-intervention and post intervention assessments. The mean hemoglobin increased from 9.78 mg/dl at pre-intervention to 14.6 mg/dl at post-intervention.

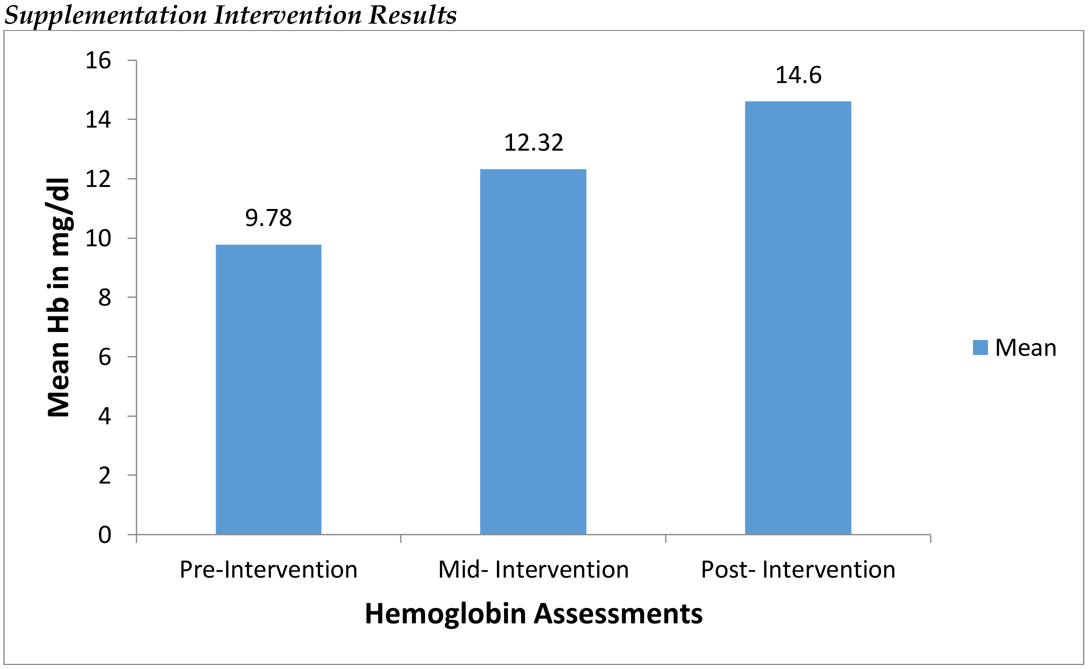

Figure 2: A Graph on Female athletes' mean Hemoglobin levels.

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.

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

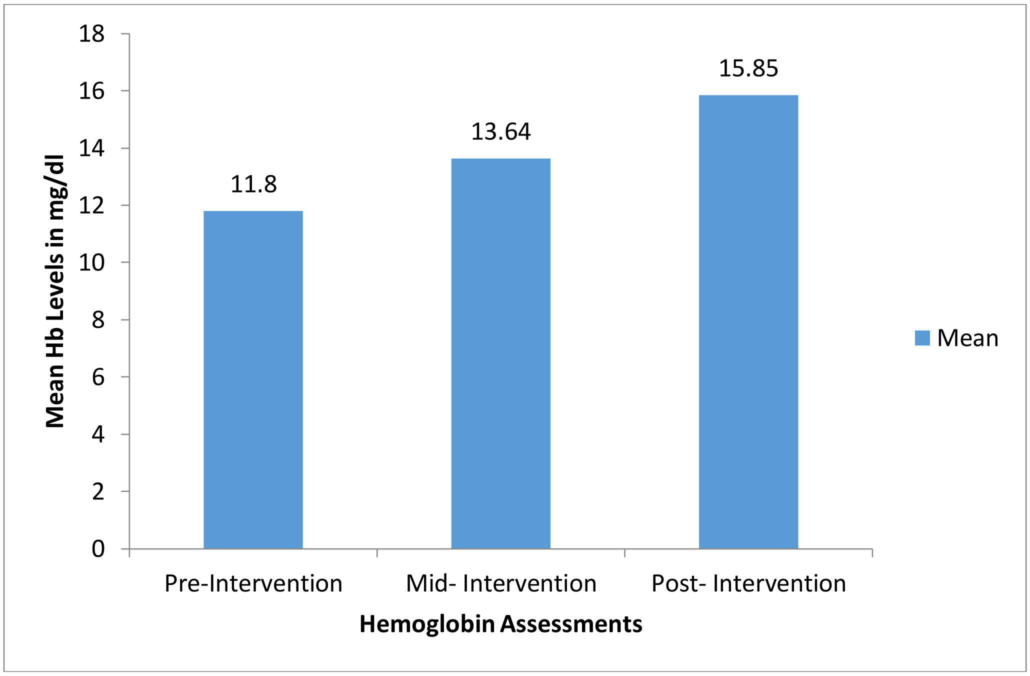

Figure 3: A Graph on Male athletes' mean Hemoglobin levels.

Like in women, hemoglobin assessment for the Control/ un supplemented 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. 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 observations made in group I- intervention/ supplemented group.

Body Composition Analysis Results

Group1 (women)-intervention group body composition analysis results.

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. The percentage body water increment was however insignificant compared to the control group (*P=0.134*).

Body composition results for Group 1 (Women) control/ unsupplemented group showed minimal or insignificant changes. 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 and 20.57 to 20.63 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 ($P < 0.011$).

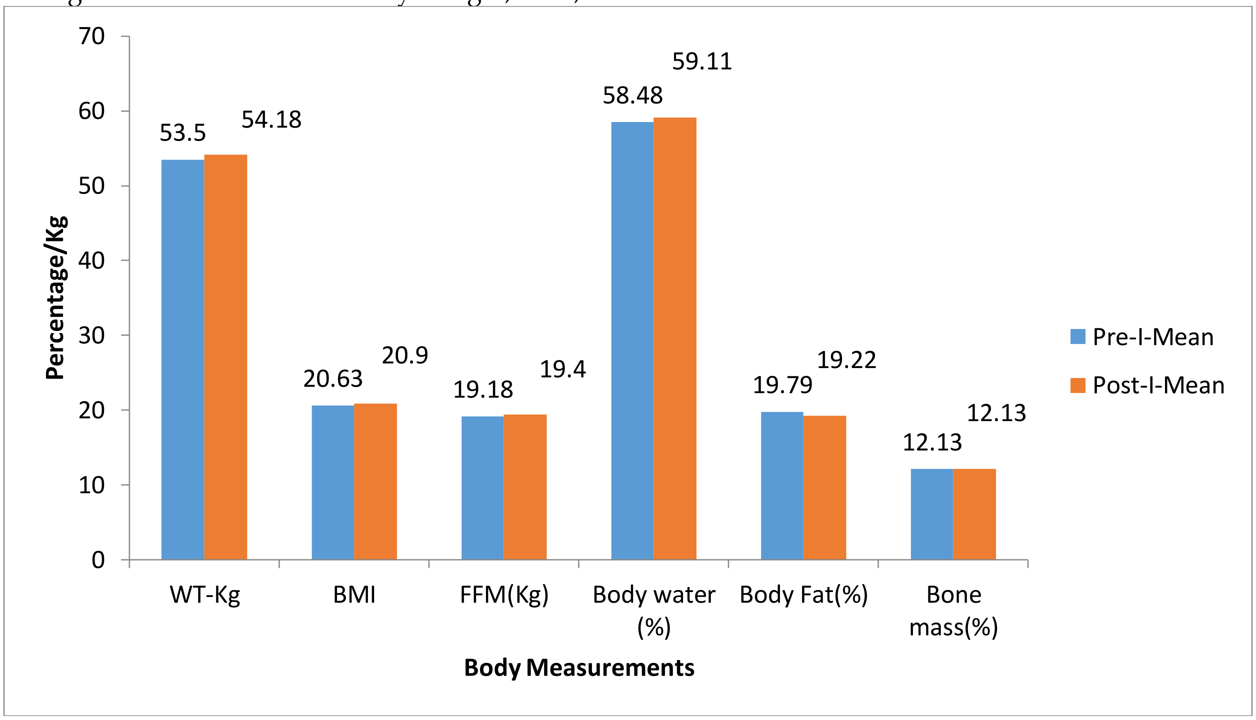

Figure 4: A Graph on the Female Athletes' Supplementation period's body composition Results.

Table 2: Group1 (Control Group) BCA Results- Summary

Measurement	HT	WT	BMI	FFM(KG)	Body water (%)	Body Fat(%)	Bone mass(%)	BMR
Pre-I-Mean	**161.7**	**53.32**	**20.57**	**19.15**	**58.42**	**19.65**	**12.14**	**1353.02**
Post-I-Mean	**161.7**	**53.5**	**20.63**	**19.18**	**58.48**	**19.79**	**12.13**	**1353.09**

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 3.

Table 3: 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	53.32	20.63	20.57	19.18	19.15	58.48	58.42	19.79	19.65	12.13	12.14

Post-I-Mean	54.18	53.5	20.90	20.63	19.4	19.18	59.11	58.48	19.22	19.79	12.13	12.13
%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. There was an increase in the mean body weight and body mass index in the same group, from 54.33 Kg to 55.35 Kg and 19.71to 20.08respectively. 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 from 65.15 to 65.01 % at the end of the intervention period.

Group II: Control group body composition analysis results.

Like in group I, body composition results for the control/ unsupplemented male group showed minimal or insignificant changes. 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 % to 65.15 % at the end of the control period.

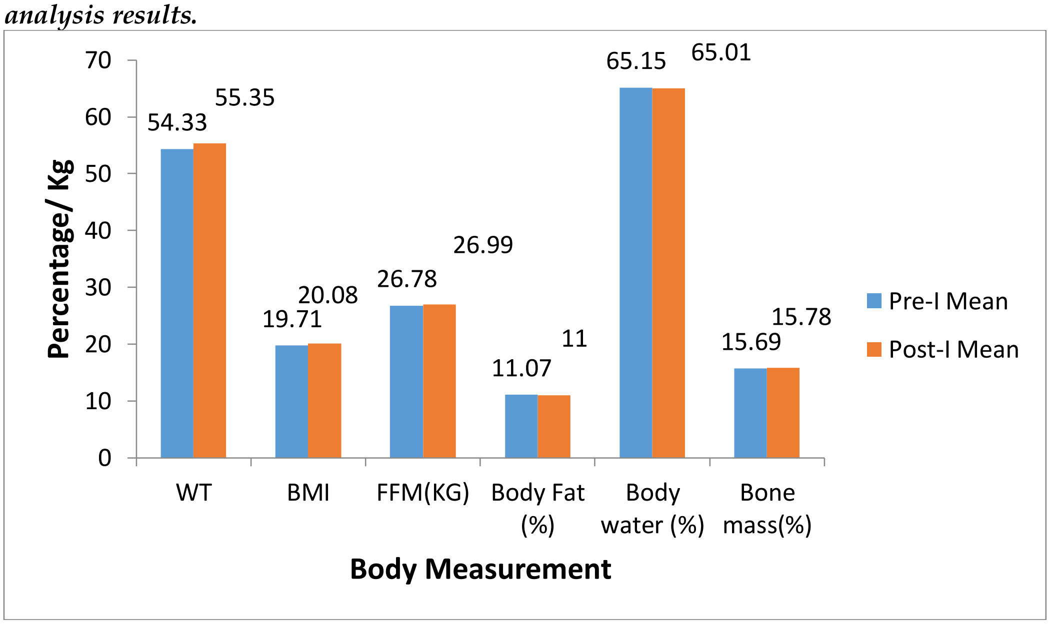

Figure 5: Graph on the Male Athletes' Supplementation group's body composition Results.

Table 4: Group II Control BCA Results- Summary

Measurement	HT	WT	BMI	FFM(KG)	Body water (%)	Body Fat(%)	Bone mass(%)	BMR
Mean	**166.61**	**54.3**	**19.70**	**26.74**	**10.76**	**65.17**	**15.68**	**1495.07**
Mean	**166.61**	**54.33**	**19.71**	**26.78**	**11.07**	**65.15**	**15.69**	**1458.46**

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 below;

Table 5: Group II (Men)'s combined results for body composition analysis

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	54.33	54.3	19.71	19.70	26.78	26.74	65.15	65.17	11.07	10.76	15.69	15.68
Post-I-Mean	55.35	54.33	20.08	19.71	26.99	26.78	65.01	65.15	11	11.07	15.78	15.69
%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.Gp represents Intervention/supplemented group&
C.Gp 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*).

Discussion

Phase I: Rationale of the Food Supplement Development and Proximate Composition Results

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 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. The Food supplement was formulated with a target of providing at least 25% 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 color, appearance, Texture, flavor and overall acceptability as shown by the sensory evaluation results. According to the proximate composition analysis done on the product, the results showed that the product developed contained 228.2mg of calcium, 3.95mg of iron, 71.9g carbohydrate, 8.72g fat, 17.37g protein, 435.88 Kcal, 8.22g moisture and 1.42g of total ash content per 100g. Since this supplementation only met approximately 25% 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.

Phase II and III: Dietary intervention and study control groups' results

During the first two (2) months after 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 further for the next two months 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.

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)*. 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*). The findings revealed however, that there was no significant improvement in the mean BMI for the male control group (P=0.226).

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 a 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 the 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.

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).

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*). 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*).

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). 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*).

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*).

Conclusion

According to the research findings, supplementation with Athle-food resulted 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 results. These findings indicate that 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.

Recommendations

From these findings we recommend that knowledge acquired from the positive results should be applied in delivery of a locally formulated food supplement to support athletes' nutritional status and body composition for enhanced performance. More research should also be carried out in this area to build on the body of knowledge for more interventions to be done.

Acknowledgements

We are grateful and appreciate the support given by the Kenya's Commission for Science, Technology and Innovation (NACOSTI) through awarding research permit for the study, without which it couldn't have been done. We also acknowledge the KNH-UoN Ethical Review Committee for approving this research to be done. Our appreciation also goes to the two camp coaches for allowing their athletes to participate in the study. Being decision makers in the camps their approval matters a lot since no athlete would go against their decision. Last but not least, we also acknowledge the important part played by the athletes in this study and therefore greatly appreciate their commitment and cooperation to ensure that the entire study was a success.

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