V SUMMARY AND CONCLUSION

As sports performance is becoming increasingly competitive, more and more stress is being placed on how well one performs. Sports nutrition has emerged as one of the strong decisive factor and an important tool in enhancing sports performance. Women are entering the sports arena and competing equally with men. The number of women participating in recreational and competitive sports has increased dramatically over the last century. Females who are involved in regular sporting activities will have greater nutritional need and it is very important to maintain the right level of nutrients to prevent any nutritional disorders.

Consequently, sports anaemia is most commonly seen in sports women due to their increased requirements. This condition can lead to impaired work performance due to decreased haemoglobin level which reduces the oxygen carrying capacity of the blood for the working muscles. Very few studies have been done to assess the iron nutriture and prevalence of anaemia among collegiate sports women. It is during this phase in life that large numbers of college students engage in competitive sports and show great enthusiasm to attain greater heights in their sports career. But the sad state of affairs is that many of them do not have adequate dietary intake and proper nutritional status to cope up with this extra demand for various nutrients and hence end up with various health problems including anaemia and other deficiency disorders.

Hence, sports anaemia particularly after long hours of endurance activity and long periods of training is often a condition that requires correction for optimum performance. The present investigation titled, “Prevalence of Anaemia among Collegiate Sports Women and Effect of Nutrition Interventions on their Anaemic Status and Sports Performance”, is a small attempt towards correction of anaemia. The objectives of the study were to assess the anaemic status of sports women belonging to all women’s colleges
affiliated to Osmania University, Hyderabad, to develop a suitable nutritional intervention strategy to correct anaemia including formulation of an iron enriched biscuits and creating awareness regarding nutrition and to evaluate its impact on their anaemic status and performance levels.

Accordingly a total of 348 sports women of the age group 17-24 years as available from all the women’s colleges, affiliated to Osmania University, Hyderabad and having district, university, state, national or international level representation were selected. The study was conducted in four phases.

In Phase I, the prevalence study was conducted and nutritional status of all the 348 collegiate sports women were assessed. Anthropometric measurements (height, weight and BMI), food consumption pattern, frequency of iron rich food intake, actual food and nutrient intakes, haemoglobin levels, clinical symptoms for anaemia and nutritional knowledge and practice of selected sports women were assessed. In Phase II an Iron Enriched Biscuit (IEB) using locally available iron rich foods was developed and organoleptic evaluation, nutrient analysis and shelf life assessment was carried out. In Phase III supplementation study using IEB was carried out on 60 anaemic sports women drawn from the prevalence study from one institution belonging to three anaemic groups (20 per group) namely mild anaemic (Hb 10-11.9g/dl), moderate anaemic (Hb 9-10.9g/dl) and severe anaemic (Hb <8g/dl) according to FAO/WHO (1992) classification. Sixty anaemic sports women 20 each falling into the above anaemic categories was selected as unsupplemented control from another institution. IEB supplementation along with 200ml lime juice was given for a period of 120 days and its impact on anaemic status and performance was evaluated. Haematological parameters like haemoglobin, PCV, RBC, MCV, MCH and MCHC was measured. Performance was assessed using cardiovascular parameters like heart rate, blood pressure, pulse rate and Cardiovascular Efficiency Score (CES). Tread mill test and field test
like 800mt and 100mt run was carried out to test endurance, speed and agility. In Phase IV all the anaemic sports women supplemented with IEB was given nutrition education throughout the period of 120 days of study. For this purpose a specially designed education kit was developed and the impact was evaluated by administering a 25 point questionnaire before and after nutrition education programme.

The results obtained is summarized below:

- More than 80 percent of the sportswomen included in the study belonged to the age group of 17–19 and 19-21. There was almost equal representation from 17–19 (41.4 percent) and 19–21 (42.8 percent) age group which mostly comprised of undergraduate students. Age group 21 and above was only 15.8 percent representing the sports women from the post graduate courses.

- Majority of the sports women (84.2 percent) were undergraduate students and only 15.8 percent were Post Graduates. Among the undergraduate students more strength was from Degree III year students (34.7 percent) and almost equal strength from Degree I year (22.4 percent) and Degree II year (27.1 percent).

- Out of the total sample selected, 73.6 percent were staying at home and participating in sports activities. Only 26.4 percent were using the hostel facility.

- Among the total number of 348 sports women studied majority of them belonged to five group event namely kabbadi (24.7 percent), hand ball (13.80 percent), Basket ball (13.20 percent), kho kho (11.2 percent) and volley ball (10.6 percent). Other group events were soft ball (4.3 percent) and hockey (1.2 percent) which had very less representation. Individual events identified were athletics, badminton,
judo, table tennis and tennikoit and 73 sports women (21%) came under this category.

- Many of the sports women under study had represented district (56.8 percent), 42 percent represented university mostly in basket ball and hand ball, 14.9 percent represented state in volley ball and hand ball, whereas only 13 percent represented at national level in soft ball and hand ball, and 1.7 percent were international players who had represented India in Japan, Malaysia, Singapore and China in soft ball, athletics and hockey.

- Majority of the sample studied (74.1 percent) were found to be non vegetarians, 21.3 percent were vegetarians and only 4.6 percent were ovo vegetarians.

- Sports women in all the age groups were taller when compared to the All India Standard (ICMR, 2000). Among the different age groups the sports women in the age category of 23 and above were the tallest (mean height 163.7 ± 9.25cm) which also matched with the WHO Standard (1986). But all other sports women in the other age groups were shorter than the WHO Standard (1986).

- As far as the weights were concerned all the groups were well above the All India Standard (ICMR, 2000) of 46.54 kg. Among the different age groups sports women of 23 and above category were the heaviest having a mean body weight of 56.0 ± 9.0 kg. Sports women in the age group category 19-21 years had a mean weight of 50.74 ± 8.87 which was the least when compared with the rest of the age groups. However all the sports women were lighter compared to the WHO Standard (1986) of 56.6 kg. Only the sports women above 23 years of age came closer to the WHO Standard with a mean weight of 56.0 ± 9.0 kg.
• Comparison of the heights among the different event groups showed that kho-kho players were the shortest (156.92 cm) than other players and basket ball players were the tallest (162.13 cm). Similarly, regarding the weights of the sports women in various events all were heavier compared to the All India Standards (ICMR, 2000) except for kho-kho players who recorded a mean weight of 45.13 kg.

• Compared to WHO Standards (1986) all the sports women were having less weight. Among the various event groups sports women belonging to individual event and other event category recorded the highest mean weight of 54.14 kg and kho-kho players had the least weight (45.13 kg). Thus, kho-kho players were the shortest and lightest among all the other event groups.

• Chronic Energy Deficiency (BMI <18.5) was seen among 31.3 percent of sports women. Of this 19.3% belonged to CED Grade I and 7.5 percent to CED Grade II and 4.6 percent to CED Grade III respectively. Only 33.9 percent of the subjects studied belonged to the normal category of BMI 20–25. The percentage of sportswomen who were overweight (BMI 25–30) was 12.0 percent with 9.4 percent of sports women in grade I obesity and 2.6 percent in grade II obesity. Remaining 22.7 percent were distributed in the low weight normal category (BMI 18.5-20).

• Majority (95.4%) of the sports women studied consumed rice on a daily basis whereas wheat was consumed only by 46.3 percent on a daily basis and 3.4 percent did not consume wheat at all. Even pulse consumption on daily basis was only by 50.6 percent of the sports women studied and remaining 32.6 percent consumed on a weekly basis and 16.8 percent on monthly basis. Majority (86.8%) of the sports women consumed vegetables on daily basis and remaining 13.2 percent consumed on a
weekly basis. Frequency of intake of raw salads was very poor, since 57.5 percent of the sports women did not have the habit of taking raw salads at all. Only 17.8 percent consumed it on a daily basis. Similar observation was noted regarding sprouted gram intake where 60.5 percent of them never consumed this and hardly, 7.8 percent of them had it on a daily basis and 18.7 percent only on weekly basis.

- Frequency of intake of fruits on daily basis was by 45.2 percent of the selected sportswomen and 43.9 percent consumed it on weekly basis. Milk and milk products were consumed by 82.4 percent of the sports women on a daily basis and 14.9 percent on a weekly basis. It was noted that 2.7 percent did not consume milk and milk products at all. Moreover a considerable percent of sportswomen avoided butter and ghee (36.3 percent), sweets (21 percent), tea and coffee (23.6 percent), soft drinks (31.7 percent) and junk foods like pizza and burger (44 percent).

- Consumption of almost all the iron rich foods was very poor on a daily basis. Majority of the sportswomen rarely consumed dry fruits, liver, jaggery, rice flakes, ragi, etc. Only 32.5 percent had daily intake of green leafy vegetables.

- Mean food intake of all the sports women were far from satisfactory. Except for sugar and fats all the food intake was far below the suggested intake of ICMR (2004). Cereal intake was only 73 percent of RDA whereas pulses were 80 percent of RDA with a mean deficit of 27 percent and 20 percent respectively. Milk and milk products consumption was also well below the recommended levels of 300ml per day with a mean intake of 225ml per day amounting to only 75 percent of RDA. Even vegetable and fruit consumption was far below the RDA.
with green leafy vegetable intake being the least that is only 32 percent of the RDA.

- The intake of all the nutrients also were far below the recommended daily allowance (RDA) which is reflective of the inadequate dietary pattern existing among college students especially adolescent girls. Energy intake was only 60 percent of the RDA whereas protein and calcium intakes were 72 percent and 84 percent of the RDA respectively. Iron intake was extremely low with a mean intake of 11mg per day meeting only 37 percent of the RDA amounting to an extreme deficit of 63 percent. Deficit of ascorbic acid intake was 63 percent of RDA.

- Regarding nutritional knowledge overall positive response was lesser when compared to the negative response which indicated the lack of nutritional knowledge among the selected sports women. Majority of the sportswomen (83.6 percent) expressed that they did not undergo any formal nutrition education. Regarding knowledge about the condition called anaemia, only 45 percent knew about it and remaining 55 percent were totally unaware.

- Regarding knowledge about cause of anaemia, only 43 percent responded as iron deficiency and 57 percent were not aware of it. As to whether anaemia affects exercise and sports performance only 45.7 percent gave the correct answer and only 46.3 percent knew the right source of iron rich foods.

- Majority (73.9%) of the sports women did not have any special diet consumption on a daily basis. Only 26.1 percent consumed special foods in the form of eggs, milk, liver, etc., during training period, 15.8 percent had special diet just a few days before the event. Comparatively a low
percentage of sports women (10.9 percent) had special foods like wheat porridge, oats, banana, fruit juice, etc, on the day of the event.

- Majority of the sports women did not have the practice of taking any commercial nutrient supplement to boost their performance. About 10.6 percent of sports women consumed B complex tablets and 2.6 percent consumed vitamin C tablets, 3.2 percent had iron tablets and 7.8 percent consumed calcium tablets on daily basis. Many of them took glucose as an instant energy supplement during the time of playing and 30.2 percent consumed Complan, Boost, Horlicks etc along with milk daily. Frequency of intake of commercial vitamin and mineral supplements was very low.

- There was a high prevalence of anaemia (86.2%) among the sports women studied. Only 13.8 percent had haemoglobin values above 12g/dl which was considered to be normal for women according to FAO/WHO (1992). As per the classification of different grades of anaemia 15.2 percent were found to be severely anaemic (Hb<8 g/dl) and 32.5 percent were found moderately anaemic (Hb 8.0 – 9.9g/dl) whereas 38.5 percent came under the category of mild anaemia (Hb 10.0 – 11.9g/dl). Comparison of haemoglobin levels by age, place of stay and type of diet did not show any significant difference. Percentage prevalence of anaemia was slightly higher (87.8%) among the vegetarians.

- There was no significant difference in the haemoglobin levels among the different event groups. Highest haemoglobin values were recorded by volley ball players (10.35±1.49 g/dl) and the least was shown by hand ball players (9.38 ± 2.52). All were found to be in the moderate anaemic (Hb 9-10.9g/dl) category.
Regarding clinical assessment many of the sports women expressed that they experienced having more than one symptom, but majority complained about tiredness and fatigue (48.3 percent) and 32.2 percent had reduced stamina. Twenty one percent of the sports women complained about extreme weakness and 14.4 percent reported dizziness and giddiness all of which can be related to symptoms of severe anaemia. Many sports women also complained about frequent headache (25.3%), breathlessness (13.2%) and palpitation (14.1%). They also complained about muscle cramps (24.1%) and menstrual disorders (19.8%) but very few complained about Pica (craving for mud, chalk powder), hyper acidity and anorexia (2.6 – 8.1%).

In phase II of the study, iron enriched biscuits (IEB) was developed and the organoleptic evaluation for the five formulations revealed that the highest score for appearance, texture, colour, flavor and taste was obtained by sample I and the least score was for sample III. IEB sample I got the highest overall acceptability score of 22 out of 25.

On storage up to 3 months for sample I there was no major difference in the organoleptic characteristics like appearance, colour, flavour, texture and overall acceptability when compared with the fresh sample value. The results showed that it retained all the organoleptic qualities and obtained an overall acceptability score of 21.2 as against the score of the fresh sample which was 22. Total acceptability score for sample III was the least and it reduced from 19.3 (fresh sample score) to 18.0 for the stored sample. Thus the organoleptic evaluation of the stored samples revealed that IEB sample I to be the most acceptable having the highest keeping quality. Hence IEB sample I was selected for supplementation study.
Nutrient analysis of the selected IEB revealed that the energy content was 517.34 kcal/100g which qualified it as a good energy dense snack for the sports persons. Protein and carbohydrate content was 12.22g and 65g respectively. The iron content on analysis was found to be 11.2mg and the formulation had a high calcium content of 400mg.

Microbial count in the formulated iron enriched biscuit on storage (room temperature) was compared with the fresh sample and it was found that the bacterial count of the fresh sample at dilution $10^{-3}$ was 7100 whereas in the three months old sample it increased to 20500 per g which was well within the prescribed limit.

In phase III supplementation study was carried out and the nutrient intake of the selected anaemic sports women both from the experimental and control groups revealed that the energy, protein and iron intake were far below the RDA (ICMR, 2004) in all the three anaemic groups. The severe anaemic group (haemoglobin <8 g/dl) both experimental and control group had the lowest intake of calories (1469 and 1345 kcals) as against the suggested RDA of 2225 kcal which is providing only 66 and 60 percent of the RDA respectively. Similarly, the mean intake of protein was only 36.67g (73% RDA) and 35.80g (72% RDA) for the same category of experimental and control groups as against the RDA of 50g. Calcium intake was fairly good for both experimental and control group of severe anaemic sports women having intakes of 345mg and 356mg each which amounted to 86 percent and 89 percent of the RDA respectively. Iron intake was extremely low for both the groups in this category with a mean iron intake of 14.7 mg and 13.5mg respectively as against the RDA of 30mg.

The nutrient intakes of the moderate anaemic sports women belonging to both experimental and control group also were far below the RDA.
Energy intakes for both experimental and control groups were 1658 and 1680 kcal respectively which was providing only 75 and 76 percent of the RDA respectively, showing a deficit in the energy intake. Similar deficit in intake was observed for protein also in both the groups with a mean intake of 42.33 and 41.25g respectively as against the RDA of 50g. Calcium intake was satisfactory in this category with the mean intake of 393 and 385mg for both experimental and control group respectively. But the mean iron intakes of 16.9 and 17.1mg for both the groups were far below the RDA of 30mg recommended for women. This intake was hardly 56 percent and 57 percent of the RDA respectively.

- Mild anaemic group had slightly higher mean intakes of all the nutrients compared to severe and moderate anaemic groups but still all the nutrient intakes were much below the RDA except for calcium which was above the RDA of 400mg. The energy intakes for both experimental and control group in this category was 1720 and 1786 kcals respectively (77 and 80 percent of RDA) as against the RDA of 2225kcal. The mean protein intakes also were only 89 percent and 86 percent of the RDA for both the experimental and control groups. Mean iron intakes were only 19.7mg and 18.9mg respectively for both the groups which corresponded to 66 and 63 percent of the RDA.

- On inclusion of IEB (6 biscuits) in the diet of the experimental group, the energy supplied by six IEB (150g) amounted to 776 kcals and hence the total energy intakes of all the three anaemic experimental group increased to 2245, 2434 and 2496kcals respectively which was well above the RDA of 2225kcal (ICMR, 2004) and corresponded to an intake of 101, 109 and 112 percent of the RDA respectively for severe, moderate and mild anaemic groups.
• Protein content of IEB was found to be 18.33g and this increased the total protein intake of all the three experimental anaemic groups namely severe, moderate and mild to 55, 61 and 63g as against the RDA of 50g. This increased intakes amounted to 110, 121 and 126 percent of RDA respectively for the above groups.

• IEB had a high calcium content of 600mg which boosted the calcium intake in all the three anaemic experimental groups much above the RDA and total intake for all the three groups increased to 945, 993 and 1038mg respectively which was almost double the RDA of 400mg.

• The content of the most important nutrient emphasised in this study namely iron in the formulated biscuit (150g) was found to be 16.8mg which amounted to more than 50 percent of the RDA of iron for women (30mg). On inclusion of IEB in their diet total iron intake improved to 31.5, 33.7 and 36.7mg respectively for severe, moderate and mild anaemic categories which was well above the RDA of 30mg. Thus IEB inclusion improved the intakes of all the above nutrients much above the RDA.

• Anthropometric measurements showed that there was no change in height for both experimental and control groups. But there was a slight increase in weight in all the three anaemic experimental groups and the mean increase was 0.90kg, 0.70 kg and 0.40 kg respectively for severe, moderate and mild anaemic groups. But only for severe and moderate anaemic groups the increment was significant at five per cent level. The control group did not show any significant increase in weight.

• In the experimental group there was an overall improvement in the BMI in all the three groups namely severe moderate and mild anaemic groups after IEB supplementation. The BMI of the three anaemic groups before supplementation were 21.06, 20.35 and 20.32 for severe, moderate and
mild anaemic group respectively and the mean increase was 0.08, 0.40 and 0.16 respectively. However the increments in BMI for all the three categories in the experimental group were not statistically significant. All in the experimental group had BMI well within the normal range. It is notable that BMI decreased in mild and severe anaemic categories of the control group and increase in the moderate anaemic group which was only 0.27. None of these values for the control group were statistically significant.

- The mid arm circumference before iron supplementation for the experimental group were 24.62 cm, 25.3 cm, and 24.64 cm for severe moderate and mild anaemic groups respectively. After the supplementation there was a slight increase and the mean increase was 0.18cm, 0.20cm and 0.26cm. However these differences were not statistically significant. In the control group a marginal increase in mid arm circumference was observed in all the anaemic groups and they were not statistically significant.

- The mean normal chest circumference for severe anaemic sports women before and after supplementation was 84.90cm and 85.70cm respectively with a mean increase of 0.80cm. This difference was significant at five percent level. Expanded chest circumference before and after supplementation were 88.50cm and 89.30cm respectively. The mean differences in expanded chest circumference values amounted to 0.80cm which also was significant at five percent level. However, the increment encountered between normal and expanded values before supplementation was 3.6cm and after supplementation was 4.3cm resulting in a mean increment of 0.70cm which was highly significant (p<0.01). Similar observations were noted with moderate and mild experimental anaemic groups which showed a highly significant
increase in all the chest circumference values namely chest normal, expanded and its difference.

- For moderate anaemic group a significant difference between the normal and expanded chest circumference value of 3.15cm before supplementation which increased to 3.93 cm after supplementation with a highly significant (p<0.01) increment of 0.78cm was observed. Whereas for mild anaemic experimental group the increment between the chest normal and expanded values amounted to 3.6cm and 4.27cm before and after supplementation respectively and the mean increase (0.67cm) was highly significant (p<0.01). The unsupplemented control group did not show any significant improvement in the chest circumference values whereas a significant impact of IEB supplementation was observed in the experimental group. This is an indication of their improved vital capacity.

- There was a significant improvement in the haematological parameters in all the experimental groups. The mean haemoglobin values of severe anaemic group was 7.62 g/dl before supplementation, which improved to 9.87 g/dl after supplementation with iron enriched biscuit. This mean increase of 2.25g/dl was found to be statistically significant (p < 0.01) whereas the control group showed only a marginal increase of 0.16g/dl. The mean haemoglobin levels of moderate anaemic experimental group was 9.05g/dl before supplementation which increased to 11.01 g/dl with a mean difference of 1.96g/dl which was also statistically significant (p<0.01). The control group in the same category recorded only an insignificant mean increase of 0.06g/dl. The mild anaemic experimental group also improved from initial haemoglobin level of 10.59g/dl to 12.23g/dl after supplementation, which shows the impact of iron enriched biscuits supplementation, with a mean increment of 1.64g/dl
which was also statistically significant ($p < 0.01$). Whereas the control group in any of the category did not show any significant increase in haemoglobin levels. A notable observation was that the highest mean increment in haemoglobin levels (2.25 g/dl) was for the mild anaemic group.

- The shift in haemoglobin levels of the various anaemic groups to a lower grade of anaemia namely severe to the moderate and moderate to the mild was evident. Thirty three sports women attained the normal value of haemoglobin that is 12 g/dl and became non anaemic. From severely anaemic group five sports women improved to moderate anaemia and 12 shifted to mild anaemia and three shifted to the normal level. In the moderate anaemic group while one remained in the same category six of them improved and came into mild anaemia category and 13 of them attained normal level of haemoglobin (12 g/dl). In the mild anaemia category while three of them remained in the same category 17 of them shifted to normal haemoglobin level and became non anaemic. Thus at the end of the supplementation period out of the 60 experimental anaemic sports women studied 33 of them obtained normal haemoglobin levels, none of them were in severe anaemia category, only six in moderate anaemia and 21 were found in the mild anaemia category. Thus overall 56 anaemic sports women out of 60 showed definite improvement after IEB supplementation which amounted to 93 percent of the studied population. Thirty three of the anaemic sports women (55%) became non-anaemic and obtained normal haemoglobin level ($\geq$12 g/dl) at the end of the supplementation period.

- Mean Packed Cell Volume (PCV) values were below normal value of 36.0–46.0 percent for all the three anaemic groups both in the experimental and control groups before supplementation. However,
there was a significant (p<0.01) improvement in the PCV values in all the three anaemic experimental groups which increased from of 25.3, 28.45, and 32.38 percent to 28.97, 34.26 and 35.53 percent respectively after supplementation in the severe, moderate and mild anaemic groups. However the control group showed a decrease in PCV values.

- The Mean Corpuscular Volume (MCV) for all the anaemic groups were below the normal range of 83-101fl. Among the experimental anaemic groups least value of 63.23 fl was shown by the severe anaemic group and the highest value of 74.43 fl was shown by the mild anaemic group. But all the three experimental groups showed significant improvement (p<0.01) in MCV values after the supplementation with IEB and the mean increment for severe, moderate and mild anaemic experimental groups were 6.78, 10.76 and 7.01fl respectively. In comparison the control group did not show any significant improvement in MCV values for the respective category

- All the three anaemic groups belonging to both experimental and control group had MCH (Mean Corpuscular Haemoglobin) values below the normal value (27-32pg) except for mild anaemic sport women in the experimental group who had a mean MCH value of 27.15pg. These values were corresponding to their low haemoglobin values which showed a significant improvement after supplementation with IEB. The initial values were 20.17, 21.66 and 25.80pg, respectively for severe moderate and mild anaemic experimental groups which improved to 24.28, 26.19 and 27.85pg respectively after supplementation by IEB. The mean increments were 4.11, 4.53, and 2.05pg and were significant at one per cent level. The control group did not show any significant improvement in MCH values and in fact there was a decrease in MCH values for moderate and mild anaemic control groups.
• Similar increase was observed for MCHC (Mean Corpuscular Haemoglobin Concentration) for all the three anaemic experimental groups. The values before supplementation were 30.14, 31.93 and 32.75g/dl for severe, moderate and mild anaemic group respectively which improved to 32.03, 33.18 and 33.49g/dl respectively after supplementation. The mean increments for all the above anaemic groups were 1.89, 1.25 and 0.74g/dl respectively and were significant at one percent level. The control groups of the same categories especially moderate and mild anaemic groups showed a decrease in the MCHC values.

• Regarding cardiovascular parameters, the mean blood pressure, both systolic and diastolic of the severe anaemic sports women in the experimental group was 107 and 73.5mmHg before supplementation and there was a significant reduction in both these measurements (104.6 and 67.45mmHg) after supplementation with iron enriched biscuits with a mean decrease was 2.14 and 6.05mmHg for systolic and diastolic blood pressure respectively which was significant at one per cent level. Similarly moderate anaemic experimental group showed a mean decrease of 2.05 and 4.40mmHg and mild anaemic group also showed a mean decrease of 1.55 and 3.20mmHg for systolic and diastolic blood pressure respectively after supplementation which was also significant at one per cent level. There was no significant reduction in systolic and diastolic blood pressure for all the anaemic sportswomen in the unsupplemented control group.

• Severe and moderate anaemic groups both experimental and control showed slightly higher heart rate than the normal value (72beats/minute). The values obtained were 76.5 and 73.9beats/minute respectively for the severe and moderate experimental group before the
dietary intervention. And they showed a significant reduction (p<0.01) in the heart rate (72.8 and 71.5beats/minute) after IEB supplementation which is an indicator of the improvement of cardiovascular capacity. The mild anaemic experimental group showed a heart rate of 71.5beats/minute before supplementation and showed a mean reduction of 2.2beats/minute. However, the control group in any of the anaemic category did not record any significant reduction.

- Regarding treadmill test the severe anaemic experimental group before supplementation could run for 11.53 minutes which increased to 12.79minutes after the supplementation with a mean increase of 1.25minutes which was statistically significant at one percent level. The control group in the same category however had a mean increase of only 0.06 minutes which was not statistically significant. Similarly the moderate and mild anaemic sports women in the experimental group recorded a treadmill time of 12.46 and 13.10 minutes respectively before supplementation which improved to 13.51 and 15.4 minutes respectively after the supplementation. The mean increment was 1.05 and 2.33 minutes respectively which was significant at one percent level. In comparison the moderate anaemic control group showed a mean decrease in time by 0.02 minutes and the mild control group showed a marginal increment of 0.01 minutes on the treadmill which was not statistically significant.

- Recovery pulse rate (RPR) after treadmill test improved in all the three experimental anaemic groups after the iron enriched biscuit (IEB) supplementation. There was a significant decrease in pulse rate in severe and moderate anaemic experimental group at one percent level and for the mild anaemic group the reduction was significant at five percent level. The mean decrease in pulse rate after supplementation was 2.8,
1.65 and 1.50 beats/minute for severe, moderate and mild anaemic group respectively. On the contrary in the control group the pulse rate increased after the experimental period.

- These results clearly showed an improvement in the cardiac efficiency which was reflected in the cardiovascular efficiency scores (CES). The CES scores for all the three anaemic experimental groups before supplementation was 62.4, 67.03 and 66.06 which increased to 66.3, 70.6 and 68.9 for the severe moderate and mild anaemic sports women respectively. The highest mean increment in CES score of 3.94 was recorded by the severe anaemic group when compared to moderate and mild anaemic group which showed a mean increase of 3.57 and 2.24 respectively which again goes to show the impact of IEB intervention.

- Regarding 800 meter run, severely anaemic group recorded a mean running time of 4.58 minutes before supplementation which improved to 4.14 min after supplementation with a mean decrease of 0.44 min which was statistically significant at one percent level. The control in the same category showed a meagre improvement in speed (0.05min) which was not statistically significant. Similarly the moderate anaemic sportswomen clocked 4.31 minutes before supplementation which improved to 3.90 min after supplementation with the mean decrease of 0.41 min which was statistically significant (p<0.01). Mild anaemic sports women in the experimental group also showed an improvement in the speed with initial running time of 4.01 which improved to 3.72 minutes after the supplementation which was statistically significant at five percent level whereas the control groups in the respective categories did not improve their running time.

- Similar improvement was noticed with recovery pulse rate (RPR) after 800 meter run. There was a significant reduction (p<0.01) in recovery
pulse rate after supplementation in severe and moderate anaemic experimental groups with a mean reduction of 4.05 and 2.75 beats per minute, whereas the control in the same category showed only a marginal decrease of 0.30 and 0.40 beats per minute. Mild anaemic experimental group also recorded significant reduction (P< 0.01) in the recovery pulse rate.

- Cardiovascular efficiency scores (CES) also showed corresponding increase in all the three experimental groups and the highest mean increase score of 3.25 recorded by the severe anaemic group which was significant at one percent level as compared to control group in the same category which showed an insignificant marginal increase of CES score of 0.10. Thus the severe anaemic group showed marked improvement in all parameters discussed under 800 meter run test compared to other two experimental anaemic groups.

- There was a significant improvement in the running time for 100 meter sprint in all the three experimental anaemic sports women. The severe, moderate and mild anaemic experimental groups recorded a mean running time of 18.32, 17.38 and 16.22 seconds before supplementation which improved to 16.82, 16.88 and 15.01 seconds after supplementation with a mean reduction of 1.50, 1.60 and 1.21 seconds which was highly significant (P< 0.01). In comparison the control groups did not show any significant improvement in running time.

- Recovery pulse rate (RPR) after 100 meter run decreased significantly (p<0.01) from 76.15 to 73.00 beats/minute, 74.31 to 72.18 beats/minute and 73.58 to 71.29 beats/minute, after IEB supplementation for the severe, moderate and mild anaemic sports women respectively belonging to experimental group. However, the control group did not
show any significant improvement. These observations clearly indicate the improved cardiac functioning in the experimental group.

- The CES of anaemic sports women increased significantly (p<0.01) and the mean increase recorded were 3.8, 3.49, and 2.85 for severe moderate and mild anaemic experimental groups respectively after the supplementation. Whereas the control group did not show any significant improvement.

- Evaluation of the impact of nutrition education programme showed a positive impact and exposure to various nutrition education strategies brought a considerable improvement in their nutritional knowledge levels. This was evident with the majority of sports women belonging to the experimental group, giving the right answers after the nutrition education programme.

  It emerges from the result of this investigation that collegiate sports women with their increased nutritional needs, compared to their non athletic counterparts had very suboptimal dietary intake, lacunae in nutritional knowledge and inadequate dietary practices. The prevalence state of anaemia among these sportswomen signifies it as a public health problem, calling for sustainable strategies to ameliorate the same for better nutrition, health status and improved sports performance.

  Iron Enriched Biscuit (IEB) formulation with locally available iron rich food products and flavored with cocoa when supplemented for 120 days, significantly improved their dietary intake, iron nutriture, haemoglobin levels, which in turn improved their anaemic status and sports performance. Food supplementation along with nutrition education helped to create awareness among these sportswomen which will definitely go a long way in promoting sustainable health benefits.
The results of the study clearly brought out the need to assess the iron/Hb status of athletes in general and sports women in particular in colleges/sports institutions. Feasibility of improving performance levels due to iron supplementation was clearly depicted. It also provides adequate evidence regarding the possibility of supplementing iron / other nutrients in the food form. The feasibility of providing easily potable and consumable formulations of multiple food products preferably locally available is also evident. This makes it easily adaptable in colleges / institutions which have sufficient budget to provide food for athletes. These observations indicate the need to raise the iron nutritional status of sports students in educational institutions to optimum levels through appropriate food formulations of common use that are easily available and economically suitable for all strata of the society. This also calls for the need to popularise and market such nutritious formulations by which it can be made available for not only to the sports women but also for all vulnerable population groups.

Though limited to a sample population in Hyderabad the investigation gives a positive promising pointer for future similar product development and supplementation studies which can even be extended to other vulnerable sections of the society like children, adolescents, pregnant and lactating women who are prone to iron deficiency anaemia (IDA). It is also recommended that further research along the following lines be undertaken which when coupled with nutrition education programmes will help to reduce the prevalence of anaemia on a sustainable basis especially for sportswomen which will help them to have the stamina to display their acquired skills. Thus appropriate dietary intervention strategies coupled with nutrition education programmes in colleges will go a long way in maximising the performance potentials which will indeed enable them to reach their peak performance and to bring laurels to their institutions / nation.
RECOMMENDATIONS

- Regular screening of sportswomen particularly for anaemia should be made compulsory in every college.
- Proper monitoring of their diet and suitable modification of diet to include more iron rich foods is recommended.
- Periodic assessment of haemoglobin (at least every 6 months) should be made mandatory for every sports personnel.
- Nutrition education of sports men and women, coaches and physical directors will help in improving the overall nutritional status of sports students.
- Role of sports dietician will give professional edge to competitive sports and hence sports nutrition science need to be developed as an area of specialization.
- A qualified sports dietician, who is a certified specialist in sports dietetics, should be employed in educational institutions to provide individualized nutrition advice and counselling to the sports students.
- Research leading to the development of user friendly product / formulation for sports personnel is required. Such nutritious products may be manufactured in consumable quantities with detailed instruction of usage and nutrition information.
- This will help to develop the significance of ready to eat foods and creation of market awareness for continuous use by common man.
- The developed product can be tested on a large sample and recommended for marketing at a much cheaper cost.