I INTRODUCTION

Success in sports has become an international issue earmarking the prestige of the country. Competitive sports are becoming a highly technical job and sports science has made rapid progress in the last few decades. Sports medicine, sports psychology, sports nutrition and sports physiology are but a few field geared up for this. Amongst these, sports nutrition has emerged as one of the strong decisive factor and an important tool in enhancing sports performance (Burke et al., 2006). Although studies regarding the interactions between nutrition and various forms of sports and exercise have been carried out for more than a century, it is only within the past few decades that extensive research has been undertaken regarding nutritional needs and specific nutrient requirements for athletes (Williams, 2006).

It is the position of the American Dietetic Association (ADA 2009), Dietitians of Canada, and the American College of Sports Medicine that physical activity, athletic performance, and recovery from exercise are enhanced by optimal nutrition. These organizations recommend appropriate selection of food and fluids, timing of intake, and supplement choices for optimal health and exercise performance. Maughan and Ronald (2001) states that, “without proper nutrition, the full potential of the athlete will not be realized, because performance will not be at its peak, training levels may not be sustained, recovery from injury will be slower, and the athlete may become more susceptible to injury and infection.”

The significance of nutrition in sports performance was identified as early as the beginning of the 20th century and great efforts have been made to discern the general physiological roles of many of the essential nutrients and there is a tremendous increase in nutrition consciousness.
(Brouha, 1959; Mac Intyre, 1968; Bergstorm and Hultman, 1972). According to Green et al., (1989) and Nieman (2000) sports nutrition has developed through self-experimentation and during the past 20 years, understanding of the nutritional requirements for maximal sports performance has greatly improved so also the athletic performance. In countries such as India where malnutrition is of a public health dimension, poor athletic performance could be partly due to poor physique and unsatisfactory physical fitness resulting from undernourishment says Tripathy (1985).

Understanding sports nutrition leads to optimal athletic performance and lifetime health benefits (AMA, 1991). Energy and macronutrient needs, especially carbohydrate and protein, must be met during times of high physical activity to maintain body weight, replenish glycogen stores, and provide adequate protein to build and repair tissue (Brown, 2002). Fat intake should be sufficient to provide the essential fatty acids and fat-soluble vitamins, as well as contribute energy for weight maintenance (Houtkooper, 2000). Maintenance of proper nutrition and meeting the needs of the players with regard to energy, protein, fat, minerals and vitamins are crucial and these nutrient needs are higher for athletes than for ordinary persons (Coleman, 1989).

Sports nutrition has many goals to enhance performance. First, it improves performance by improving body composition, which increases speed, quickness, mobility, and strength. Second, it will help the speed of recovery, which will in turn create more capacity for practicing and competition as the body is becoming more fit and adjusted to the coupling of the good nutrition incorporated into the workout regimen. Third, it will allow one to increase energy for both practice and competition, which will definitely help one's performance (Smolin and Grosvenor, 2000). A strategic diet will also increase immunity, allowing
one to stay healthy and be able to continue and intensify practice and training (Mahan and Stump, 2000). Thus nutritional status is a critical determinant of athletic performance opines Nogueira and Costa (2004).

Without the right kind and proportion of foods to balance body’s nutrient needs, even the physical conditioning and expert coaching do not suffice to bring out the best says Lambert et al., (2004). Macro and micronutrients play an important role in energy production, haemoglobin synthesis, and maintenance of bone health, adequate immune function and protection of body against oxidative damage (Sharkey, 2003). They assist with the synthesis and repair of muscle tissue during recovery from exercise and injury (Driskell, 2006 and Braun et al., 2000). Meeting energy needs is a nutrition priority for athletes.

Women are entering the sports arena and competing equally with men. The increase in women’s participation has resulted in an increase in research on women athletes (Grandjean et al., 2000). The number of women participating in recreational and competitive sports has increased dramatically over the last century. The Modern Olympics are a good mark of the growth of women’s involvement in sports. No women participated in the 1896 Olympics, compared to the 3,799 women (34.2%) of the 10,700 competing athletes who participated in the 1996 Atlanta Olympics. In the 2008 Olympics at Beijing, of the 10,500 Olympians who competed, 42 per cent were females - the highest percentage ever, according to International Olympics Committee (IOC).

Nutritional needs of women are definitely different from their male counterparts bringing out the need to review the nutritional implication of exercise in women (Hinton et al., 2004 and Gabel, 2000). This is mainly due to the fact that women are more prone to dietary deficiencies as they
have ongoing cycles taking place inside their body (Manore, 2002). Consequently the woman who is involved in sports will have a completely different set of nutritional needs than that of their non-sports counterparts (Haymes et al., 2006). Females who are involved in regular sporting activities will have more needs for certain nutrients and it is very important to keep the right level of nutrients to prevent any nutritional disorders (Chris et al., 2010 and Malczewska et al., 2000). The main nutritional factors in sports nutrition for women would be the requirement for iron and calcium to help the body perform at its peak. Data show that women athletes tend to have nutrition related problems, specially related to energy, fat, iron, and calcium intake says Miller (2003) and Constantini et al., (2000).

Inadequate dietary intake is the primary nutritional concern of today’s female athlete. As these athletes fail to consume enough energy to support the physical demands of training they become at risk for disordered eating, amenorrhea and osteoporosis, conditions collectively identified as the female athlete triad (Gabel, 2006 and Nattiv et al., 2007).

Anaemia is a global problem, prevalent both in the developing and developed countries alike, the prevalence being much lower in the latter than in the former (WHO, 2006). South Asian countries including India represent a high prevalence area of the world for iron deficiency anaemia (Rajagopalan, 2009). In India over 320 million people suffer from Iron Deficiency Anaemia (IDA), the prevalence of IDA being 60-70 percent among children, 50 percent in adolescent girls and 40-80 percent among women (NNMB, 2008). Current five year plan (Eleventh Plan) aims to reduce the prevalence of anaemia among women and girls by 50 percent by the end of the plan period (Planning Commission, 2007). United Nations reemphasized that control of nutritional anaemia should be one of the global
development goals to be achieved in the early years of this new millennium (Krause et al., 2004). The most important cause of this grim micronutrient malnutrition scenario is inadequate dietary intake (Gopalan, 2008).

Anaemia has been identified as the most common medical condition among athletes especially among female athletes (Antonio et al., 2001). Anaemia is said to occur when the concentration of haemoglobin falls below that specified as normal for the individual’s age and sex. Iron deficiency anaemia in view of its high prevalence in developing countries assumes greater importance as a factor that may limit the Physical Work Capacity (PWC), as haemoglobin is associated with oxygen transport (Boyadjiev et al., 2000). Anaemia among sports women is a major concern and possible causes for sports anaemia are plasma volume expansion, reduced haemoglobin synthesis, and increased destruction of RBC (Benardot, 2006). A diet low in iron can aggravate this condition. Also in athletes there can be depletion of iron stores and increased losses of iron through urine, sweat, internal bleeding, injury etc. (Volpe, 2006). Female athletes have yet another source of blood loss-menstruation which leads to physiological loss of iron (Hallberg et al., 1991). By not providing the body with the correct iron intake, it will become a leading factor in reducing performance during sports. Over 50 percent of female endurance athletes have depleted iron stores, which suggests that dietary intervention may be necessary to prevent anemia (Florentino, 2003).

Early onset of fatigue during exercise is a common complaint among athletes, especially female athletes. Overtraining, stress, or many other external factors can cause fatigue, but many cases of fatigue are attributable to a lack of iron in the blood, a condition known as anaemia says Kimberly and Mueller (2006).
Research studies show that as many as 45 per cent of female runners of high school age have low iron stores (Malczewska et al., 2000). The NFHS–3 survey also highlighted the presence of wide spread anaemia throughout the life cycle, affecting 79 percent of children and 56 percent of women of reproductive age. One of the consequences of anaemia is impaired work performance, as the decreased haemoglobin (Hb) level reduces the oxygen carrying capacity of the blood for the working muscles (Dubnov and Constantini, 2004). Symptoms of iron-deficiency anaemia include muscle burning, shortness of breath during exercise, nausea, frequent infections, respiratory illnesses and a pale, washed-out appearance (Beard and Tobin, 2000).

The term "sports anaemia" is commonly used to describe iron depletion and consequent reductions in haemoglobin to anemic levels. Sports anaemia occurs in athletes who dramatically increase their training intensity (Magnusson et al., 1984). Red blood cell count and haemoglobin concentration has been shown to be lower in athletes than sedentary individuals says (Boyadjiev and Taralov, 2001) which may support the hypothesis that exercise creates an added demand for iron that exceeds its intake. Athletes may be at risk for developing iron deficiency because of sweat losses, intestinal losses, increased demand for total body haemoglobin, menstrual losses in female and poor dietary intake (ADA, 2003).

Sports anaemia refers to a period in early training when athletes may develop low blood haemoglobin and likely reflects a normal adaptation to physical training. Aerobic training enlarges the blood volume and with the added fluid, the RBC count per unit of blood drops, says Antonio et al., (2001). True anaemia exist in athletes if the haemoglobin level is under 13g/dl in man or 12g/dl in women (Clark, 1999). Athletes
who subject themselves to prolonged, strenuous exercise like daily endurance training may develop a degree of anaemia. Possible causes for sports anaemia are plasma volume expansion, reduced Hb synthesis, and increased destruction of RBC. Thus chronic iron deficiency that results from consistently poor iron intake can negatively affect health, physical and mental performance, and warrants prompt medical intervention and monitoring (Cowell et al., 2003).

The three basic approaches to the prevention of iron deficiency anaemia are supplementation with medicinal iron, dietary modification, enrichment and fortification of food with iron (Rao, 1993). In athletes who are iron deficient, iron supplementation not only improves blood biochemical measures and iron status but also increases work capacity as evidenced by increasing oxygen uptake, reducing heart rate, and decreasing lactate concentration during exercise (Lukaski, 2004). One of the cheapest, safest and sustainable methods of dietary intervention is the incorporation of iron rich foods in the diet and ensuring its bioavailability so as to bring about a lasting solution to the problem of iron deficiency anaemia (Narasinga Rao, 2003). Thus the obvious approach to combat anaemia is to improve the diet by incorporating iron rich cereals, millets, pulses and green leafy vegetables.

Iron deficiency anaemia undoubtedly impairs work capacity and thereby sports performance especially in female athletes with their increased nutritional demands and menstrual losses. Very few studies have been done to assess the prevalence or extent of anaemia among collegiate sports women and it is a very important phase in their life. It is a period when large numbers of college students engage in competitive sports and enter into greater heights in their national and international sports career. Lots of incentives are given to sports students for admission into various...
universities and for getting jobs. So increasing number of college students are showing great enthusiasm in joining competitive sports to bring laurels to their institution, university, state and of course the nation. But the sad state of affairs is that many of them do not have adequate dietary intake and proper nutritional knowledge to cope up with this extra demand for various nutrients and hence end up with various health problems especially anaemia and related nutritional disorders.

There is not much information on iron nutriture of athletes in general and sports women in particular. There is a great need to ascertain the nutritional profile of sports women particularly in this era when more and more women are entering the field of competitive sports. To build a strong sports force, one need to start from school / college level training, as this is the time ripe to bring out the potential among sports personnel. To catch them at this age, to understand their health / nutritional picture and performance level is a dire need. Moreover athletes are inadequately informed about nutrition and many think about nutrition only during the season of sports, whereas proper nutrition is a year round task (Kunkel et. al., 2001). Dietary intervention coupled with nutrition education is the sustainable solution for combating iron deficiency anaemia (Maughan and Ronald, 2004).

Unless sports anaemia is treated in women athletes it can lead to fatigue, decreased performance, weakness and other complications. As anaemia is a widely prevalent nutritional disorder among women particularly sportswomen, there is a great need to work out strategies to ameliorate this on a sustainable basis. Correction of anaemia through supplementation with locally feasible iron rich food formulations, with awareness creation through nutrition education programmes is a conceivable strategy. Dietary supplementation can improve their nutritional
status, haemoglobin levels and there by improve their physical work capacity. Providing locally available enriched foods works out to be more cost effective and healthier than giving iron supplementation in the form of elemental iron (Power et al., 1994). Moreover, food supplementation has the dual advantage of not only improving the haematological picture but also providing complementary nutrients for iron utilization (Bagriansky, 1996). Good sources of dietary iron from animal sources are found in meat, eggs, poultry, liver and fish. Plant sources of iron include fortified cereals, millets, soya products, enriched rice products, pulses and legumes, green leafy vegetables etc, but are not absorbed as well as animal sources. However, you can increase absorption of iron from plant sources by consuming Vitamin C containing foods at the same time (Keith et al., 2006). Thus improving work capacity and endurance, increasing oxygen uptake, reducing heart rate, and reduced muscle fatigue are benefits of improved iron status.

In addition, imparting nutrition knowledge will bring in sustainable healthy dietary habits which alone can help athletes practice the knowledge gained, throughout their career as sports women (Jacobson et al., 2001). Nutrition education is an effective tool in helping athletes modify their nutrient intake (Clark et al., 1988). Gregorie (1991) stated that athletes' desire for accurate and practical nutrition information represents an increasing challenge and responsibility for dietitians, teachers, and coaches. Further, they note that more instructional materials need to be developed. There is, however, a lack of research focused on developing the most effective ways to educate athletes about sports nutrition (Jonnalagadda et al., 2001).

Hence in this study an attempt has been made to elicit detailed information on the extent of prevalence of anaemia among collegiate sports
women and to implement nutrition intervention strategies for correction of anaemia and to enhance their sports performance.

4. Objectives of the Study

The general objective of this investigation was to assess the extent of prevalence of anaemia among collegiate sports women, develop suitable nutrition intervention strategy by developing iron rich food formulation to correct the situation so as to improve their iron nutriture and performance levels and also to impart nutrition knowledge for sustained benefits.

The specific objectives were:

- To study the prevalence of anaemia and its related symptoms and complications among collegiate sports women from the city of Hyderabad.
- To assess their nutritional profile through anthropometry, clinical assessment, haemoglobin level and food consumption pattern.
- To formulate an iron enriched biscuit (IEB) using locally available foods like whole cereals, millets, pulse flour, rice flakes and dates.
- To ascertain the organoleptic quality, nutrient content and shelf life of the formulated iron enriched biscuit (IEB).
- To study the effect of the formulated iron enriched biscuit on the anaemic status and performance levels of selected sports women.
- To disseminate knowledge through a specially designed nutrition education kit and evaluate the nutritional knowledge gained by sports women.