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Correlation Of Dietary Vitamin Intake And Seleceted Health Markers Among Adolescent Basketball Players

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ABSTRACT
Objective: This study investigates the correlation between the consumption of vitamins and specific health markers-—hemoglobin levels, blood pressure, pulse rate, and respiratory rate—in adolescent basketball players. **Methods:** A cohort of adolescent basketball players (aged 13-15 yrs, females 200; males 200) was assessed for their dietary intake of key vitamins using a detailed food frequency questionnaire. Blood samples were collected to measure hemoglobin levels, and clinical evaluations were conducted to record blood pressure, pulse rate, and respiratory rate. Statistical analyses were performed to identify correlations between micronutrient intake and the health markers. **Results:** The study found significant correlations between the intake of certain vitamins and the health markers measured. Higher folate intake was positively correlated with hemoglobin levels ($p<0.01$), indicating better oxygen transport capacity. Additionally, thiamine, riboflavin, beta carotene and vitamin C showed significant correlations with improved pulse and respiratory rates and blood pressure ($p<0.01$), reflecting enhanced cardiovascular and respiratory function. **Conclusion:** The findings underscore the importance of adequate vitamin intake in maintaining optimal hemoglobin levels, blood pressure, pulse rate, and respiratory rate in adolescent basketball players. These correlations highlight the need for targeted nutritional strategies to support the health and athletic performance of young athletes. Further research is recommended to explore the causal relationships and potential benefits of dietary interventions in this population.

Keywords: *Vitamins, Hemoglobin, Blood Pressure, Pulse Rate, Respiratory Rate, Adolescent Basketball Players*.

INTRODUCTION:

The role of nutrition in athletic performance has gained significant attention in recent years; with a growing body of evidence suggesting that adequate intake of vitamins is crucial for maintaining optimal health and enhancing athletic performance (Rosenbloom et al., 2002). Adolescence is a critical period characterized by rapid growth and development, which increases the nutritional needs of young athletes (Petrie et al., 2004). For adolescent basketball players, whose physical and cognitive demands are high, ensuring sufficient intake of essential micronutrients is particularly important.

Vitamins play diverse roles in the body, from supporting metabolic processes to aiding in the repair and maintenance of tissues. For instance, vitamins such as B-complex vitamins are vital for energy metabolism, while antioxidants like vitamins C and A protect against oxidative stress induced by intense physical activity (Rodriguez et al., 2009). Nutrition plays a pivotal role in the performance and overall health of athletes, particularly in adolescent basketball players who experience high physical demands alongside rapid growth and development. Adequate intake of vitamins is essential to support these physiological processes and optimize athletic performance (Rosenbloom et al., 2002). This study focuses on the correlation between the consumption of vitamins and specific health markers—hemoglobin levels, blood pressure, pulse rate, and respiratory rate—in adolescent basketball players.

Hemoglobin, a key component of red blood cells, is critical for oxygen transport throughout the body. Micronutrient such as folate is essential for the synthesis of hemoglobin and the prevention of anemia (Beard &

Tobin, 2000). Adolescent athletes are particularly susceptible to folate deficiency due to increased requirements for growth and physical activity (Beard, 2001). Ensuring adequate intake of vitamins can significantly impact athletic performance and recovery by maintaining optimal oxygen delivery to muscles.

Pulse rate and respiratory rate are indicative of cardiovascular and respiratory health, both of which are crucial for the endurance and performance of athletes. Sufficient intake of antioxidants such as vitamin C can help reduce oxidative stress, potentially improving overall cardiovascular and respiratory function during intense physical activity (Pepe et al., 2009).

Despite the recognized importance of these micronutrients, many adolescent athletes do not meet the recommended dietary allowances (RDAs), which can negatively impact these health markers (Ziegler et al., 2003). Understanding the correlation between micronutrient intake and these specific health markers can provide valuable insights for developing nutritional strategies tailored to the needs of young basketball players.

This study aims to investigate the relationship between the consumption of key vitamins and the levels of hemoglobin, blood pressure, pulse rate, and respiratory rate in adolescent basketball players. By identifying potential deficiencies and their impact on these health markers, the study seeks to offer evidence-based recommendations to enhance the health and performance of young athletes.

METHODOLOGY:

Sample Population and Size:

Total 400 regular practicing basketballers (girls and boys) of age group 10 to 15 years were chosen from leading basketball clubs from Nagpur city, Maharashtra, India. 100 girls and 100 boys from each age group of 10 to 12 years and 13 to 15 years) were purposively selected.

Nutrient Intake:

Precise information on food intake of subjects was gathered through 24 hour's dietary recall method for three consecutive days (three day's dietary recall). This was done to collect very accurate information about the quantity of foods consumed by the basketballers. The data about food intake from their first meal of the after arising in the morning till the last meal consumed before bed time was collected. Information about inclusion of type and quantity of cereals, millets, pulses, legumes, vegetables (roots, tubers, green leafy and other), fruits, milk and its products, nuts, oil seeds, dry fruits, fats and oils, sugars, eggs, non-vegetarian foods (meat, chicken, fish, sea foods etc). Based on 24 hour's dietary recall method for consecutive three days, nutritive values of diets consumed by the players were computed using the food composition tables given by Gopalan, C. et al. (2012) and Longvah, T. et al. (2017). Actual nutrient intake values of basketball players with respect to vitamins were calculated & compared with recommended dietary allowances (RDAs)(National Institute of Nutrition (NIN)/Indian Council of Medical Research (ICMR), 2009).

Biochemical and Clinical Parameters:

Blood hemoglobin level, pulse rate, blood pressure and respiratory rateof basketballers were assessed using standard equipments and procedures.

Based on the hemoglobin level, basketballers were classified for degree of anemia. as per the guidelines given by WHO/UNICEF/UNU (2001).

Statistical Analysis:

Obtained data for basketballers were compared with the standards and recommended dietary allowances (RDAs). Percentage excess or deficit was calculated. Between and within group comparisons were done.

Meanandstandard deviation along with minimum and maximum values were drawnand percentages were calculated for various parameters for female and male basketballers from age groups 10-12 yrs and 13-15 yrs.

z test: For females and males (for each age group) comparison between data and standards/RDAswas done using one sample z test. This large sample test (independent samples test) was used to assess the significance of the difference between sample mean and standard/RDA. Comparisons were done for hand measurements, nutrient intake and hand grip strength physical fitness parameters.

Two sample z test was used for within gender group comparisons. Female basketballers from age group 10-12 yrs were compared with those from age group 13-15 yrs whereas male basketballers from age group 10-12 yrs were compared with those from age group 13-15 yrs. This was done to see effect of age on various parameters.

To assess effect of gender on hand grip strength, between gender comparisons were done using two sample z test. For this, female basketballers from age group 10-12 yrs were compared with male basketballers from age group 10-12 yrs. Similarly, female basketballers from age group 13-15 yrs were compared with male basketballers from age group 13-15 yrs.

Critical value of z was tested at both 0.01 and 0.05 levels of significance (1.96 and 2.58, respectively).

Pearson's coefficient of correlation test: Pearson's product moment coefficient of correlation method was used to derive relationship between various parameters for each age group of female and male basketballers. Within group strength of relationship between various measures was assessed. A level of significance at both 5% (0.05) and 1% (0.01) levels was assumed to draw conclusions.

RESULTS AND DISCUSSION:

Intake of Vitamins:

Table 1 presents data on daily intake of vitamins by basketballers and Table 2 shows distribution of subjects based on adequacy of dietary intake of vitamins.

Table 1: Data on Daily Intake of Vitamins by Basketballers

Sr. No.	Parameters	GIRLS			BOYS		
		Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	z Values¶	Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	z Values¶
1	**Carotene (µg)**						
i	**M±SD**	2518.96±632.00	1154.85±549.45	**16.29***	876.52±380.10	508.83±132.08	**9.14***
ii	**Range**	1671.63-5197.57	636.60-4862.96		458.61-4217.61	290.58-813.95	
iii	**RDA**	4800.00	4800.00		4800.00	4800.00	
iv	**% Deficit**	-47.52	-75.94		-81.74	-89.40	
v	**z Values#**	**36.09***	**66.34***		**103.22***	**324.90***	
2	**Thiamine (mg)**						
i	**M±SD**	1.69±0.29	1.71±0.32	**0.31**	1.55±0.17	1.56±0.14	**0.55**
ii	**Range**	1.12-2.33	1.15-2.22		1.21-2.61	1.17-1.90	
iii	**RDA**	1.00	1.20		1.10	1.40	
iv	**% Excess**	+69.00	+42.50		+40.90	+11.43	
v	**z Values#**	**23.87***	**15.66***		**26.70***	**11.60***	
3	**Riboflavin (mg)**						
i	**M±SD**	1.26±0.27	1.38±0.25	**3.22***	1.62±0.15	1.53±0.15	**4.44***
ii	**Range**	0.64-1.76	1.00-2.04		1.22-1.91	1.20-2.03	
iii	**RDA**	1.20	1.40		1.30	1.60	
iv	**%Deficit/Excess**	+5.00	-1.43		+24.62	-4.38	
v	**z Values#**	**2.09****	**0.98**		**21.80***	**5.01***	
4	**Niacin (mg)**						
i	**M±SD**	21.53±3.90	23.78±4.37	**3.84***	26.26±3.74	27.41±2.42	**2.57****
ii	**Range**	14.69-33.96	13.70-37.09		18.53-40.70	21.97-34.56	
iii	**RDA**	13.00	14.00		15.00	16.00	
iv	**% Excess**	+65.62	+69.86		+75.07	+71.31	
v	**z Values#**	**21.86***	**22.39***		**30.12***	**47.06***	
5	**Pyridoxine (mg)**						
i	**M±SD**	1.40±0.20	1.54±0.23	**4.37***	1.61±0.14	1.79±0.31	**5.28***
ii	**Range**	0.88-1.91	1.12-2.33		1.26-1.96	1.25-2.71	
iii	**RDA**	1.60	2.00		1.60	2.00	
iv	**%Deficit/Excess**	-12.50	-23.00		+0.63	-10.50	
v	**z Values#**	**9.92***	**20.19***		**0.68**	**6.92***	
6	**Folic Acid (µg)**						
i	**M±SD**	214.34±36.68	196.51±41.57	**3.22***	201.73±40.06	227.09±53.25	**3.81***
ii	**Range**	134.43-310.00	121.98-354.56		133.72-326.72	138.14-373.60	
iii	**RDA**	140.00	150.00		140.00	150.00	

iv	**% Excess**	+53.10	+31.07		+44.09	+51.39	
v	**z Values#**	**20.27***	**11.19***		**15.41***	**14.48***	
7	**Vitamin C (mg)**						
i	**M±SD**	152.62±47.75	144.73±50.76	**1.85**	174.11±37.19	180.04±33.41	**1.19**
ii	**Range**	85.48-266.33	83.27-324.63		105.65-291.49	108.46-250.05	
iii	**RDA**	40.00	40.00		40.00	40.00	
iv	**% Excess**	+281.55	+261.83		+335.28	+350.10	
v	**z Values#**	**24.63***	**20.63***		**36.06***	**41.92***	

¶ - z values are for between group comparison (i.e. comparison between age groups 10-12 yrs & 13-15 yrs); # - z values are for comparison between data of subjects & RDAs; * - Significant at both 5 % & 1% levels (p<0.01); ** - Significant at 5 % level but insignificant at 1 % level (0.01<p<0.05); Values without any mark indicate insignificant difference at both 5% & 1% levels (p>0.05).

Table 2: Distribution of Subjects based on Adequacy of Dietary Intake of Vitamins

Sr. No.	Parameters	GIRLS (%)		BOYS (%)	
		Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)
1	**Carotene (µg)**				
i	Intake Below RDA	96	99	99	100
ii	Adequate Intake	3	1	1	0
iii	Intake Below RDA	1	0	0	0
2	**Thiamine (mg)**				
i	Intake Below RDA	0	3	0	8
ii	Adequate Intake	7	34	42	25
iii	Intake Below RDA	93	63	58	67
3	**Riboflavin (mg)**				
i	Intake Below RDA	19	44	6	44
ii	Adequate Intake	48	24	11	46
iii	Intake Below RDA	33	32	83	10
4	**Niacin (mg)**				
i	Intake Below RDA	0	1	0	0
ii	Adequate Intake	41	15	39	15
iii	Intake Below RDA	59	84	61	85
5	**Pyridoxine (mg)**				
i	Intake Below RDA	33	70	9	57
ii	Adequate Intake	61	29	87	34
iii	Intake Below RDA	6	1	4	9
6	**Folic Acid (µg)**				
i	Intake Below RDA	1	6	3	6
ii	Adequate Intake	13	30	28	15
iii	Intake Below RDA	86	64	69	79
7	**Vitamin C (mg)**				
i	Intake Below RDA	0	0	0	0
ii	Adequate Intake	16	26	0	0
iii	Intake Below RDA	84	74	100	100

The mean daily intakes of carotene in girls aged 10-12 yrs & 13-15 yrs as well as in boys aged 10-12 yrs & 13-15 yrs were recorded as 2518.96±632.00 µg, 1154.85±549.45 µg, 876.52±380.10 µg & 508.83±132.08 µg, respectively which was extremely lower in boys than in girls from both age groups with a large difference calculated as 1642.44 µg & 646.02 µg between younger and older groups, respectively. This can be attributed to consumption of various sources of caroteneby girls like dark green leafy vegetables such as spinach, fenugreek leaves, cabbage & fruits and vegetables like orange, papaya, mango, carrots, pumpkin, sweet potatoes etc. However, the limitation occurred because three day's dietary recall was used & based on three day's intake, carotene intake of players was derived & it might have happened that during this period few players might not have consumed rich sources of this vitamin which resulted in lower intake of carotene.

The mean daily intake of carotene decreased with the age among basketballers with younger groups of girls & boys consumed significantly higher mean daily carotene than older groups of girls & boys, respectively (16.29 & 9.14, respectively, $p<0.01$). A huge gap was observed between lowest and highest intake values of carotene intake by the players which were noted as 636.60 µg in girls aged 10-12 yrs & 5197.57 µg in girls aged 13-15 yrs, 290.58 µg in boys aged 10-12 yrs & 4217.61 µg in boys aged 13-15 yrs. Because of the huge individual differences for the daily intake of carotene among subjects, all the groups of basketballers failed to meet the RDAs for carotene which might be due to poor selection of food sources of this vitamin in their diets. % deficit in comparison to RDAs were calculated as 47.52, 75.94, 81.74 & 89.40%, respectively in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs with the calculated z values of 36.09 & 66.34 in girls aged 10-12 yrs & 13-15 yrs, respectively and 103.22 & 324.90 in boys aged 10-12 yrs & 13-15 yrs, respectively (Table 1). Animal foods like liver, salmon and eggs along with milk & its products are rich in vitamin A. Dark green and orange colored vegetables and fruits are rich in carotenoids which can be converted into vitamin A in the body.

Boisseau, N. et al. (2002) found that the diets of 11 adolescent soccer players (15 yrs)quite inappropriate in terms of the intake of carotene. Papadopoulou, S. K. et al. (2002) found no difference between 16 adolescent Greek female volleyball players from junior national team and 49 adolescent Greek female volleyball players from junior national championship for intakeof vitamin A.

It is clear from Table 2 that daily carotene intake was highly insufficient in maximum player's diets. 96-99% in girls aged 10-15 yrs & boys aged 10-12 yrs found to have intake of daily carotene below RDA, whereas none of boys from 13-15 yrs age group found to meet the RDA for carotene, which might be due to inappropriate choices or selection of foods in players. 1-3% players had adequate intake of carotene, whereas 1% of younger girls (10-12 yrs) found to have carotene intake above RDA. Vrzhesinskaia, O. A. et al. (2004) found 82-100 per cent of 14-16 years old (17 girls and 14 boys) young basketball players with deficiency of carotenoids. Karabudak, E. et al. (2016) reported vitamin A intake as adequate among 77 rhythmic and artistic gymnasts (age ranged 7-15 years). Roy, M. et al. (2018) reported insufficient intake of carotene among 40 Indian junior female national hockey players.

Thiamine:

Thiamine plays a critical role in energy metabolism, nerve function, and muscle contraction. Adequate thiamine levels ensure efficient energy production, which is vital for sustaining the high-energy demands of basketball training and competition (Leklem, 1990). For basketball players, optimal muscle function and coordination are critical for performance, agility, and reducing the risk of injuries. Ensuring sufficient thiamine intake helps support these physiological processes, contributing to better athletic performance and quicker recovery times. Thiamine deficiency can lead to neurological impairments, which can adversely affect an athlete's performance and well-being (Martin et al., 2003).Intense physical activity, such as that experienced by basketball players, increases the production of free radicals, which can cause oxidative damage to muscles and other tissues. By contributing to the body's antioxidant defense system, thiamine helps mitigate this damage, aiding in faster recovery and reducing the risk of chronic injuries and fatigue (Gibson et al., 2013).

The mean daily thiamine intake was higher in girls aged 10-12 yrs & 13-15 yrs (1.69±0.29mg& 1.71±0.32 mg, respectively) as compared to boys aged 10-12 yrs & 13-15 yrs (1.55±0.17 mg & 1.56±0.14 mg, respectively). The lowest individual values for thiamine intake were recorded as 1.12 mg, 1.15 mg, 1.21 mg & 1.17 mg among girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively whereas the highest individual values for thiamine intake were recorded as 2.33 mg, 2.22 mg, 2.61 mg & 1.90 mg among girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively (Table 1).

Basketballers exceeded the RDAs for daily thiamine in their diets with % excess calculated as 69.00%, 42.50%, 40.90% & 11.43% in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively. Significant differences was noted betweendaily mean intake and RDAs of thiamine for players, the z valueswere relatively higher in younger groups than older groups (z=23.87, 15.66, 26.70 &11.60, respectively for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively, $p<0.01$). However, gender group comparison for daily mean thiamine intake showed insignificant differences (z=0.31 for girls aged 10-12 yrs vs. girls aged 13-15 yrs & z=0.55, for boys aged 10-12 yrs vs. boys aged 13-15 yrs, $p>0.05$). Basketballers included lots of whole grains like cereals & millets along with pulses & legumes in their diets which provided them additional thiamine.

Prajakta, N. et al. (2010) found mean intake of thiamine of 37 young female swimmers, aged 10-14 yrs more than RDAs. Karabudak, E. et al. (2016) reported thiamine intake of 77 rhythmic and artistic gymnasts (age ranged 7-15 years) below dietary reference intake. Roy, M. et al. (2018) reported insufficient intake of thiamine among 40 Indian junior female national hockey players.

Thiamine sources were abundantly included in the diets of basketballers. 93% girls aged 10-12 yrs, 63% girls aged 13-15 yrs, 58% boys aged 10-12 yrs & 67% boys aged 13-15 yrs consumed excess thiamine than the RDAs whereas only 3% & 8% older girls & boys, respectively showed deficient consumption of thiamine. 7-42% basketballers had adequate intake of thiamine (Table 2).

Riboflavin:

Riboflavin plays a vital role in energy production, cellular function, and antioxidant protection. For young basketball players, who have increased nutritional needs due to physical exertion and growth, adequate riboflavin intake is essential for optimizing performance and overall health. Riboflavin is a key component of the coenzymes flavin mononucleotide and flavin adenine dinucleotide which are involved in numerous redox reactions in the body's energy production pathways (Powers, 2003). These coenzymes are crucial for the metabolism of carbohydrates, fats, and proteins, converting these macronutrients into ATP, the primary energy currency of cells (McCormick, 1989). For basketball players, efficient energy production is critical for sustaining high-intensity training and competitive performance. Riboflavin plays a crucial role in this process. The vitamin's involvement in mitochondrial energy production supports muscle contraction and endurance (Gropper et al., 2017). Young basketball players require optimal muscle function and growth to meet the physical demands of their sport. Adequate riboflavin intake ensures that their muscles receive the energy needed for performance and recovery.Riboflavin contributes to the body's antioxidant defense system by supporting the activity of glutathione reductase, an enzyme that helps regenerate glutathione, one of the most important intracellular antioxidants (Evans & Halliwell, 2001). During intense physical activity, such as basketball, the production of reactive oxygen species increases, which can lead to oxidative stress and muscle damage. Riboflavin's role in maintaining glutathione levels helps protect cells from oxidative damage, reducing recovery time and the risk of injury (Powers & Jackson, 2008). Riboflavin is involved in the synthesis of neurotransmitters and the maintenance of nerve cells (Bender, 2003). For young athletes, a well-functioning nervous system is vital for coordination, reflexes, and overall cognitive performance on the court. Adequate riboflavin intake supports these neurological functions, contributing to better focus and reaction times during games and practice sessions.

Both the groups of older female & male basketballers were unable to meet the daily recommendations of riboflavin (z=0.98, $p>0.05$ & z=5.01, $p<0.01$) whereas both the groups of younger female & male basketballers showed excess mean daily consumption of riboflavin in comparison with RDAs (z=2.09, $0.01<p<0.05$ & z=21.80, $p<0.01$). Younger boys consumed higher consumption of milk, paneer, cheese and egg which are good sources of riboflavin (Table 2).

Prajakta, N. et al. (2010) reported riboflavin intake higher than RDAs in 37 young female swimmers, aged 10-14 yrs. Similar results were reported by Daneshvar, P. et al. (2013) in 28 young male Isfahani wrestlers (aged 17-25 yrs). Jain, R. et al. (2008) found the mean riboflavin intake of 100 Delhi based national/state level sportswomen, aged 18-25 years, participating in team games-volleyball, hockey, football and kabaddi much lower than the recommendation. Roy, M. et al. (2018) also found insufficient intake of riboflavin among femaleIndian junior national hockey players. Karabudak, E. et al. (2016) reported riboflavin intake as adequate or even above dietary reference intake in 77 rhythmic and artistic gymnasts (age ranged 7-15 years).

For the present study, greater differences were observed for individual riboflavin intake of basketballers. The lowest riboflavin intake was recorded as 0.64 mg, 1.00 mg, 1.22 mg & 1.20 mg whereas the highest riboflavin intake was recorded as 1.76 mg, 2.04 mg, 1.91 mg & 2.03 mg, respectively in females (10-12 yrs), females (13-15 yrs), males (10-12 yrs) & males (13-15 yrs) as also clear from Table 1. As shown in Table 2, it can be seen that 83% of boys from age group (10-12 yrs showed daily intake of riboflavin above the RDA whereas the % of players who showed excess intake of daily riboflavin than RDAs was 33%, 32% & 10% for girls (10-12 yrs), girls (13-15 yrs) 7 boys (13-15 yrs), respectively. 44% older females as well as 44% older males showed deficient consumption of daily riboflavin whereas 19% females aged 10-12 yrs were unable to meet the daily recommendation of riboflavin. 24-48% girls (10-12 yrs & 13-15 yrs, respectively) and 11-46% boys (10-12 yrs & 13-15 yrs, respectively) had adequate intake of riboflavin in their daily meals.

Niacin:

Niacin plays a crucial role in energy metabolism, DNA repair, and the synthesis of important signaling molecules. Niacin is integral to the body's energy production processes. It is a precursor to the coenzymes nicotinamide adenine dinucleotide and nicotinamide adenine dinucleotide phosphate which are involved in numerous metabolic reactions. These coenzymes play a critical role in the catabolism of carbohydrates, fats, and proteins, converting these macronutrients into ATP, the primary energy currency of cells (Higdon, 2000). For basketball players, efficient energy production is vital for sustaining high levels of performance during training and games. The high energy demands of basketball require robust mitochondrial function for sustained muscle performance. Niacin contributes to the maintenance and enhancement of mitochondrial function through its role in oxidative phosphorylation (Lin & Guarente, 2003). Adequate niacin intake helps ensure that muscle cells produce sufficient ATP, supporting muscle contraction and endurance. Moreover, niacin's involvement in reducing muscle fatigue and improving recovery is essential for young athletes who must quickly recover between intense training sessions and competitions. For young basketball players, maintaining cardiovascular health is critical for optimal athletic performance and long-term well-being (Ganji et al., 2003). Niacin has been shown to exhibit anti-inflammatory properties, which can help reduce exercise-induced inflammation and support faster recovery (Hughes et al., 1996). Niacin is involved in the synthesis of neurotransmitters and the maintenance of neural health (Bender, 2003). For young basketball players, optimal nervous system function is critical for coordination, reaction time, and cognitive performance on the court.

Niacin intake showed higher mean values in boys aged 10-12 yrs & 13-15 yrs (26.26±3.74 mg & 27.41±2.42 mg, respectively) as compared to girls aged 10-12 yrs & 13-15 yrs (21.53±3.90 mg & 23.78±4.37 mg, respectively) and the difference was calculated as 4.73 mg for 10-12 yrs age group & 3.63 mg for 13-15 yrs age group (Table 1). A gap of 19.27 mg, 23.39 mg, 22.17 mg & 12.59 mg was noted between the highest & lowest value of individual intake of niacin by females aged 10-12 yrs, females aged 13-15 yrs, males aged 10-12 yrs & males aged 13-15 yrs, respectively. The lowest and highest values of niacin intake were recorded as 13.70 & 37.09 mg for girls & 18.53 & 40.70 mg for boys, respectively. Basketballers surpassed the RDAs of mean niacin intake with % excess derived as 65.62, 69.86, 75.07 & 71.31% in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively as also clear from Table 4.17 (z=21.86, 22.39, 30.12 & 47.06, respectively, $p<0.01$). This might be because subjects included non-vegetarian foods like chicken, fish & mutton in their diets, which are also good sources of niacin. Within gender group difference were significant at both 5% & l% levels for female & males, with older groups consumed significantly higher mean niacin than younger groups (z=3.84, $p<0.01$ and z=2.57, $0.01<p<0.05$).

Prajakta, N. et al. (2010) revealed that irrespective of age groups, mean intake of niacin of 37 young female swimmers, aged 10-14 yrs was found to be more than RDA. Niacin intake of 100 Delhi based national/state level sportswomen, aged 18-25 years studied by Jain, R. et al. (2008) was much lower than the recommendation. Roy, M. et al. (2018) reported insufficient intake of niacin among 40 Indian junior national hockey female players. Daneshvar, P. et al. (2013) reported that the mean intakes of niacinby 28 young male Isfahani wrestlers (aged 17-25 yrs) were higher than the RDAs in these wrestlers.

None of the players reported niacin intake below RDA in the present study (Table 2). Majority of basketballers (59% girls from age group 10-12 yrs, 84% girls from age group 13-15 yrs, 61% boys from age group 10-12 yrs & 85% boys from age group 13-15 yrs) reported excess daily intake of niacin than RDAs. 15-41% girls & 15-39% boys under present study were taking adequate amount of niacin.

Pyridoxine:

Pyridoxine/vitamin B6 is a water-soluble vitamin that plays a pivotal role in numerous physiological processes. Pyridoxine is a coenzyme involved in the metabolism of amino acids, which are the building blocks of proteins (Leklem, 1990). For young basketball players, whose muscle tissues undergo constant stress and require regular repair, pyridoxine is indispensable. It ensures that their bodies can efficiently utilize dietary proteins to build and repair muscle tissues, thereby supporting muscle function and performance. Vitamin B6 is involved in the metabolism of carbohydrates and fats, which are key sources of energy (Leklem, 1990). Adequate pyridoxine levels help ensure that young basketball players have sufficient energy reserves to sustain prolonged periods of physical activity. Pyridoxine is essential for the synthesis of neurotransmitters such as serotonin, dopamine, and gamma-aminobutyric acid (Dakshinamurti, 2001) which play key roles in regulating mood, focus, and muscle coordination. For young athletes, optimal cognitive function and mental focus are crucial for performance on the court. Adequate intake of pyridoxine supports these neurological functions, helping to maintain concentration, coordination, and overall mental well-being during training and competitions.Vitamin B6 is involved in the production of antibodies and cytokines, which are essential for immune responses (Meydani et al., 1991). For young basketball players, maintaining a strong immune system is important to prevent infections and illnesses that can disrupt training and performance. Pyridoxine is crucial for the synthesis of hemoglobin, the protein in red blood cells that carries oxygen throughout the body (Combs, 2012). Adequate hemoglobin levels are essential for maintaining oxygen delivery to muscles during exercise, thereby supporting aerobic capacity and endurance. Young basketball players, who engage in high-intensity aerobic activities, benefit from sufficient pyridoxine intake as it ensures efficient oxygen transport and utilization, enhancing overall performance and reducing fatigue.

The mean values for pyridoxine intake were noted as 1.40±0.20 mg in girls aged 10-12 yrs, 1.54±0.23 mg in girls aged 13-15 yrs, 1.61±0.14 mg in boys aged 10-12 yrs & 1.79±0.31 mg in boys aged 13-15 yrs (Table 1). With the exception of boys aged 10-12 yrs, none of the other groups were able to meet the RDAs for mean daily pyridoxine intake. The mean pyridoxine intake of girls aged 10-12 yrs, girls aged 13-15 yrs & boys aged 13-15 yrs was found to be significantly less than RDAs ($z=9.92$, 20.19 & 6.92, respectively, $p<0.01$). Younger boys had mean daily pyridoxine intake slightly above the RDA ($z=0.68$, $p>0.05$).

Boisseau, N. et al. (2002) found that the diets of 11 adolescent soccer players aged about 15 years were quite inappropriate in terms of the intake of pyridoxine. Roy, M. et al. (2018) reported insufficient intake of pyridoxine among female 40 Indian junior national hockey players. Daneshvar, P. et al. (2013) studied reported that the mean intakes of pyridoxine were higher than the RDAs in 28 young male Isfahani wrestlers (aged 17-25 yrs). Karabudak, E. et al. (2016) reported pyridoxine intake as adequate in 77 rhythmic and artistic gymnasts (age ranged 7-15 years).

For the present study, there was a significant difference occurred ($p<0.01$) between younger & older girls ($z=4.37$) as well as between younger & older boys ($z=5.28$) for mean daily pyridoxine intakes, with older groups had higher intakes than younger groups. Table 2 demonstrates the distribution of basketballers based on adequacy of pyridoxine. Quite larger number of older female & male basketballers showed deficient daily intake of pyridoxine (70% & 57% girls & boys aged 13-15 yrs, respectively). In contrast, majority of younger girls (61%) & boys (87%) had adequate daily consumption of pyridoxine. Very few players reported excess daily intake of pyridoxine (6% girls aged 10-12 yrs, 1% girls aged 13-15 yrs, 4% boys aged 10-12 yrs & 9% boys aged 13-15 yrs). 29-61% girls & 34-87% boys had sufficient pyridoxine in their diet.

Folic acid:

Folic acid, also known as folate or vitamin B9, is essential for numerous physiological processes, including DNA synthesis, red blood cell formation, and nervous system function. Folic acid plays a key role in the synthesis of red blood cells (RBCs) in the bone marrow. RBCs contain hemoglobin, a protein that binds to oxygen and carries it to tissues throughout the body. Insufficient folic acid intake can lead to impaired RBC production, resulting in anemia characterized by fatigue, weakness, and reduced oxygen-carrying capacity (Gibson et al., 2006). For young basketball players, maintaining optimal levels of folic acid ensures adequate oxygen delivery to muscles during physical exertion, supporting endurance and performance on the court. It is required for the production of nucleotides, the building blocks of DNA and RNA. Adequate folic acid intake is crucial for ensuring proper cell growth, repair, and tissue regeneration, which are essential for muscle development and recovery in young athletes. Additionally, folic acid plays a role in maintaining the integrity of nerve cells and supporting optimal nervous system function, contributing to coordination and reflexes during basketball games (Crider et al., 2018). Adequate folic acid levels are necessary for maintaining proper methylation patterns, which influence various physiological processes, including metabolism, immune function, and neurotransmitter synthesis. Ensuring sufficient folic acid intake supports optimal gene expression and cellular function, contributing to overall health and performance in young basketball players (Ghandour et al., 2018). Folic acid has been shown to have beneficial effects on cardiovascular health. It helps metabolize homocysteine, an amino acid linked to an increased risk of cardiovascular disease when present in elevated levels (Jacques et al., 1996). By reducing homocysteine levels, folic acid supports cardiovascular function and reduces the risk of heart disease and stroke. For young basketball players, maintaining cardiovascular health is essential for optimal athletic performance and long-term well-being.

Mean values for folic acid intake were found to be 214.34±36.68 µg, 196.51±41.57 µg, 201.73±40.06 µg & 227.09±53.25 µg in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively. There found greater differences for individual intake of folic acid by basketballers as also seen from Table 4.17. The lowest and highest values for folic acid intake were found as 121.98 µg & 354.56 µg, respectively among girls whereas these values were 133.72 µg & 373.60 µg, respectively among boys (Table 1).

Players from all age groups were found to have higher mean daily intake of folic acid than RDAs & % excess were 281.55, 261.83, 335.28 & 350.10% in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively. Players included good amounts of dark leafy greens like spinach, fenugreek leaves, cauliflower greens, ambat chukka, ghol bhaji along with whole grains, beans and citrus fruits like orange, sweetlime etc. in their diets which are good sources of folic acid. The difference between the mean daily intake of folic acid by basketballers and RDAs of folic acid were significant at both 5% & 1% levels (z=20.27, 11.19, 15.41 & 14.48 in girls from 10-12 yrs age group, girls from 13-15 yrs age group, boys from 10-12 yrs age group &boys from 13-15 yrs age group, respectively, $p<0.01$). Also, within gender groups comparisons for daily mean folic acid intake showed significance of differences, with younger group of girls consumed significantly higher mean folic acid than older group of girls (z=3.22) and older group of boys consumed significantly higher mean folic acid than younger group of boys (z=3.81).

As also clear from Table 2, folic acid intake in basketballers found to have above RDAsin 86% female players from 10-12 yrs age group, 64% female basketballers from 13-15 yrs age group, 69% male basketballers from 10-12 yrs age group & 79% of older male players.

Asha, L. et al. (2009) signified that folic acid intake among 32 basketball players of Dharwad city (Karnataka, India) had the highest percent adequacy (7.23%). Kostopoulos, N. et al. (2017) concluded that an increased intake of folate favourably associates with blood cell count increments in 18 elite basketball players of four Greek A1 division teams. Papadopoulou, S.D. et al. (2008) found that basketball athletes showed significantly higher intake of folic acid ($p<0.05$). Daneshvar, P. et al. (2013) reported higher mean intakes of folic acid than the RDAs among 28 young male Isfahani wrestlers (aged 17-25 yrs).

In the present study, 13% female players (10-12 yrs), 30% female players (13-15 yrs), 28% male players (10-12 yrs) & 15% male players (13-15 yrs) had adequate intake of folic acid(Table 3).4.29, 1%, 6%, 3% & 6% in girls aged 10-12 yrs, girls aged 13-15 yrs,boys aged 10-12 yrs & boys aged 13-15 yrs, respectively, were found to be deficit in folic acid consumption.

Folic acid deficiency has been suggested to be the most common vitamin deficiency in humans and can result in anemia (Keith, R. E., 1989). Driskell, J. (2006) opined that although short-term marginal deficiencies of B-vitamins have not been observed to impact performance, severe deficiency of folic acid may result in anemia and reduced endurance performance. Few studies located deficiency of folic acid among players engaged in different sports disciplines. Karabudak, E. et al. (2016) reported low folic acid intake below dietary reference intake in 77 rhythmic and artistic gymnasts (age ranged 7-15 years). Roy, M. et al. (2018) observed insufficient intake of folic acid among 40 Indian junior national hockey players.

Vitamin C:

For young basketball players, whose bodies are subjected to oxidative stress during training and competition, adequate intake of vitamin C is essential for reducing oxidative damage, supporting muscle recovery, and minimizing the risk of injury. Vitamin C plays a key role in the synthesis of collagen, a structural protein that forms connective tissues, such as tendons, ligaments, and cartilage (Carr & Maggini, 2017; Pullar et al., 2017). During physical activity, especially high-impact sports like basketball, the body undergoes repetitive stress that can lead to microtears and tissue damage. Adequate vitamin C intake supports collagen synthesis, facilitating tissue repair and recovery, and reducing the risk of musculoskeletal injuries in young athletes. For young basketball players, maintaining a robust immune system is essential for preventing illnesses that can disrupt training schedules and compromise performance. Adequate vitamin C intake supports immune health, enabling athletes to train consistently and compete at their best. Vitamin C enhances the absorption of non-heme iron, the type of iron found in plant-based foods and iron-fortified products (Hemila & Chalker, 2013; Hurrell & Egli, 2010). For young basketball players, maintaining optimal neurotransmitter levels is crucial for mental focus, reaction time, and coordination during games and practices. Adequate vitamin C intake supports neurological function, contributing to better performance and overall well-being (May, 2012).

Mean daily intake of vitamin C was insignificantly ($p>0.05$) lower in girls aged 13-15 yrs (144.73±50.76 mg) than that in girls aged 10-12 yrs (152.62±47.75 mg) whereas mean daily intake of vitamin C was insignificantly ($p>0.05$) higher in boys aged 13-15 yrs (180.04±33.41 mg) than that in boys aged 10-12 yrs (174.11±37.19 mg). The z values were 1.85 for girls & 1.19 for boys. Huge differences were noted for individual intake of vitamin C. A gap of 180.85 mg, 241.36 mg, 185.84 mg & 141.59 mg was recorded between the highest & lowest vitamin C intake values for girls (10-12 yrs), girls (13-15 yrs), boys (10-12 yrs) & boys (13-15 yrs), respectively. All age groups of basketballers showed very high daily mean consumption of vitamin C than RDAs, with % excess of 281.55 for girls aged 10-12 yrs (z=24.63), 261.83 for girls aged 13-15 yrs (z=20.63), 335.28 for boys aged 10-12 yrs (z=36.06) & 350.10 for boys aged 13-15 yrs (z=41.92) as also seen from Table 1.

Nande, P. et al. (2009) found mean daily intake of vitamin C among 13 females and 46 males players (aged 19-22 yrs) engaged in different sports disciplines significantly exceeding the RDAs ($p<0.01$).

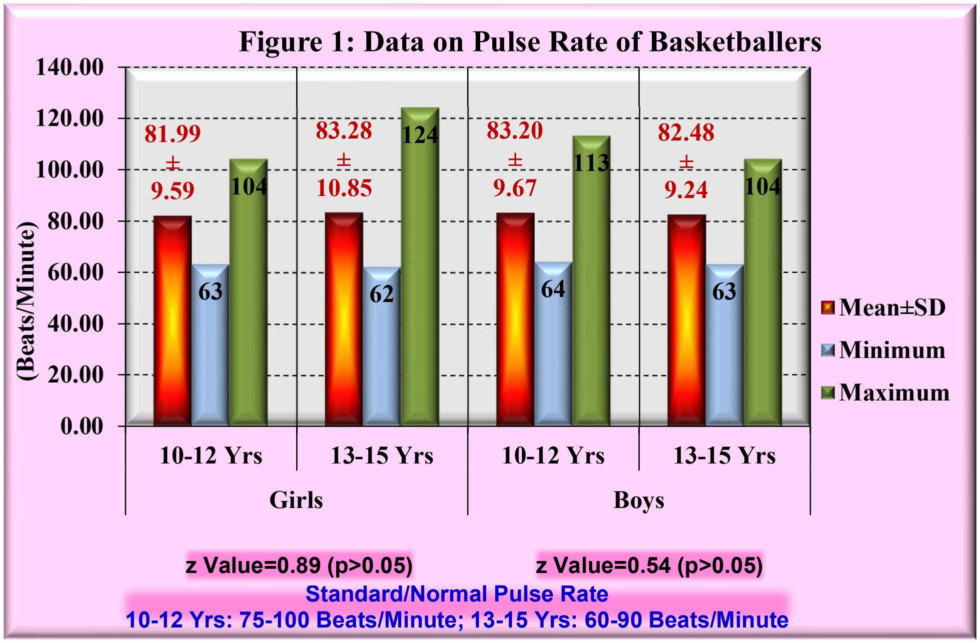
For the present research, older group of female basketballers consumed less mean daily vitamin C than younger group of female basketballers (z=1.85). In contrast, older group of male basketballers consumed higher mean daily vitamin C than younger group of male basketballers (z=1.19). However, the differences were insignificant for both the genders ($p>0.05$) (Table 1). Players got vitamin C majorly through citrus fruits like orange, sweet lime & lemon which they consumed in the form of juices which fulfilled their requirements for vitamin C. Karabudak, E. et al. (2016) reported vitamin C intake above dietary reference intake in 77 rhythmic and artistic gymnasts (age ranged 7-15 years). Daneshvar, P. et al. (2013) reported higher mean intakes of vitamin C were than the RDAs in 28 young male Isfahani wrestlers (aged 17-25 yrs). Roy, M. et al. (2018) found insufficient intake of vitamin C among 40 Indian junior national hockey players. Jain, R. et al. (2008) found the mean vitamin C intake of 100 Delhi based national/state level sportswomen, aged 18-25 years much lower than the recommendation.

Table 2 presents distribution of basketballers based on the adequacy of vitamin C. It was seen that 100% boys from age group 10-12 yrs as well as from the age group 13-15 yrs showed excess daily consumption of vitamin C which could be attributed to drinking of citrus fruit juices instead of branded sports drinks by players. 84% among girls aged 10-12 yrs & 74% among girls aged 13-15 yrs reported higher consumption of vitamin C than RDAs. 16% of younger & 26% of older female basketballerswere matching the dietary recommendation permitted for vitamin C intake.None of the basketballers reported inadequacy for vitamin C intake.

Biochemical and Clinical Parameters:

Pulse Rate:

For young basketball players, monitoring pulse rate can provide insights into their physical condition and readiness for intense physical activity.Regular monitoring of pulse rate helps assess cardiovascular fitness. A lower resting pulse rate typically indicates a higher level of cardiovascular efficiency, often seen in well-trained athletes (Gledhill et al., 1994). Improved cardiovascular fitness enhances endurance, allowing basketball players to perform at a high level throughout games and practices.Tracking pulse rate helps in managing training loads and recovery. Elevated resting pulse rates may indicate overtraining or insufficient recovery, signaling the need for rest or adjustments in training intensity (Achten & Jeukendrup, 2003).



For the present research, the highest mean value of pulse rate was recorded among older female players aged 13-15 yrs (83.28±10.85 beats/minute) followed by younger male players aged 10-12 yrs (83.20±9.67 beats/minute), older male playersaged 13-15 yrs (82.48±9.24 beats/minute) & younger female players aged 10-12 yrs (81.99±9.59 beats/minute) as seen from Figure 1. Pulse rate was recorded in resting position in players. Irrespective of age & gender, mean pulse rate values of basketballers were found to be within the normal range.

In girls from 10-12 yrs age group, girls from 13-15 yrs age group, boys from 10-12 yrs age group & boys from 13-15 yrs age group, the minimum pulse rate was noted as 63, 62, 64 & 63 beats/minute, respectively whereas the maximum pulse rate values were noted as 104, 124, 113 & 104 beats/minute, respectively, as also shown in Figure 1. Younger vs. older groups of girls as well as younger vs. older groups of boys did not show statistical difference ($p>0.05$) for their mean pulse rate values ($z=0.89$ for younger vs. older girls & $z=0.54$ younger vs. older boys). Similarly, between gender comparison for mean pulse rate also showed insignificant differences ($p>0.05$) ($z=0.89$ for girls aged 10-12 yrs vs. boys aged 10-12 yrs and $z=0.56$ for girls aged 13-15 yrs vs. boys aged 13-15 yrs).

Ostojic, S. M. et al. (2006) described structural and functional characteristics of 60 elite Serbian basketball players in different positional roles and reported that the highest pulse rate frequencies during the last minute of the shuttle run test were lower in guards ($p<0.01$) as compared with forwards and centers. Majority of groups of players showed mean pulse rate insignificantly above the normal value of 70 beats/ minute ($p>0.05$) in a study carried by Nande, P. et al. (2009) assessed on 13 females and 46 males players (aged 19-22 yrs) engaged in different sports disciplines. Afman, G. et al. (2014) validated a basketball simulation test relative to competitive basketball games using well-trained basketball players (n=10) and found that pulse rate did not systematically differ between the 60-min basketball simulation test and competitive basketball, with a strong positive correlation in pulse rate response ($r=0.9$, $p<0.001$). Sixteen elite male and female junior basketball players (aged 15-19 years) were assessed by Klusemann, M. J. et al. (2012) for optimising technical skills and physical loading in small-sided basketball games and it was reported that pulse rate (86±4% & 83±5% of maximum; mean±SD) was moderately higher in 2v2 than 4v4 small-sided games, respectively.

McCormick, B. et al. (2012) examined twelve male basketball players (age:15 yrs) from one high-school basketball team for differences between three-on-three basketball games and five-on-five basketball games that lasted for eight minutes in terms of average pulse rate & they found no significant differences in average pulse rate in players in both game conditions. Abdelkrim N. B. et al. (2010) examined the relationship between athlete's physical capability and game performance in 18 male junior basketball players.The 19.3+/-3.5 and 56.0+/-6.3% of the playing time was spent above 95% and at 85-95% of maximum pulse rate, respectively. Montgomery, P. et al. (2010) characterized the physical and physiological responses during different basketball practice drills and games in male basketball players (n=11; 19.1±2.1 yrs) and found no substantial difference in mean pulse rate between offensive and defensive drills.

Time-motion analysis and physiological data of modern basketball was assessed by Abdelkrim, N. B. et al. (2007) by investigating 38 elite under-19-year-old basketball players during competition& the mean (SD) pulse rate during total time was recorded as 171 (4) beats/min, with a significant difference ($p<0.01$) between guards and centres. Vamvakoudis, E. et al. (2007) examined the effects of prolonged basketball skills training on maximal aerobic power in 20 basketball players and 18 control boys (aged 11(1/2), 12, 12(1/2), 13 years old) & results showed that the basketball group had lower pulse rate values in all ages.

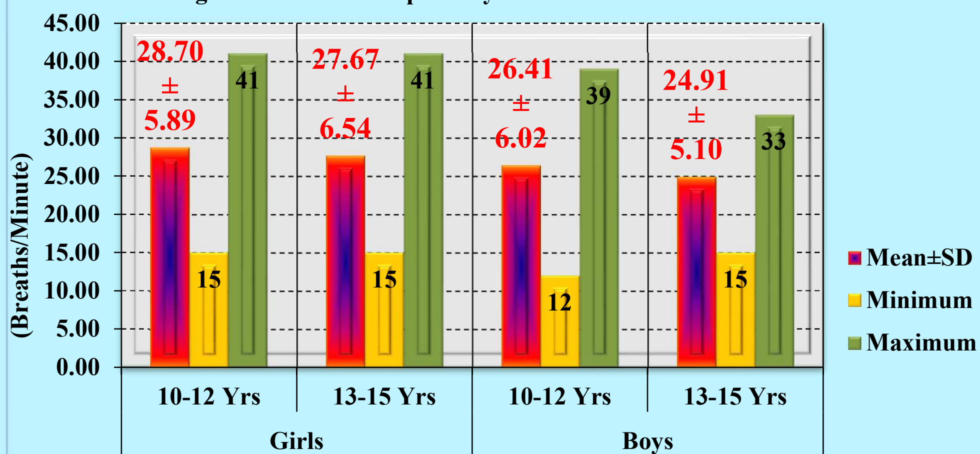
Among all four age groups of basketballers, pulse rate correlated positively ($p<0.01$) with thiamine (r=0.6255, 0.6111, 0.5332 & 0.5566, respectively), riboflavin (r= 0.5144, 0.5655, 0.6258 & 0.5785, respectively) & niacin (r= 0.6877, 0.6325, 0.5888 & 0.6544, respectively). A higher pulse rate can indicate cardiovascular strain or inadequate cardiovascular conditioning. Nutrient deficiencies affecting cardiovascular health (e.g., niacin, thiamine) may correlate with elevated pulse rates.

Respiratory Rate

Respiratory rate is the number of breaths taken per minute and is crucial for evaluating respiratory and overall physiological function; especially during physical exertion. Efficient breathing patterns ensure adequate oxygen delivery to muscles, crucial for sustaining high-intensity efforts (Powers & Howley, 2012). During intense exercise like basketball, maintaining optimal respiratory rate helps prevent early fatigue and enhances endurance performance.Post-exercise respiratory rate can indicate recovery status. A faster return to resting respiratory rate after exercise suggests good aerobic fitness and efficient recovery mechanisms (Nicolo et al., 2014). Monitoring respiratory rate helps athletes and coaches gauge the effectiveness of training programs and recovery strategies.

Figure 2 shows the data on mean, standard deviation, minimum & maximum respiratory rate of basketballers.

Figure 2: Data on Respiratory Rate of Basketballers



z Value=1.47 (p>0.05) z Value=0.34 (p>0.05)

Standard /Normal Respiratory Rate
10-12 Yrs: 18-30 Breaths/Minute; 13-15 Yrs: 12-16 Breaths/Minute

For this study, mean respiratory rate of female & male basketballers from age group 10-12 yrs was found to be within the normal range whereas female & male basketballers from age group 13-15 yrs showed mean respiratory rate exceeding the normal range as also seen from Figure 2.

Higher the respiratory rate, harder the heart needs to work. The mean values of respiratory rate for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yr & boys aged 13-15 yrs were recorded as 28.70±5.89, 27.67±6.54, 26.41±6.02 & 24.91±5.10 breaths/minute, respectively. Age group wise within gender differences were found to be insignificant at both 5% & 1% levels (z=1.47 for girls aged 10-12 yrs vs. girls aged 13-15 yrs and z=0.34for boys aged 10-12 yrs vs. boys aged 13-15 yrs).

Proper breathing is one of the most overlooked resources in sports and fitness. Improper breathing can hinder performance since CO_2 is not properly cleared, thereby causing a build-up of waste and altering the pH of the body. Huge individual differences were noted among respiratory rate of basketballers with the lowest values were recorded as 15, 15, 12 & 15 breaths/minute, respectively & highest values were recorded as 41, 41, 39 & 33 breaths/minute, respectively forgirls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yr& boys aged 13-15 yrs (2).

Mean respiratory rate recordings for boys aged 10-12 yrs & boys aged 13-15 yrs were found to be less than that for girls aged 10-12 yrs & girls aged 13-15 yrs, respectively, however, the differences were found to be statistically insignificant ($z=1.04$ for girls aged 10-12 yrs vs. boys aged 10-12 yrs and $z=0.78$ for girls aged 13-15 yrs vs. boys aged 13-15 yrs).

Atan, T. et al. (2007) done research on pulmonary functions of 50 non-athletes and 250 athletes from different team sports branches (basketball, football, volleyball, and handball) of 15-16 age group, when the respiratory rates were analyzed, it was determined that values were not significantly different between subjects ($p>0.05$) & it was concluded that respiratory functions were higher among individuals who do exercise compared to those who do not. Savas, S. et al. (2007) investigated passage of blood levels of the 12 healthy University male basketball players before and after a strenuous training session and concluded that increased respiration rate in basketballers during the training period resulted in elevated levels of lead in blood by 297%.

Basketball players (N=30) aged 18-28 years (both males and females) with different levels of expertise (university, state and national) were studied by Paul, M. et al. (2012) to determine the reconstitution of psychomotor and performance skills through biofeedback training & results showed that respiration rate differences were statistically significant in each group along with interaction of group and time ($p<0.001$) indicating that biofeedback training may help to train stressed athletes to acquire a control over their psychophysiological processes, thus helping an athlete to perform maximally. Agafonkina, T. V. and Tikhonov, V. F. (2014) determined the characteristics of the breathing pattern in 38 kettlebell lifters & it was found that the number of breathing cycles per cycle of competitive exercise and consequently, respiratory rate remained constant, independent of physical load.

Pyridoxine & folic acid are micro-nutrients important for hematology in sports persons. In the present research, respiratory rate was found to have inverse association with pyridoxine intake ($r= -0.0038$ to -0.1510, $p>0.05$) & folic acid intake ($r=-0.0032$ to -0.2487, $p>0.05$) among all four groups of basketballers indicating that higher the intake of these micro nutrients lesser are the number of inhalation & exhalation the players needed. Also, there found negative correlation of respiratory rate of players with vitamin C intake ($r=-0.0305$ to -0.1474, $p>0.05$). A study by Woolf et al. (2020) explored dietary patterns and cardiovascular health in athletes, emphasizing the role of vitamin C intake in reducing oxidative stress and improving cardiovascular function.

Blood Pressure

Maintaining optimal blood pressure is essential for overall health and performance. Hypertension (high blood pressure) can lead to long-term cardiovascular damage, while hypotension (low blood pressure) might cause dizziness and reduced exercise tolerance, both of which can negatively affect a basketball player's performance and health (Kannel, 1996). Regular monitoring of blood pressure can help assess cardiovascular adaptations to training. Endurance training often results in lower resting blood pressure, indicating improved cardiovascular efficiency and reduced risk of hypertension (Cornelissen & Fagard, 2005).

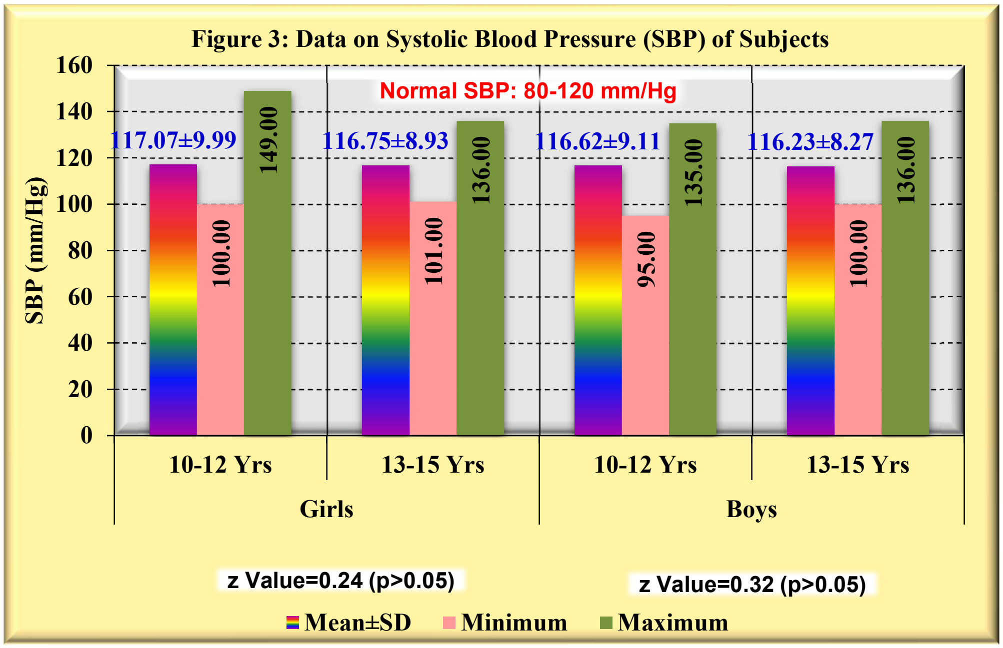


Figure 3: Data on Systolic Blood Pressure (SBP) of Subjects

The blood pressure of basketball players was recorded at resting state. Figure 3 clearly shows that all the groups of basketballers had mean systolic blood pressure (SBP) within the normal range.

However, female players from 10-12 yrs age group (117.07±9.99 mm/Hg) & female players from 13-15 yrs age group (116.75±8.93 mm/Hg) had higher mean SBP values than male players (116.62±9.11 mm/Hg in male players from 10-12 yrs age group & 116.23±8.27 mm/Hg in male players from 13-15 yrs age group).

The highest SBP was recorded as 149.00 mm/Hg in girls & 136.00 mm/Hg in boys. The lowest SBP was recorded as 100.00 mm/Hg in girls & 95.00 mm/Hg in boys (Figure 4.37).

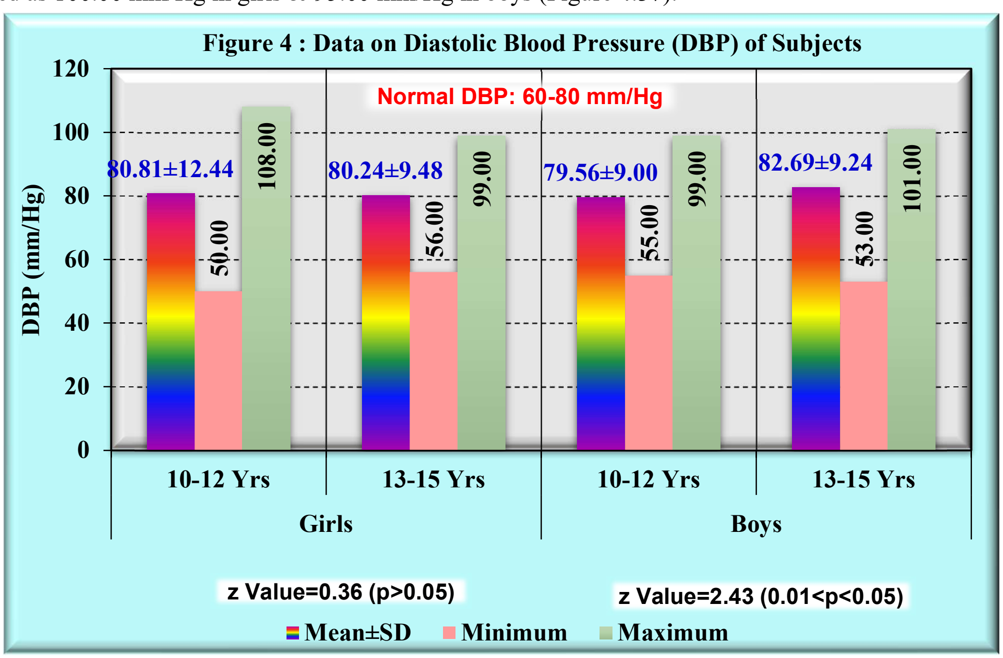


Figure 4 : Data on Diastolic Blood Pressure (DBP) of Subjects

In the present study, with the exception of younger boys, diastolic blood pressure (DBP) in all the other groups were found to be minimally exceeding the normal values as also can be seen in Figure 4. Recorded mean values of DBP ranged between 80.24 to 80.81 mm/Hg in girls & 79.56 to 82.69 mm/Hg in boys. Fluctuation was observed in minimum & maximum DBP values of players which were recorded as 50.00-108.00, 56.00-99.00, 55.00-99.00 & 53.00-101.00 mm/Hg, respectively in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs.

Systolic blood pressure and diastolic blood pressure values were recorded to be closer to the normal values in 13 females and 46 males players (aged 19-22 yrs) engaged in different sports disciplines in a study carried out by Nande, P. et al. (2009).

For the present study, both the genders represented insignificant within age group differences ($p>0.05$) for mean SBP ($z=0.24$ in girls & 0.32 in boys). However, girls aged 10-12 yrs & girls aged 13-15 yrs did not show any significant difference for mean DBP ($z=0.36$, $p>0.05$) but older group of male basketballers showed significantly higher mean DBP ($z=2.43$, $0.01<p<0.05$).

Mean DBP demonstrated insignificance of differences between girls aged 10-12 yrs & boys aged 10-12 yrs ($z=0.81$, $p>0.05$) as well as between girls aged 13-15 yrs & boys aged 13-15 yrs ($z=0.85$, $p>0.05$).

Mean SBP & DBP demonstrated insignificance of differences for girls aged 10-12 yrs vs. boys aged 10-12 yrs ($z=0.33$ for SBP & $z=0.81$ for DBP, $p>0.05$) as well as for girls aged 13-15 yrs vs. boys aged 13-15 yrs ($z=0.43$ for SBP & $z=0.85$ for DBP, $p>0.05$).

Kelley, G. A., and Kelley, K. S. (2000) stated that participation in resistance exercise results in decreases of approximately 2% and 4% in systolic and diastolic blood pressure, respectively and also suggested that even small reductions in blood pressure have a beneficial effect in reducing cardiovascular disease morbidity and mortality. Because exercise is therapeutic for persons with hypertension, athletes with sustained systolic blood pressure of less than 160 mm Hg and diastolic blood pressure of less than 100 mm/Hg should not be restricted from sports, indicated Cambridge, T. M. et al. (2010).

Brown, B. S. et al. (1974) assessed maximal aerobic capacity, hematological determinations as well as selected anthropometric and strength measures among the entire University of Arkansas basketball team during preseason & results showed significant changes in diastolic blood pressure (-7.2 mm/Hg) in players. The relation between blood pressure and habitual physical activity during leisure time was investigated by Strazzullo, P. et al. (1988) in a random sample of 272 school children (mean age-11.3 years) in Italy & it was observed that a low level of physical activity during leisure time in 11-year-old children was associated with higher systolic blood pressure independent of sex, age, and adiposity.

De Matos, L. D. et al. (2011) studied the prevalence of pre-existing diseases & cardiovascular risk factor in a population of 623 amateur and professional athletes aged 13-77 yrs & hypertension was the most prevalent diagnosed disease in athletes, and cardiovascular risk factors showed important prevalence, especially in athletes older than 35 yrs. Buell, J. L. et al (2008) evaluated 76 football linemen in National Collegiate Athletic Association for the presence of metabolic syndrome & of the 70 athletes, 34 were identified as having metabolic syndrome according to the measures of blood pressure. Kelley, G. A. et al. (2003) examined the effects of exercise on resting systolic and diastolic blood pressure in children and adolescents (n=1266) & reported reductions in blood pressure by approximately 1% and 3% for resting systolic and diastolic blood pressures, respectively. A study by Woolf et al. (2020) explored dietary patterns and cardiovascular health in athletes, emphasizing the role of vitamin C intake in reducing oxidative stress and improving cardiovascular function. Among all four groups of female and male basketballers, blood pressure values correlated negatively with intake of vitamin C, thiamine, riboflavin & niacin ($r= 0.1200$ to 0.5889).

Hemoglobin Level:

Adequate hemoglobin levels are essential for optimal athletic performance, particularly for young basketball players who require significant aerobic capacity and endurance. Hemoglobin binds to oxygen in the lungs and carries it through the bloodstream to the muscles, where it is used for aerobic respiration to produce energy necessary for muscle contraction and endurance (Guyton & Hall, 2006). During intense physical activities like basketball, the demand for oxygen increases significantly. Adequate hemoglobin levels ensure efficient oxygen delivery to meet this demand, enhancing stamina and performance (Sawka et al., 2007). Higher hemoglobin levels are associated with improved maximal oxygen uptake because more oxygen can be transported and utilized by working muscles. This is particularly important for basketball players, who require sustained energy output for running, jumping, and quick directional changes (Bassett & Howley, 2000). Adequate hemoglobin levels help maintain aerobic metabolism during prolonged activity, delaying the onset of fatigue and allowing for better performance and quicker recovery times post-exercise (Brooks, Fahey, & Baldwin, 2005). Adequate hemoglobin levels are crucial for ensuring a sufficient supply of oxygen to the brain. Oxygen is vital for cognitive functions, such as concentration, decision-making, and reaction time, all of which are essential for basketball performance (Smith & Blumenthal, 2010). Low hemoglobin levels can lead to reduced cognitive performance, impairing an athlete's ability to make quick decisions and maintain focus during games.Low hemoglobin levels can lead to anemia, characterized by symptoms such as fatigue, weakness, and dizziness (Haas & Brownlie, 2001). Anemia can severely impact a young basketball player's performance, reducing their ability to train effectively and compete at their highest level. Ensuring adequate hemoglobin levels helps prevent these symptoms, supporting overall health and athletic performance.

Table 3 shows the detailed data on haemoglobin level of male & female basketballers. Figure 5 shows the percentage wise distribution of basketballers based on degree of anemia based on hemoglobin level.

Table 3: Data on Haemoglobin Level of Basketballers (g/dL)

Sr. No.	SUBJECTS	PARAMETERS (Hemoglobin Level in g/dL)	AGE GROUPS 10-12 Yrs (n=100)	13-15 Yrs (n=100)	z Values¶
1	G I R L S	**M±SD**	11.72±1.11	11.91±1.18	**1.21**
		Range	8.20-13.70	9.20-14.00	
		Standard↕	**≥12.0**	**≥12.0**	
		z Values#	**2.56****	**0.74**	
2	B O Y S	**M±SD**	11.76±1.08	12.09±1.18	**2.07****
		Range	9.10-14.50	9.00-14.50	
		Standard↕	**≥12.0**	**≥12.0**	
		z Values#	**2.22****	**0.77**	
z Values■			**0.28**	**1.07**	-

↕- WHO, UNICEF & UNU (2001);¶ - z values are for between group comparison (i.e. comparison between age groups 10-12 yrs & 13-15 yrs); # - z values are for comparison between data of subjects &standards; ■ - z values are for between gender comparison (i.e. comparison between girls & boys from age group 10-12 yrs & between girls & boys from age group 13-15 yrs); * - Significant at both 5 % & 1% levels ($p<0.01$) ** - Significant at 5 % level but insignificant at 1 % level ($0.01<p<0.05$); Values without any mark indicate insignificant difference at both 5% & 1% levels ($p>0.05$).

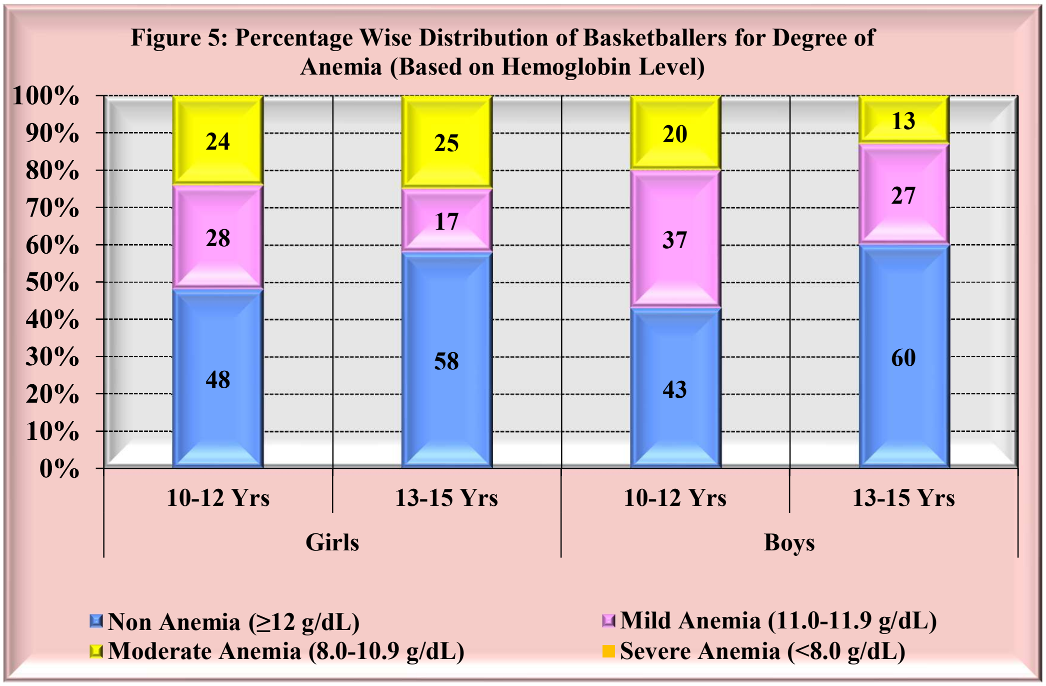
Table 3 clearly shows that female players aged 10-12 yrs & 13-15 yrs had lower mean haemoglobin levels than male players aged 10-12 yrs & 13-15 yrs, respectively which can be attributed to blood losses in girls during menstrual cycle. However, for this research the relationship between hemoglobin level & menstruation was not considered. The differences between girls aged 10-12 yrs & boys aged 10-12 yrs as well as between girls aged 13-15 yrs & boys aged 13-15 yrs for their mean hemoglobin levels were found to be insignificant (z=0.28 & 1.07, respectively). Mean hemoglobin level values for girls (10-12 yrs), girls (13-15 yrs), boys (10-12 yrs) & boys (13-15 yrs) were observed as 11.72±1.11 g/dL,11.91±1.18 g/dL, 11.76±1.08 g/dL & 12.09±1.18g/dL respectively.

For the present study, huge variations were observed in the minimum & maximum values of haemoglobin level of basketballers, which were noted as 8.20-13.70g/dL, 9.20-14.00g/dL, 9.10-14.50 g/dL & 9.00-14.50 g/dL in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively).

In the present study, except older boys (13-15 yrs), mean hemoglobin levels of girls (10-12 yrs), girls (13-15 yrs) & boys (10-12 yrs) were found to be lower than the standards given by WHO, UNICEF & UNU (2001). The differences were insignificant for girls aged 13-15 yrs ($z=0.74$, $p>0.05$) & boys aged 10-12 yrs ($z=0.28$, $p>0.05$) but significant for girls aged 10-12 yrs ($z=2.56$, $0.01<p<0.05$). Possible reasons for lower haemoglobin levels in players could be increased iron requirements, poor iron intake with faulty dietary habits or impaired iron absorption. In contrast to this, older boys aged 13-15 yrs showed mean hemoglobin level higher than standard cut off level, however, the difference was not significant ($z=1.07$, $p>0.05$)

As Table 3 shows, there was insignificant difference between mean haemoglobin levels of girls from age groups 10-12 yrs & 13-15 yrs ($z=1.21$, $p>0.05$). Older group of male basketballers possessed significantly greater mean hemoglobin level than younger group of male basketballers ($z=2.07$, $0.01<p<0.05$).

Haemoglobin level is considered as a best indicator for assessing anemia. An attempt was made to know the percentage wise distribution of basketballers for degree of anemia based on their hemoglobin level which is presented in Figure 5.



It was observed from Figure 5 that majority of female players from 10-12 yrs age group, female players from 13-15 yrs age group,male players from 10-12 yrs age group& male players from 13-15 yrs age group were non-anemic as they had hemoglobin level ≥12 g/dL (48%, 58%, 43% & 60%, respectively). 28 & 17% girls from age groups 10-12 & 13-15 yrs and 37% & 27% boys from age groups 10-12 & 13-15 yrs were classified as 'mildly anemic' with their hemoglobin level ranged between 11.0-11.9 g/dL. It was found that 24% girls aged 10-12 yrs, 25% girls aged 13-15 yrs, 20% boys aged 10-12 yrs & 13% boys aged 13-15 yrs, respectively fell in the category of 'moderately anemic' with their hemoglobin level ranged from 8.0 to 10.9 g/dL.

Cerretelli, P. (1992) demonstrated that lower levels of hemoglobin are able to influence oxygen delivery to skeletal muscle and consequently negatively impact muscular strength. Nande, P. et al. (2009) studied 13 females and 46 males players (aged 19-22 yrs) engaged in different sports disciplines and found that minimum hemoglobin values showed prevalence of anemia among groups of players such as female athletics & badminton players & male badminton, cricket, judo, gymnastics & weight lifting players (values were found to be less than 10 g/dL). The result of diet survey conducted by Asha, L. et al. (2009) on 32 basketball players of Dharwad city (Karnataka, India) signified that the mean haemoglobin level of the sample was 13.88 g/100 ml.

Prevalence of anemia in players which if not treated can affect performance of the players. None of the basketballers were found to have severe anemia as also clear from Figure 5.

Sangeetha, K. M. et al. (2014) assessed nutritional status of 100 sports persons (20-35 yrs) from Tamilnadu, which also included 9% basketballers & found that the hemoglobin levels showed that about 60% of selected sports persons were anemic and 40 percent had the normal level of hemoglobin. Brown, B. S. et al. (1974) assessed maximal aerobic capacity, hematological determinations as well as selected anthropometric and strength measures among the entire University of Arkansas basketball team during pre-season & blood measures showed a significant drop in hemoglobin (-0.41 g %). Ostojic, S. M. et al. (2006) studied the differences in physical and physiological characteristics in different positional roles among 60 elite Serbian basketball and reported that value for hemoglobin was not significantly different among basketballers as per positions. Roy, M. et al. (2018) assessed and compared adequacy intake of nutrients between an equal number of males (18.2±2.3 years) and females (17.1±2.2 years) in a total of 40 Indian junior national hockey players from Kolkata and results indicated significant differences in haemoglobin level of both the sexes.

For this study, among girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, hemoglobin level correlated positively with pyridoxine intake ($r=0.2165$, 0.0004, 0.0606 & 0.0019, respectively, $p>0.05$).

Vitamin C helps the body to absorb the iron at a better rate. Vitamin C also plays an important role in synthesizing red blood cells whereasfolic acid has a role in treating anemia. With the exception of older boys, among girls aged 10-12 yrs, girls aged 13-15 yrs & boys aged 10-12 yrs, hemoglobin level showed positive correlations with vitamin C intake (r=0.0411, 0.1050 & 0.0030, respectively, p>0.05) & folic acid intake (r=0.0526, 0.1725 & 0.0361, respectively, p>0.05). Older boys depicted negative correlation of hemoglobin level with intakes of folic acid & vitamin C (r= -0.0812 & -0.0458, respectively, p>0.05).

CONCLUSION:

This study investigated the correlation between the consumption of vitamins and the physiological markers of hemoglobin levels, blood pressure, pulse rate, and respiratory rate in adolescent basketball players. The findings underscore the crucial role that adequate intake of essential micronutrients plays in maintaining and enhancing the health and performance of young athletes. Adequate intake of pyridoxine and folic acid was significantly associated with optimal hemoglobin levels, crucial for efficient oxygen transport and aerobic capacity. This supports enhanced endurance and overall athletic performance. The study observed that appropriate consumption of vitamins was linked to healthier blood pressure levels, pulse rate and respiratory rate. Vitamins such as thiamine, riboflavin and niacin were found to correlate positively with a stable pulse rate. These vitamins are vital for energy production and cardiovascular efficiency, contributing to improved endurance and quicker recovery times. Adequate level of vitamins was associated with optimal respiratory function. These nutrients support respiratory muscle function and overall lung capacity, crucial for sustaining high-intensity exercise. The results of this study highlight the importance of a balanced diet rich in essential vitamins for adolescent basketball players. Further research should explore the long-term effects of micronutrient supplementation on athletic performance and recovery in adolescent athletes. Additionally, investigating the role of other lesser-known micronutrients could provide a more comprehensive understanding of the nutritional needs of young athletes. In conclusion, this study underscores the pivotal role of vitamins in supporting the physiological functions essential for athletic performance. Ensuring adequate intake of these nutrients can significantly enhance the health, endurance, and overall performance of adolescent basketball players, paving the way for both immediate and long-term athletic success.

REFERENCES:

- Abdelkrim, N. B. Chaouachi, A. Chamari, K. Chtara, M. and Castagna, C. Positional Role and Competitive-Level Differences in Elite-Level Men's Basketball Players. Journal of Strength and Conditioning Research, 2010, 24(5): 1346-1355; Citation from: http://www.ncbi.nlm.nih.gov/pubmed/20393355; Retrieved on: 14th February, 2019.
- Abdelkrim, N. B. Fazaa, S. E. and Ati, J. E. Time-Motion Analysis and Physiological Data of Elite Under-19-Year-Old Basketball Players during Competition. British Journal of Sports Medicine, 2007, 41(2): 69-75; Citation from: https://www.researchgate.net/publication/6659570_Time-motion_analysis_ and_physiological_data_of_elite_under-19-year-old_basketball_players_ during_ competition_Br_J_Sports_Med; Retrieved on:16thJune, 2016.
- Achten, J., & Jeukendrup, A. E. Heart rate monitoring: applications and limitations. Sports Medicine, 2003, 33(7), 517-538.
- Afman, G. Garside, R.M. Dinan, N. Gant, N. Betts, J.A. and Williams, C.Effect of Carbohydrate or Sodium Bicarbonate Ingestion on Performance During a Validated Basketball Simulation Test. International Journal of Sport Nutrition and Exercise Metabolism, 2014, 24(6): 632-644; Citation from: https://journals.human kinetics.com/doi/abs/10.1123/ijsnem.2013-0168; Retrieved on: 28th September 2018.
- Agafonkina, T. V. and Tikhonov, V. F. Investigation of the Breathing Pattern Structure in Competitive Exercises of Kettlebell Lifters. Human Physiology, 2014, 40(3): 319-322; Citation from: https://www.researchgate.net/publication/271663679_Investigation_of_ the_structure_breathing_pattern_in_competitive_exercises_have_athletes_kettlebell_Lifters; Retrieved on: 4th February, 2019.
- Asha, L. Kasturiba, B. Naik, R. K. and Malagi, U. Nutritional Status of Basketball Players of Dharwad City. Karnataka, The Journal of Agricultural Science, 2009, 22(1): 161-165; Citation from: https://www.cabdirect.org/cabdirect/abstract/2009 3147195; Retrieved on: 16th January, 2019.
- Atan, T. Akyol, P. and Cebi, M. Comparison of Respiratory Functions of Athletes Engaged in Different Sports Branches. Turkish Journal of Sport and Exercise, 2012, 14(3): 76-81; Citation from: http://dergipark.gov.tr/download/article-file/200755; Retrieved on: 4th February, 2019.

- Bassett, D. R., & Howley, E. T. Limiting factors for maximum oxygen uptake and determinants of endurance performance. Medicine and Science in Sports and Exercise, 2000, 32(1), 70-84.
- Beard, J. L. Iron Biology in Immune Function, Muscle Metabolism and Neuronal Functioning. Journal of Nutrition, 2001, 131(2S-2), 568S-580S.
- Bender, D. A. (2003). Niacin (Vitamin B3). In Nutritional Biochemistry of the Vitamins (pp. 191-220). Cambridge University Press.
- Bender, D. A. (2003). Riboflavin. In Nutritional Biochemistry of the Vitamins (pp. 107-134). Cambridge University Press.
- Boisseau, N. Creff, C. Le. Loyens, M. and Poortmans, J. R. Protein Intake and Nitrogen Balance in Male Non-Active Adolescents and Soccer Players. European Journal of Applied Physiology, 2002, 88(3): 288-293; Citation from: https://link.springer.com/article /10.1007/s00421-002-0726-x; Retrieved on: 16th January, 2019.
- Brooks, G. A., Fahey, T. D., & Baldwin, K. M. (2005). Exercise Physiology: Human Bioenergetics and Its Applications. McGraw-Hill.
- Brown, B. S. Moore, G. C. Kim, C. K. & Phelps, R. E. Physiological and Hematological Changes among Basketball Players during Preseason, Research Quarterly. American Alliance for Health, Physical Education and Recreation, 1974, 45(3): 257-262; Citation from:https://shapeamerica.tandfonline.com/doi/abs/10.1080/10671315.1974.10615270#.XFWwSFUzbIV; Retrieved on: 2nd February, 2019.
- Carr, A. C., & Maggini, S. Vitamin C and Immune Function. Nutrients, 2017, 9(11), 1211.
- Casa, D. J., Armstrong, L. E., Hillman, S. K., Montain, S. J., Reiff, R. V., Rich, B. S., ... & Stone, J. A. National athletic Trainers' Association Position Statement: Fluid Replacement for Athletes. Journal of Athletic Training, 2000, 35(2), 212-224.
- Cerretelli, P. Muscle Energetics and Ultrastructure in Chronic Hypoxia. Respiration, 1992, 59(2): 24-29; Citation from: https://academic.oup.com/biomedgerontology/article/59/3/ M249/579710; Retrieved on: 5th February, 2019.
- Combs, G. F. (2012). The Vitamins: Fundamental Aspects in Nutrition and Health. Academic Press.
- Cornelissen, V. A., & Fagard, R. H. Effects of Endurance Training on Blood Pressure, Blood Pressure-Regulating Mechanisms, and Cardiovascular Risk Factors. Hypertension, 2005, 46(4), 667-675.
- Crider, K. S., Bailey, L. B., & Berry, R. J. Folic Acid Food Fortification—its History, Effect, Concerns, and Future Directions. Nutrients, 2018, 10(10), 1532.
- Dakshinamurti, K. (2001). Vitamins and Their Derivatives in the Central Nervous System. Handbook of Neurochemistry and Molecular Neurobiology: Neural Metabolism and Neurotransmission, 365-390.
- Daneshvar, P. Hariri, M. Ghiasvand, R. Askari, G. Darvishi, L. and Iraj, B. Dietary Behaviors and Nutritional Assessment of Young Male Isfahani Wrestlers. International Journal of Preventive Medicine, 2013, 4(1):S48; Citation from: https://www.ncbi.nlm. nih.gov/pmc/articles/PMC3665025/; Retrieved on: 17th January, 2019.
- Driskell, J. Summary: Vitamins and Trace Elements in Sports Nutrition. In: Driskell, J. and Wolinsky, I. editors. Sports Nutrition. Vitamins and Trace Elements. New York (NY): CRC/Taylor & Francis, 2006:323-331; Citation from: https://www.medscape.com /viewarticle/717046_8; Retrieved on: 19th January, 2019.
- Evans, P., & Halliwell, B. Micronutrients: Oxidant/Antioxidant Status. British Journal of Nutrition, 2001, 85(S2), S67-S74.
- Ganji, S. H., Kamanna, V. S., &Kashyap, M. L. Niacin and Cholesterol: Role in Cardiovascular Disease (Review). Current Atherosclerosis Reports, 2003, 5(2), 148-153.
- Ganz, T., & Nemeth, E. Iron Homeostasis in Host Defense and Inflammation. Nature Reviews Immunology, 2012, 12(8), 608-617.
- Ghandour, R. A., Colson, N. J., Brown, L. E., & Ward, A. C. Folic acid, an Additional Player in Maintaining Hematopoietic Stem and Progenitor Cell Functionality. Cellular and Molecular Life Sciences, 2018, 75(20), 3773-3782.
- Gibson, G. E., Hirsch, J. A., Cirio, R. T., & Jordan, B. D. Abnormal Thiamine-Dependent Processes in Alzheimer's Disease. Lessons from Diabetes. Molecular and Cellular Neuroscience, 2013, 55, 17-25.

- Gibson, R. S., Bailey, K. B., & Gibbs, M. Folate Status of Young Canadian Women after Folic Acid Fortification of Grain Products. Journal of the American College of Nutrition, 2006, 25(1), 3-9.
- Gledhill, N., Cox, D., & Jamnik, R. Endurance Athletes' Stroke Volume does not Plateau: Major Advantage is Diastolic Function. Medicine and Science in Sports and Exercise, 1994, 26(9), 1116-1121.
- Gopalan, C. Ramasastri, B. V. and Balsubramanian, S. C. (2012) Nutritive Value of Indian Foods. NIN Publication, ICMR, Hyderabad, 47-80.
- Gropper, S. S., Smith, J. L., & Carr, T. P. (2017). Advanced Nutrition and Human Metabolism. Cengage Learning.
- Guyton, A. C., & Hall, J. E. (2006). Textbook of Medical Physiology. Elsevier Saunders.
- Haas, J. D., & Brownlie, T. Iron Deficiency and Reduced Work Capacity: a Critical Review of the Research to Determine a Causal Relationship. Journal of Nutrition, 2001, 131(2S-2), 676S-688S.
- Higdon, J. (2000). An evidence-based approach to vitamins and minerals: health benefits and intake recommendations. Thieme Medical Publishers.
- Hughes, T. A., Everhart, J. E., & Hubbard, V. S. Niacin and Liver Toxicity. Annals of Internal Medicine, 1996, 125(1), 77.
- Hurrell, R., & Egli, I. Iron Bioavailability and Dietary Reference Values. American Journal of Clinical Nutrition, 2010, 91(5), 1461S-1467S.
- Jain, R. Puri, S. and Saini, N. Dietary Profile of Sportswomen Participating in Team Games at State/ National level. Indian Journal of Public Health, 2008, 52(3):153-155; Citation from: https://www.researchgate.net/profile/Anand_Krishnan4/publication/2397 4117_Homelessness_a_hidden_public_health_problem/links/09e415094898bcbaaf000000.pdf#page=41; Retrieved on: 16th January, 2019.
- Kannel, W. B. Blood Pressure as a Cardiovascular Risk Factor: Prevention and Treatment. JAMA, 1996, 275(20), 1571-1576.
- Karabudak, E. Koksal, E. Ertas, Y. and Kucukerdonmez, O. Dietary Intake of Turkish Gymnast and Non-Gymnast Children. Nutrition & Dietetics, 2016, 73: 184-189; Citation from:https://onlinelibrary.wiley.com/doi/abs/10.1111/1747-0080.12191; Retrieved on: 15th January, 2019.
- Keith, R. E. Vitamins in Sport and Exercise. In: Hickson, J. F. and Wolinsky, I. eds. Nutrition in Exercise and Sport, 2ndEdition. Boca Raton, FL: CRC Press, 1989:15; Citation from: https://www.ncbi.nlm.nih.gov/pubmed/15212745; Retrieved on: 20th January, 2019.
- Klusemann, M. J. Pyne, D. B. Foster, C. and Drinkwater, E. J. Optimising Technical Skills and Physical Loading in Small-Sided Basketball Games. Journal of Sports Sciences, 2012, 30(14):1463-1471; Citation from: http://www.tandfonline.com/doi/full/10.1080/02640 414.2012.712714; Retrieved on: 1st February, 2019.
- Krinsky, N. I., & Johnson, E. J. (2005). Carotenoid Actions and Their Relation to Health and Disease. Molecular Aspects of Medicine, 2005, 26(6), 459-516.
- Leklem, J. E. Vitamin B6: a status report. Journal of Nutrition, 1990, 120 (suppl_11), 1503-1507.
- Lin, S. J., & Guarente, L. Nicotinamide Adenine Dinucleotide, a Metabolic Regulator of Transcription, Longevity and Disease. Current Opinion in Cell Biology, 2003, 15(2), 241-246.
- Longvah, T. Ananathan, R. Bhaskarachary, K. & Venkaiah, K. (2017). Indian Food Composition Tables. National Institute of Nutrition (Indian Council of Medical Research), Department of Health Research, Ministry of Health & Family Welfare, Government of India, Hyderabad, Telangana State, India, 1-578.
- Martin, P. R., Singleton, C. K., & Hiller-Sturmhöfel, S. The Role of Thiamine Deficiency in Alcoholic Brain Disease. Alcohol Research & Health, 2003, 27(2), 134-142.
- May, J. M. Vitamin C Transport and Its Role in the Central Nervous System. Sub-Cellular Biochemistry, 2012, 56, 85-103.
- McCormick, D. B. Two Interconnected B Vitamins: Riboflavin and Pyridoxine. Physiological Reviews, 1989, 69(4), 1170-1198.
- Meydani, S. N., Ribaya-Mercado, J. D., Russell, R. M., &Sahyoun, N. Vitamin B-6 Deficiency Impairs Interleukin 2 Production and Lymphocyte Proliferation in Elderly Adults. American Journal of Clinical Nutrition, 1991, 53(5), 1275-1280.

- Nande, P. Mudafale, V. and Vali, S. Micronutrient Status of Male and Female Players Engaged in Different Sports Disciplines. Journal of Exercise Science and Physiotherapy, 2009, 5(1): 1-13; Citation from: https://search.informit.com.au/documentSummary;dn =857592318298859;res=IELHEA; Retrieved on: 19th January, 2019.
- National Institute of Nutrition (NIN)/Indian Council of Medical Research (ICMR). Nutrient Requirements & Recommended Dietary Allowances for Indians. A Report of the Expert Group of the Indian Council of Medical Research (ICMR), National Institute of Nutrition (NIN), Hyderabad, 2009.
- Nicolò, A., Bazzucchi, I., Haxhi, J., Felici, F., & Sacchetti, M. Comparing Continuous and Intermittent Exercise: An "Isoeffort" And "Isotime" Approach. PLOS ONE,2014, 9(4), e94990.
- Olson, J. A. Carotenoids and Human Health. Archives of Latinoamerican Nutrition, 1999, 49(3 Suppl 1), 7S-11S.
- Ostojic, S. M. Mazic, S. and Dikic, N. Profiling in Basketball: Physical and Physiological Characteristics of Elite Players. Journal of Strength and Conditioning Research, 2006, 20(4):740-744; Citation from: https://www.researchgate.net/publication/6649391_ Profiling_in_Basketball_Physical_and_Physiological_Characteristics_of_Elite_Players;Retrieved on: 1st February, 2019.
- Papadopoulou, S. D. Papadopoulou, S.K. Vamvakoudis, E. and Tsitskaris, G. Comparison of Nutritional Intake between Volleyball and Basketball Women Athletes of the Olympic National Teams. Gazzetta Medica Italiana Archivio per le Scienze Mediche, 2008, 167(4):147-52; Citation from: https://www.researchgate.net/profile/Sophia_Papadopoulou 2/publication/235253597_Comparison_of_Nutritional_Intake_between_Volleyball_and_Basketball_Women _Athletes_of_the_Olympic_National_Teams/links/0fcfd510a88a59a17e000000/Comparison-of-Nutritional-Intake-between-Volleyball-and-Basketball-Women-Athletes-of-the-Olympic-National-Teams.pdf; Retrieved on: 27th September, 2018.
- Papadopoulou, S. K. Papadopoulou, S. D. & Gallos, G. K. Macro- and Micro-nutrient Intake of Adolescent Greek Female Volleyball Players. Human Kinetics Journals, 2002, 12(1): 73-80; Citation from: https://journals.humankinetics.com/doi/abs/10.1123/ijsnem. 12.1.73; Retrieved on 16th January, 2019.
- Paul, M. Garg, K. and Sandhu, J.S. Role of Biofeedback in Optimizing Psychomotor Performance in Sports, Asian Journal of Sports Medicine, 2012, 3(1): 29-40; Citation from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3307964/ ; Retrieved on: 25th September,2108.
- Pepe, S., Marasco, S. F., Haas, S. J., Sheeran, F. L., Krum, H., & Rosenfeldt, F. L. Coenzyme Q10 in Cardiovascular Disease. Mitochondrion, 2009, 7, S154-S167.
- Petrie, H. J., Stover, E. A., & Horswill, C. A. (2004). Nutritional Concerns for the Child and Adolescent Competitor. Nutrition, 2004, 20(7-8), 620-631.
- Powers, H. J. Riboflavin (Vitamin B-2) and Health. American Journal of Clinical Nutrition, 2003, 77(6), 1352-1360.
- Powers, S. K., & Jackson, M. J. Exercise-Induced Oxidative Stress: Cellular Mechanisms and Impact On Muscle Force Production. Physiological Reviews, 2008, 88(4), 1243-1276.
- Powers, S. K., & Howley, E. T. (2012). Exercise Physiology: Theory and Application to Fitness and Performance. McGraw-Hill Education.
- Prajakta, N. Bhawnani, N. and Sabiha. V. Assessment of Nutritional Status and Physical Fitness of Female Swimmers. Journal of Exercise Science and Physiotherapy, 2010, 6(1): 7-21; Citation from: http://medind.nic.in/jau/t10/i1/jaut10i1p7.pdf; Retrieved on: 16th January, 2019.
- Pullar, J. M., Carr, A. C., & Vissers, M. C. The Roles of Vitamin C in Skin Health. Nutrients, 2017, 9(8), 866.
- Rodriguez, N. R., DiMarco, N. M., Langley, S., & American Dietetic Association. Position of the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and athletic performance. Journal of the American Dietetic Association, 2009, 109(3), 509-527.
- Rosenbloom, C. A., Jonnalagadda, S. S., & Skinner, R. Nutrition Knowledge of Collegiate Athletes in a Division I National Collegiate Athletic Association Institution. Journal of the American Dietetic Association, 2002, 102(3), 418-420.

- Roy, M. Chatterjee, S. Swapan, K. & Dey. Comparison of Dietary Intake, Energy Adequacy and Anthropometric Parameters between Indian Junior Male and Female Hockey Players. Malaysian Journal of Nutrition, 2018, 24: 241-250; Citation from:https://www.researchgate.net/publication/327551930_Comparison_of_dietary_intake_energy_adequacy_and_anthropometric_parameters_between_Indian_junior_male_and_female_hockey_players; Retrieved on: 18th January, 2019.
- Sangeetha, K. M. Ramaswamy, L. and Jisna, P. K. Assessment of Nutritional status, Nutritional knowledge & Impact of Nutrition Education among Selected Sports Persons of Coimbatore District. International Journal of Science and Research, 2014, 3(11): 970-978; Citation from: https://www.ijsr.net/archive/v3i11/T0NUMTQ5NjI=.pdf; Retrieved on: 30th January, 2019.
- Savas, S. Senel, O. Okan, I. & Celikkan, H.The Change of Blood Pb Levels of basketball Players after Strenuous Exercise, Neuroendocrinology Letters, 2007, 28(2):187-190; Citation from: https://www.researchgate.net/profile/Hueseyin_Celikkan/publication/639 2189_The_change_of_blood_Pb_levels_of_basketball_players_after_strenuous_exercise/links/5a4ff760458 515e7b72a80b7/The-change-of-blood-Pb-levels-of-basketball-players-after-strenuous-exercise.pdf; Retrieved on: 4th February, 2019.
- Sawka, M. N., Burke, L. M., Eichner, E. R., Maughan, R. J., Montain, S. J., & Stachenfeld, N. S. (2007). American College of Sports Medicine Position Stand. Exercise and Fluid Replacement. Medicine and Science in Sports and Exercise, 2007, 39(2), 377-390.
- Sies, H., & Stahl, W. Carotenoids and UV Protection. Photochemical & Photobiological Sciences, 2004, 3(8), 749-752.
- Smith, P. J., & Blumenthal, J. A. Dietary Factors and Cognitive Decline. JAMA, 2010, 303(18), 1832-1833.
- Vamvakoudis, E. Vrabas, I. S. Galazoulas, C. Stefanidis, P. Metaxas, T. I. and Mandroukas, K. Effects of Basketball Training on Maximal Oxygen Uptake, Muscle Strength, and Joint Mobility in Young Basketball Players. Journal of Strength and Conditioning Research, 2007, 21(3):930-936; Citation from: https://www.researchgate.net/publication/6153235_Effects_of_Basketball_Training_on_Maximal_Oxygen_Uptake_Muscle_Strength_and_Joint_Mobility_in_Young_Basketball_Players; Retrieved on:24th February, 2016.
- Vrzhesinskaia, O.A. Pereverzeva, O.G. Beketova, N.A. Isaeva, V.A. Kharitonchik, L.A. Kodentsova, V.M. Martinchik, A.N. and Baturin, A.K. Vitamin Sufficiency of Young Basketball Players. Voprosy Pitaniia, 2004, 73(2):22-24; Citation from: https://www.ncbi.nlm.nih.gov/pubmed/15154367, Retrieved on: 26th January, 2019.
- WHO/UNICEF/UNU (2001).
- Ziegler, P. J., Nelson, J. A., & Jonnalagadda, S. S. Nutrition and metabolic foundations of strength and power sports. Medicine and Science in Sports and Exercise, 2003, 35(10), 1868-1873.

Kostopoulos, N. Apostolidis, N. Mexis, D. Mikellidi, A. and Nomikos, T. Dietary Intake and the Markers of Muscle Damage in Elite Basketball Players after a Basketball Match. Journal of Physical Education and Sport, 2017, 17(1): 394-401; Citation from: http://efsupit.ro/images/stories/1%20March%202017/Art%2 058.pdf; Retrieved on: 28th September, 2018