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DIETARY IRON INTAKE, HEMOGLOBIN LEVEL AND RELATED HEALTH PARAMETERS: DIFFERENCES AMONG NORMAL WEIGHT, OVERWEIGHT AND OBESE SCHOOL GOING GIRLS (10-12 YEARS)

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ABSTRACT The aim of the study was to see the differences in health status of normal weight, overweight and obese school going girls between the age of 10 yrs, 11 yrs and 12 yrs for dietary iron intake and hemoglobin level. In total 450 girls [50 each from normal weight (NW), overweight (OW) and obese (O) for every age group] were studied. Anthropometric measurements included standing height and body weight. Blood samples were tested for hemoglobin level. Respiratory rate was measured and VO_2max was derived by conducting 12 minute's Cooper's run-walk test. Result revealed that there is low dietary iron intake among overweight & obese girls in comparison with normal weight girls. Values of mean blood hemoglobin level for overweight & obese girls in comparison with normal weight girls were found to be low. Overweight girls were rated "fair" and obese girls were found to be "poor" for their mean VO_2max and they showed higher mean values of respiratory rate.

KEYWORDS : iron deficiency, obesity, hemoglobin, VO_2max

INTRODUCTION:

Obesity is now undoubtedly a growing worldwide health problem. According to the statistical data from 2003, about 30% of the adults and 15% of the children (2-19 years old) globally were classified as obese (Anderson, P. M. and Butcher, K. E., 2006). Childhood obesity is not only epidemic in developed countries, such as Western European countries, Australia and USA, but also in developing countries (Silventoinen, K. et al., 2006). In the USA, an astonishing 1/3rd of children and adolescents (about 23 million) are overweight or obese. Even in China, the obesity rate in children is increasing dramatically during the last decade (Ogden, C. L. et al., 2010). The possibility for a child being obesity to become an obese adult is as high as 80% (Abraham, S. et al., 1971). And the more obese in childhood the more likely will obesity persist into adulthood (Donnelly, J. E. et al., 1996). As per meta-analysis done by Gedam, D. S. (2013) on different cross-sectional studies performed in various parts of India among school children, the prevalence of overweight to range between 2.3% and 25.1% and that of obesity to range from 0.3% to 11.3%. The prevalence of overweight is 8% in rural Haryana. The prevalence of overweight and obesity is higher in upper socioeconomic class (17.2% overweight and 4.8% obese) as compared to lower socioeconomic class (4% and <1%, respectively). Various studies over the last decades in India have shown that there is an increase in prevalence of overweight and obesity. In a meta-analysis of nine studies in which 92,862 subjects were identified and analysed, the prevalence of overweight was estimated to be 12.64% (95% CI 8.48-16.80%) and that of obesity to be 3.39% (95% CI 2.58-4.21%).

Childhood obesity is associated with comorbidities, which affect body negatively. Recent studies suggest that micronutrient deficiencies may contribute to fat deposition and chronic inflammation (Garcia, O. P. et al., 2009). A higher risk of low concentrations of iron has been observed in obese children and adolescents compared to children and adolescents with normal weight (Aeberli, I. et al., 2009). Cross-sectional studies in industrialized countries have consistently shown that obese individuals are at increased risk of iron deficiency (Cepeda-Lopez, A. C. et al., 2006). Ausk, K. J. and Ioannou, G. N. (2008) showed that increasing BMI is associated with higher serum ferritin levels and lower serum levels of iron and transferrin saturation. Another study conducted among 740 school children in Iran showed that prevalence of iron deficiency increased with the subject's body mass index (Moayeri, H. et al., 2006). Bougle, D. and Brouard, J. (2013) stated that alterations of iron metabolism can occur in overweight and obese children and adults. They further included that obesity is a low-grade inflammatory disease which may increase iron tissue storage at the expense of circulating blood iron, potentially leading to tissue overload and decreased of iron available for haematopoiesis.

Iron deficiency in children can be a result of insufficient dietary iron intake, decreased iron absorption or obesity induced inflammatory response which may affect physical performance at the end. Therefore, the present study focuses on observing the differences in iron status as well as relative parameters of iron including hemoglobin level, respiratory rate and VO_2 max of normal weight, overweight and obese school going girls between the ages of 10 to 12 yrs.

METHODOLOGY:

The present research was conducted to see the differences in health status of normal weight, overweight and obese school going girls between the age of 10 yrs, 11 yrs and 12 yrs as far as dietary iron, hemoglobin level and related health parameters are concerned. The study was conducted in Mumbai, Nashik, Pune and Nagpur cities in Maharashtra, India. From randomly selected schools, normal weight (i.e. healthy weight), overweight and obese girls were purposively selected (n=450). The subjects were grouped as a control and experimental as shown in Table 1.

Table 1: Age wise classification of the subjects

Sr. No.	Age (Years)	Girls (n = 450)		
		Control	Experimental	
		Normal Weight (NW)	Overweight (OW)	Obese (O)
1	10	50	50	50
2	11	50	50	50
3	12	50	50	50
Total		150	150	150

From height & weight, body mass index (body mass index) of subjects was derived [Weight (kg) ÷ Height (m^2)]. Worldwide, BMI is used as a screening tool to identify possible weight problems for children. WHO (World Health Organization) and CDC (Centres for Disease Control and Prevention) recommend the use of BMI to screen for overweight and obesity among children (http://www.who.int/childgrowth/standards/bmi_for_age/en/, WHO, 2012 and http://www.cdc.gov/healthyweight/assessing/bmi/). Following BMI percentile criteria given by CDC has been used to select the control and experimental groups

Table 2: BMI Percentile Criteria

Sr. No.	Weight Status Category	Percentile Range
1	Normal Category i.e. Healthy Weight	5th to less than 85th percentile
2	Overweight Category	85th to less than 95th percentile
3	Obese Category	Equal to or greater than 95th percentile

It has also been suggested that reduced iron intake due to poor dietary choices by overweight individuals may contribute to poor iron status (Seltzer, C. C. et al., 1963, Yanoff, L. B. et al., 2007, Zimmermann, M. B. et al., 2008), but there is little data to support this, hence to evaluate iron intake, subjects were interviewed to gather information regarding diet and food consumed usually. For this, 24 hour's dietary recall method was used and iron content of diets consumed by subjects was calculated using standard food composition tables (Gopalan et al., 2012). Adequacy of iron intake of subjects was done by comparing the intake values with recommended dietary allowances (RDAs) (NIN/ICMR. 2009).

To correlate dietary iron consumption with hemoglobin levels, it is necessary to test blood hemoglobin levels. To collect blood samples for blood hemoglobin testing, consents were taken from the head of participating schools as well as from the parents or guardians of the children who were part of this survey. Blood samples were collected with the help of pathologist, hemoglobin level of each participant was determined in the laboratory and reports were collected. Hemoglobin cut-off 11.5g/dL as recommended by WHO was used for assessment of anemia for children aged 10 and11 yrs and 12.0 g/dL for children 12 yrs. Children with hemoglobin below the age specific cut-off were interpreted as anaemic.

Respiratory rate is the number of breaths per minute and indicates the body's need for oxygen. Hemoglobin level affects respiratory rate and ultimately VO_2 max. Respiratory rate of all the subjects were measured by counting the number of breaths subject took in one-minute period at rest.

Cooper's 12 minutes run-walk test which is used as an indicator of cardiorespiratory fitness was conducted. The subjects were asked to run as much as they can for 12 minutes; the distance covered was noted in meters. VO_2max i.e. maximal consumption of oxygen which is an indicator of aerobic work capacity was derived using below formula: VO_2max = (Distance covered in meters - 504.9) ÷ 44.73 (Nande, P. J. & Vali, S. A., 2010).

RESULTS AND DISCUSSION:

Anthropometric data regarding height and weight of subjects is displayed in Table 3. Anthropometric measurements, were compared between Normal weight (n = 50), Overweight (n = 50) and Obese (n = 50) female children. The mean values of standing height of normal weight girls of all age groups (10y, 11y and 12y) were higher compared with the mean values of overweight and obese girls. Despite this, the mean values of body weight and BMI were lower in normal weight girls as compared to overweight and obese girls.

Table 3: Data on anthropometric measurements of subjects

Sr. No.	Parameters	10 Years			11 Years			12 Years		
		NW	OW	O	NW	OW	O	NW	OW	O
1.	**Height (cm)**									
i	Mean±SD	140.54±6.52	137.40±6.35	135.56±8.14	144.66±9.01	143.75±6.82	142.25±7.21	149.5±7.16	144.84±5.61	143.69±8.06
ii	Range	124.0 -153.0	124.5 - 152.0	119.4- 157.0	125.5 - 164.0	127.8 - 157.0	124.5 - 154.5	134.7 - 166.1	132.2 - 155.0	124.2 - 157.0
2.	**Body Weight (kg)**									
i	Mean±SD	34.26±4.99	39.44±3.47	45.36±5.21	36.11±6.09	43.73±4.87	47.81±5.18	37.88±5.77	47.04±4.09	55.38±6.31
ii	Range	25.5 - 44.2	32.5 - 50.1	33.2 - 57.3	26.9 - 52.3	34.0-53.5	37.7- 59.5	29.0 - 52.7	40.0 - 57.2	44.5 - 73.4
3.	**BMI (kg/m^2)**									
i	Mean±SD	17.29±1.83	20.90±0.77	24.70±2.18	17.05±1.73	21.10±1.01	23.62± 1.88	16.97±1.85	22.40±0.97	26.81±1.95
ii	Range	14.59 - 23.13	19.41 - 22.39	21.8 - 32.77	14.39 - 20.67	20.15 - 24.69	21.13 - 29.42	14.56 - 21.22	19.56 - 24.76	22.9 - 31.89

Data on dietary iron intake and blood hemoglobin level is presented in Table 4.

Table 4: Data on daily dietary iron intake and blood hemoglobin level of subjects

Sr. No.	Parameters	10 Years			11 Years			12 Years		
		NW	OW	O	NW	OW	O	NW	OW	O
1.	**Iron (mg)**									
i	Mean±SD	44±11	35±8	41±17	52±11	35±8	41±16	48±10	38±9	40±16
ii	Range	23-68	18-55	17-82	29-73	21-56	20-87	32-73	21-55	23-82
iii	RDA	27	27	27	27	27	27	27	27	27
iv	%Excess	+63.0	+29.6	+51.9	+92.6	+29.6	+51.9	+77.8	+40.7	+48.1
2.	**Blood Hemoglobin (g/dL)**									
i	Mean±SD	12.2±0.87	11.4±0.69	10.6±0.96	12.3±0.87	11.5±0.94	10.5±1.25	12.2±0.82	10.9±0.81	10.8±0.97
ii	Range	10.0-14.2	9.8-12.9	8.0-12.6	10.0-14.2	9.5-14.0	7.0-13.1	10.6-14.3	9.50-13.0	8.9-13.0
iii	Reference Standard	11.5	11.5	11.5	11.5	11.5	11.5	12.0	12.0	12.0
iv	%Deficit	+6.1	-0.9	-7.8	+7.0	0	-8.7	+1.7	-9.2	-10.0

Table 4 revealed that though the dietary iron intake was found to higher than RDAs among normal weight, overweight and obese girls of all the age groups (the mean values ranging 44-52 mg, 35-38 mg, & 40-41 mg, respectively), the blood hemoglobin levels were found to be lower than reference cut off values among overweight and obese girls, ranging from 10.6 g/dL to 11.5 g/dL. There found significant decline in the mean daily intake of iron with increase in body weight (z=7.00 to 22.31, $p<0.01$). However, the maximum iron intake values were noted among obese subjects which may be attributed to consumption of oral health supplements which fulfilled the intake. Deficiency of iron can lead to anemia.

Hemoglobin aids in availability of oxygen to the tissues, which further affects the cardiac output. Iron an important micronutrient, has an important role in oxygen transport and its use (Hagler, L. et al., 1981). It was noted that on the basis of mean hemoglobin level, overweight & obese girls were unable to meet the cut off levels (Table 4). Overall, 42% overweight & 26% obese girls were rated as "mildly anemic" and 33.33 & 61.33% overweight & obese girls were rated as "moderately anemic". Overall, 68% normal weight girls were found to be "normal" for their hemoglobin status whereas only 24.67 overweight & 12% obese girls were "normal" for their hemoglobin status. With increase in BMI there found decline in the mean values of hemoglobin. The lowest concentration of hemoglobin among obese girls was recorded as 7.0 g/dL.

One of the possible reasons may be because of low absorption of iron from gastrointestinal tract. Aigner, E. et al. (2014) mentioned in their study that obesity may promote iron deficiency by inhibition of dietary iron uptake from the duodenum and disturbed iron homeostasis. The results from the present study can be correlated with these results. In their study, Moayeri, H. et al. (2006) showed that iron deficiency was more prevalent among subjects with higher BMI values. The present study strongly supports their conclusion. Nead, K. G. et al. (2004) in their study confirmed that overweight children were twice as likely to be iron deficient as normal weight children. The present study supports their conclusion.

Hemoglobin, which is an essential component of the respiratory system for oxygen transport, any substantial reduction in red blood cells and hemoglobin during iron deficiency reflects a reduced capacity of oxygen transport to tissue (Yip R., 2000). As hemoglobin is essential for oxygen transport, low hemoglobin level leads to decreased oxygen transport therefore need for oxygen by the body increases. To supply increased need of oxygen body tries to inhale more oxygen may lead to increased respiratory rate.

Data on respiratory rate and VO_2max of the subjects is displayed in Table 5.

Table 5: Data on respiratory rate and VO_2max of the subjects

Sr. No.	Parameters	10 Years			11 Years			12 Years		
		NW	OW	O	NW	OW	O	NW	OW	O
1.	Respiratory Rate (breaths/minute)									
i	Mean±SD	22±1.83	24±2.42	25±2.82	24±3.34	26±2.62	27±3.54	22±2.55	25±2.79	26±3.23
ii	Range	18-25	19-31	18- 31	17-33	21-32	20-36	17-27	20-30	20-35
2.	Vo_2max (ml/kg/minute)									
i	Mean±SD	50.5±7.7	32.6±7.2	31.6±12.2	52.8±7.9	34.8±7.0	23.9±10.3	53.2±9.3	30.6±6.6	21.9±8.8
ii	Range	32.3-64.2	22.3-55.8	2.9-52.4	35.7-70.9	22.3-49.1	6.6-49.1	32.3-72.6	20.6-49.1	3.8-39.0

The present study revealed that with the decrease in hemoglobin level and increase in BMI, respiratory rate was increased, ranging between 24-27 breaths per minute among overweight and obese girls as compared to normal weight girls (22-24 breaths per minute). Decrease in hemoglobin as seen in anemia reduces the availability of oxygen to the tissues, which indicates more need for oxygen and thereby increase in respiratory rate, further affects the cardiac output. Also, increased body fat makes it difficult to fulfil the demands of lungs. Excess body fat may alter the pressure-volume characteristics of the thorax and restrict the descent of the diaphragm, thereby limiting lung expansion. This reduced ventilation at the lung bases can lead to the closure of peripheral lung units, ventilation to perfusion ratio abnormalities and arterial hypoxemia, especially in the supine position (Caro, C. G. et al., 1960). The expiratory reserve volume is also reduced and the work of breathing is increased (Naimark, A. and Cherniack, R. M., 1960).

Normal weight girls from all three age groups (10 yrs, 11 yrs & 12 yrs) were rated "superior" for their mean VO_2max whereas overweight girls from all three age groups (10 yrs, 11 yrs & 12 yrs) were rated "fair" for their mean VO_2max. Obese girls from age groups 11 yrs & 12 yrs were found to be "poor" for their mean VO_2max, hence, confirming the fact that greater the BMI, lower the hemoglobin level & higher the respiratory rate, lower is the aerobic work capacity. Decrease in hemoglobin levels reduces oxygen consumption leading to lower VO_2max. A decrease in maximal consumption of oxygen-an indicator of aerobic work capacity occurs in anaemic individual leads to reduction in oxygen-transport capacity of the blood by the body during heavy work (Wolgemuth, J. C. et al., 1982 and Willis, W. T. et al., 1987).

CONCLUSION:

Findings of the present study confirm that there is reduced dietary iron availability in overweight female children and that this is unlikely due to low dietary iron supply. The present study establishes the fact that in spite of a proper dietary iron intake by majority of female subjects of all the age groups, there is decrease in blood hemoglobin level, with the increase in BMI. There could be many factors such as decreased iron absorption due to increase in fat mass or obesity induced inflammatory responses, which need to be found out. The present study also established the correlation between decreased hemoglobin level, decreased VO_2max and increased respiratory rate, indicating that lower hemoglobin level affect overall aerobic work capacity of these school going overweight & obese female girls of 10 yrs, 11 yrs and 12 yrs. Therefore, proper weight management strategies should be adapted from the early age for better iron absorption and making dietary iron more available to the body.

REFERENCES:

i. Abraham, S. Collins, G. and Nordsieck, M. Relationship of childhood weight status to morbidity in adults. HSMHA Health Reports, 1971; 86: 273-284.
ii. Aeberli, I. Hurrell, R.F. and Zimmermann, M. B. Overweight children have higher circulating hepcidin concentrations and lower iron status but have dietary iron intakes and bioavailability comparable with normal weight children. International Journal of Obesity (London), 2009; 33: 1111–1117.
iii. Aigner, E. Feldman, A. and Datz, C. Obesity as an Emerging Risk Factor for Iron Deficiency. Nutrients, 2014; 6: 3587-3600.
iv. Anderson, P. M. and Butcher, K. E. Childhood obesity: trends and potential causes. Future Child, 2006; 16: 19-45.
v. Ausk, K. J. and Ioannou, G.N. Is obesity associated with anemia of chronic disease? A population-based study. Obesity, 2008; 16(10): 2356–2361.
vi. Bougle, D. and Brouard, J. Iron in Child Obesity - Relationships with Inflammation and Metabolic Risk Factors. Nutrients, 2013; 5: 2222-2230.
vii. Caro, C. G. Butler, J. and Dubois, A. B. Some effects of restriction of chest cage expansion on pulmonary function in man: an experimental study. Journal of Clinical Investigations, 1960; 39: 573–583.
viii. Cepeda-Lopez, A. C. Osendarp, S. J. M. Melse-Boonstra, A. Aeberli, I. Gonzalez-Salazar, F. Feskens, E. Villalpando, S. and Zimmermann, M. B. Sharply higher rates of iron deficiency in obese Mexican women and children are predicted by obesity-related inflammation rather than by differences in dietary iron intake. American Journal of Clinical Nutrition, 2011; 93: 975–983.
ix. Chen,S. B. Lee, Y. C. Ser, K.H. Chen, J. C. Chen, S. C. Hsieh, H. F. Lee, W. J. SerumC-reactive proteinand white blood cell count inmorbidly obese surgical patients. Obesity Surgery, 2009; 19(4): 461–466.
x. Donnelly, J. E. Jacobsen, D. J. Whatley, J. E. Hill, J. O. Swift, L. L. and Cherrington, A. Nutrition and physical activity program to attenuate obesity and promote physical and metabolic fitness in elementary school children. Obesity Research, 1996; 4: 229-243.
xi. Garcia, O. P. Long, K. Z. and Rosado, J. L. Impact of micronutrient deficiencies on obesity. Nutrition Review, 2009; 67: 559–572.
xii. Gedam, D. S. Childhood Obesity - challenges in the Indian Scenario. International Journal of Medical Research and Review, 2013; 1(1): 1–4.
xiii. Gopalan, C. Rama Shastri, B. V. and Balasubramanian, S. C. Nutritive value of Indian Foods. National Institute of Nutrition and Indian Council of Medical Research, 2012.
xiv. Hagler, L. Askew, E. W. Neville, J. R. Mellick, P. W. Coppes, R. I. Jr. and Lowder, J. F. Jr. Influence of dietary iron deficiency on hemoglobin, myoglobin, their respective reductases, and skeletal muscle mitochondrial respiration. American Journal of Clinical Nutrition, 1981; 34(10): 2169-2177.
xv. http://www.who.int/childgrowth/standards/bmi_for_age/en/
xvi. Moayeri, H. Bidad, K. Gholami, N. Anari, S. and Zadhoush, S. Increasing prevalence of iron deficiency in overweightand obese children and adolescents (Tehran AdolescentObesity Study). European Journal of Paediatrics, 2006; 165: 813–814.
xvii. Naimark, A. and Cherniack, R. M. Compliance of the respiratory system and its components in health and obesity. Journal of Applied Physiology, 1960; 15: 377–382.
xviii. Nande, P. J. and Vali, S. A., 2010. Fitness Evaluation Tests for Competitive Sports, 1st edition, Himalaya Publishing House, 23– 25.
xix. National Centre for Health Statistics in collaboration with the National Centre for Chronic Disease Prevention and Health Promotion (2000) Body mass index for age percentiles. (Retrieved on 23/10/2017) http://www.cdc.gov/growthcharts
xx. Nead, K. G. Halterman, J. S. Kaczorowski, J. M. Auinger, P. and Weitzman, M. Overweight children and adolescents: a risk group for iron deficiency. Paediatrics, 2004; 114(1): 104–108.
xxi. NIN/ICMR. Nutrient Requirements and Recommended Dietary Allowances for Indians, 2009.
xxii. O'Leary, F. Hayen, A. Lockie, F. and Peat, J. Defining normal ranges and centiles for heart andrespiratory rates in infants and children: a cross-sectionalstudy of patients attending an Australiantertiary hospital paediatric emergency department. Archives of Disease in Childhood, 2015; 100: 733–737.
xxiii. Ogden, C. L. Carroll, M. D. Curtin, L. R. Lamb, M. M. and Flegal, K. M. Prevalence of high body mass index in US children and adolescents, 2007-2008. Journal of American Medical Association, 2010; 303: 242-249.
xxiv. Seltzer, C. C. and Mayer, J. Serum iron and iron-binding capacity in adolescents: comparison of obese and non-obese subjects. American Journal of Clinical Nutrition, 1963; 13: 354–361.
xxv. Silventoinen, K. Sans, S. Tolonen, H. Monterde, D. Kuulasmaa, K. Kesteloot, H. Trends in obesity and energy supply in the WHO MONICA Project. International Journal of Obesity and Related Metabolic Disorders, 2004; 28: 710-718.
xxvi. The Physical Fitness Specialist Certification Manual, The Cooper Institute for Aerobics Research, Dallas TX, revised 1997 printed in Advance Fitness Assessment & Exercise Prescription, 3rd Edition, Vivian H. Heyward, 1998, page 48.
xxvii. Willis, W. T. Brooks, G. A. Henderson, S. A. andDallman, P. R. Effects of iron deficiency and training onmitochondnial enzymes in skeletal muscle. Journal ofAppliedPhysiology, 1987; 62: 2442-2446.
xxviii. Wolgemuth, J. C. Latham, M. C. Hall, A.Chesher, A. and Crompton, D. W. Worker productivity and the nutritionalstatus of Kenyan road construction labourers. American Journal of Clinical Nutrition, 1982; 36(1): 68-78.
xxix. Yanoff, L. B. Menzie, C. M. Denkinger, B. Sebring, N. G. McHugh, T. and Remaley, A. T. Inflammation and iron deficiency in the hypoferremia of obesity. International Journal of Obesity (London), 2007; 31: 1412–1419.
xxx. Zimmermann, M. B. Zeder, C. Muthayya, S. Winichagoon, P. Chaouki, N. and Aeberli, I. Adiposity in women and children from transition countries predicts decreased iron absorption, iron deficiency and a reduced response to iron fortification. International Journal of Obesity, 2008; 32: 1098–1104.
xxxi. Yip, R. Significance of an abnormally low or high hemoglobin concentration during pregnancy: special consideration of iron nutrition. American Journal of Clinical Nutrition, 2000; 72(1): 272s-279s.
xxxii. Caro, C. G. Butler, J. and Dubois, A. B. Some effects of restriction of chest cage expansion on pulmonary function in man: an experimental study. Journal of Clinical Investigations, 1960; 39: 573–583.
xxxiii. Naimark, A. and Cherniack, R. M. Compliance of the respiratory system and its components in health and obesity. Journal of Applied Physiology, 1960; 15: 377–382.