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Hidden Hunger among Late Adolescent Girls in Karaikal- A Pilot Study

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ABSTRACT:
Introduction: *the period of adolescence is characterized by changes in body characteristics, attitudes influenced by social pressure and identity seeking behaviors. in this period of rapid growth, the heightened nutritional demands are usually inadequately satisfied by incorrect choice of foods, peer pressures in diet, influences of media, over concern in body constitution and deliberate neglect of nutritional supplements. adolescent nutrient deficiencies in india included both macro and micronutrients but now it is micronutrient deficiency amidst macronutrient excess. thereby increasing prevalence of overweight and obesity among adolescents and micronutrient deficiencies prevalent in them. lack of craving for the deficient nutrient and absence of visible clinical manifestations render micronutrient deficiencies go undetected and hence termed as "hidden hunger". the present study evaluates the micronutrient status of individual nutrient among late adolescent girls belonging to middle and upper socio economic class in karaikal district of puducherry state. the correlation of these deficiencies to socio economic status, diet and physical activity are assessed.*
Materials and Methods: *A cross sectional study was conducted including late adolescent girl students in the age group of 17 to 21 years from vinayaka missions medical college, nursing college and allied health sciences college of karaikal from february 2020 to october 2020. after getting clearance from institutional ethical committee, written informed consent from enrolled students. students with chronic illness, on long term medications and nutritional supplements during the study period were excluded and one hundred adolescent girls were enrolled for the study.*
Results*: Among 100 girls enrolled, of them 39 (39%) were between 17 to <18 years, 28 (28%) were between18 to < 19 years, 29(29%) were 19 < 20 years and 4 (4%) between 20 to <21 years of age. amongst the late adolescent girls 22(22%) belonged to upper socio economic category, 48(48 %) upper middle class and 30 (30%) middle class. 12(12%) were undernourished, 27(27 %) had normal body mass index and 39(39%) were overweight and 22(22 %) were obese. dietary score of macronutrient was above the recommended level in 67(67 %) of adolescent girls, below the recommended level in 09(09 %). dietary score of micronutrient intake was average in 17 (17%) and below the minimum basic requirement in 73(73 %) of enrolled girl students. 87 (87 %) did not meet the who recommendation for age based overall physical activity under gpaq 2019.in their early and mid-adolescent age, though 99(99%) were enrolled in weekly iron and folic acid supplementation program, only 84(84%) were compliant with biannual albendazole supplements and 79(79%) of girls took weekly iron and folic acid supplements. clinical manifestations of micronutrient deficiency were evident in only 07(07%).*
Conclusion: *the prevalence of micronutrient deficiency is high in late adolescent girls in the region of karaikal. it is prevalent in middle class and upper class societies also. obesity and overweight in this social class predisposes these adolescents to such deficiencies.*
KEY WORDS: *hidden hunger, adolescent girls, micronutrients, macronutrients.*

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I. INTRODUCTION:

The period of adolescence is characterized by changes in body characteristics, attitudes influenced by social pressure and identity seeking behaviors. In this period of rapid growth, the heightened nutritional demands are usually inadequately satisfied by factors like incorrect choice of foods, peer pressures in diet, influences of media, over concern in body constitution and deliberate neglect of nutritional supplements. Menstrual loss and family neglect also play a role in adolescent girls' unmet nutritional demands [1]. Adolescent nutrient deficiencies in India included both macro and micronutrients a few decades back, but now it is micronutrient deficiency amidst macronutrient excess. This is reflected by increasing prevalence of overweight and obesity among adolescents in both urban and rural areas [2] and micronutrient deficiencies prevalent in

them. Dietary sources from food or supplements are the major sources of micronutrients in humans. Physical growth, pubertal development, concentration and cognitive development are adversely affected by micronutrient deficiencies and obesity increases cardiovascular morbidity [3]. Despite improvement in dietary availability of macronutrients, UNICEF warns of increasing micronutrient deficiencies especially in developing countries [4].Micronutrients play vital role to maintain physical and biochemical barriers of immune function. They are important to sustain the hormonal milieu in humans [5]. Repeated diet surveys done by National Nutrition Monitoring Bureau of National Institute of Nutrition (ICMR) in several states of India indicate that Indian diets are qualitatively deficient in micronutrients particularly iron, calcium, folic acid, vitamin A and riboflavin due to low intake of income elastic protective foods like pulses, vegetables, green leafy vegetables, fruits and foods of animal origin [6]. Loss of the available micronutrients in cleansing and cooking of dietary sources add to these deficiencies. Adiposity related inflammation hinders the absorption of several micronutrients perpetuating the vicious cycle of micronutrient deficiency mediated adiposity in overweight and obese adolescents [7][8]. Lack of craving for the deficient nutrient and absence of visible clinical manifestations render micronutrient deficiencies go undetected and hence termed as "Hidden Hunger" [9] The World Health Organization addresses identification and intervention of these nutritional issues at least in the period not later than adolescence to achieve optimum current, future and intergenerational nutritional health [10]. The present study evaluates the micronutrient status of individual nutrient among late adolescent girls belonging to middle and upper socio economic class in Karaikal district of Puducherry state. The correlation of these deficiencies to socio economic status, diet and physical activity are assessed.

II. MATERIALS AND METHODS:

This cross sectional study was conducted including late adolescent girl students in the age group of 17 to 21 years from Vinayaka Missions Medical College, Nursing College and Allied Health Sciences College of Karaikal from February 2020 to October 2020. After getting clearance from Institutional Ethical Committee, written informed consent from enrolled students was obtained. Students with chronic illness, on long term medications and nutritional supplements during the study period were excluded and one hundred adolescent girls were enrolled for the study. Structured pretested questionnaire was completed for each of the enrolled participant by single trained medical staff. Details included basic information, dietary score for macro and micro nutrients using Food Frequency Questionnaire (FFQ) of National Institute of Nutrition (NIN), Hyderabad [Annexure I], details of nutritional supplements in high school and higher secondary school age (12-17 yrs.), socio economic status score using modified Kuppuswamy scale 2019 [Annexure II], physical activity score using WHO – GPAQ 2019 [Annexure III] were calculated. General physical examination including clinical signs of malnutrition and micronutrient deficiency states was recorded; "z" scores for weight and height for age were calculated using WHO Anthropometric Software [11] and systemic examination carried out. Venous blood samples were collected for analysis of complete blood count using Mindray hematology analyzer. Serum samples were assayed of serum iron, ferritin, folic acid, Vitamin B12, Zinc; vitamin D using Maglumi 800 fully automated immunoassay analyzer. Randomly selected 10% of Vitamin B12 deficient serum samples were assayed for homocysteine and methyl melonic acid using Si 222 Digital Nephelometer .Serum Vitamin C was assayed using HPLC analyzer.

Statistical Analysis: Data recorded in proforma was managed on Excel spreadsheet. All the entries were double checked for possible typographical error. Data analysis was performed using SPSS software version 21.0 (SPSS.Inc). Categorical variables were analyzed using both absolute and relative frequencies, continuous variables based on the median. Pearson Chi square and Fischer extract tests were used to compare the categorical variables. Numerical variables were analyzed using non parametric Mann-Whitney U test. The odds ratio with 95% CI were calculated for risk factors predisposing to micronutrient deficiencies which were identified as those with $p<0.05$ in the univariate analysis. They were selected for inclusion in a stepwise forward logistic regression model to determine the significant risk factors for micronutrient deficiencies.

III. RESULTS AND DISCUSSION:

Among 133 adolescent girls selected, 100 girls were enrolled. Of them 39 (39%) were between 17 to <18 years, 28 (28%) were between18 to < 19 years, 29(29%) were 19 < 20 years and 4 (4%) between 20 to <21 years of age. Amongst the enrolled late adolescent girls 22(22%) belonged to upper socio economic category, 48(48 %) upper middle class and 30 (30%) middle class. Of the enrolled adolescent girls, 12(12%) were undernourished, 27(27 %) had normal body mass index and 39(39%) were overweight and 22(22 %) were obese.

Dietary score of macronutrient was above the recommended level in 67(67 %) of adolescent girls, below the recommended level in 09(09 %) of enrolled girls. Dietary score of micronutrient intake was average in 17 (17%) and below the minimum basic requirement in 73(73 %) of enrolled girl students.

0ut of 100 enrolled girls, 87 (87 %) did not meet the WHO recommendation for age based overall physical activity under GPAQ 2019.

In their early and mid-adolescent age, though 99(99%) were enrolled in weekly iron and folic acid supplementation program, only 84(84%) were compliant with biannual albendazole supplements and 79(79%) of girls took weekly iron and folic acid supplements.

Clinical manifestations of micronutrient deficiency were evident in only 07(07%) of enrolled girls.

Characteristics	***Values***
Age	19 (2.1,4)
BMI	3(1,3)
Socio economic status	2 (1,2)
Score of macronutrient in diet	3 (1,2)
Score of micronutrient intake	1(1,1)
Physical activity score	1(0,1)
Compliance with adolescent iron and folic acid supplements	1(0,1)
Pallor/fatigue	22(0.44,2.6)
Angularstomatitis, glossitis, chelitis	16(0.53,3)
Nonspecific aches and pains	19(0.9,1.8)
Osteomalacia	5(1.0,0.77)
Growth retardation/delayed puberty /delayed wound healing	41(0.89,0.7)
Bleeding gums/ rashes/ malaise / thin gums/	55(0.63,0.4)

All values are based on median (IQR, R) as per recommendations of WHO for BMI, FFQ & GPAQ

Table 1: Baseline demographic and clinical characteristics of enrolled girls (N=100)

Micronutrient deficiencies from assay of venous samples revealed an overall deficiency of one or more nutrients in 79% of late adolescent girls. This is higher than the global prevalence presented by UNICEF in 2019 [12]. Clinical evidence of micronutrient deficiency was detected in 9% of girls. This is in comparison to the study by Patton et al. which recommends micronutrient screening of adolescents based on growth, dietary insufficiency and behavioral scores rather than overt manifestations of clinical signs of such deficiencies [13].Deficiency was highest among19-21yrs girls and least in the 17to <18 yrs age group ($p<0.05$).This is in contrast to a higher prevalence of micronutrient deficiency in the 10-12 years and 16-18 years among Chinese adolescents [14]. But the present study does not include early and mid-adolescent age girls and china does not promote mid-day meal program as India. Micronutrient deficiency had significant correlation with overweight (0.8, CI>95%, $p<0.05$), obesity ($p<0.0001$), low dietary intake of micro nutrients (0.68, CI 95%, $p<0.0001$) and physical inactivity (0.55, CI >95%, $p<0.05$).The Brazilian study shows higher prevalence of micronutrient deficiencies in overweight and obese adolescent girls and young adult women, but the cause or effect remains to be determined. The theories for obesity causing micronutrient deficiencies were obesity mediated gastro intestinal inflammation preventing micronutrient absorption, high dietary content of carbohydrates interfering with active absorption of fat soluble vitamins and attenuation of intestinal crypts interfering with vitamin B12 absorption [15]. Dietary content of micro nutrients and their bio availability at the end of food processing, cooking and oro-intestinal digestion is an important determinant of micronutrient deficiency in any population in similarity to the present study which shows a significant correlation between dietary micronutrient deficit and biochemical deficiency of various micronutrients in the serum [16]. There was no significant difference in micronutrient deficiencies among girls of various socio economic status (0.68, CI >95%, $p=0.2$). This is comparable to the Korean population which revealed a positive correlation of micronutrient deficiency to low maternal education and not the socio economic status [17], in contrast to Pakistani study revealed a significant association of micronutrient deficiency to lower socio economic families [18]. But maternal education was not included as a risk factor in the latter study.

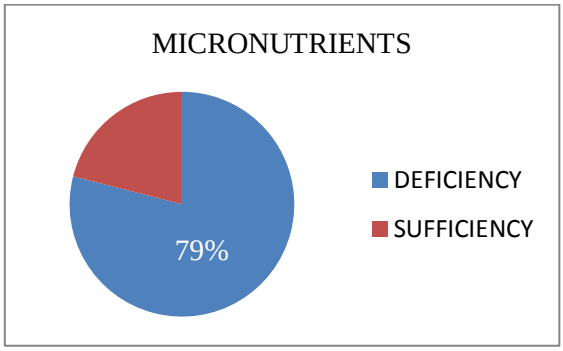

Figure 1 : PREVALENCE OF MICRONUTRIENT DEFICIENCY

Age specific distribution of different micronutrients is given as.

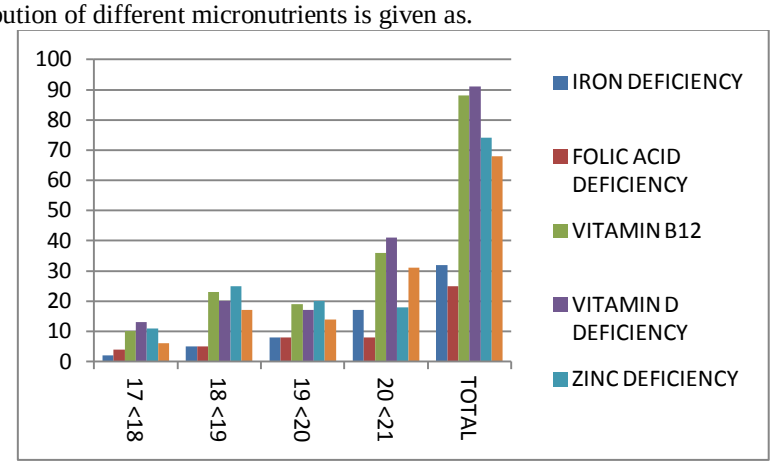

Figure 2: AGE WISE DISTRIBUTION OF MICRONUTRIENT DEFICIENCIES

Iron deficiency was detected in 32%, folic acid deficiency in 25%, vitamin B12 deficiency in 88%. This is somewhat lesser than the prevalence in Bihar [19] but comparable to the neighboring state of Tamilnadu [20]. The lower prevalence is probably related to better reach of adolescent anemia control services in these states of Puducherry and Tamilnadu and lower school enrollment of adolescent girls in states like Bihar. Anemia was the only clinically visible sign of iron folic acid and /or vitamin B12 deficiency. It was evident in 72% of iron deficient girls (n=23), and 79% of girls with combined deficiency of iron, folic acid and vitamin B12 deficiency (n=69). A similar study in Himachal Pradesh Tertiary Care Hospital revealed severe deficiencies of iron, folic acid and /or Vitamin B12 presented with clinical anemia but moderate and mild deficiencies go u noticed clinically [21]. Iron deficiency was significantly higher in girls who were non-compliant with weekly iron intake during early and mid-adolescent age (0.013, CI >95%, p<0.0001) [22]. Folic acid was deficient irrespective of iron levels in serum (0.98, CI>95%, p=1.0) and vitamin B12 deficiency (1.1, CI >95%, p=0.32). Vitamin B12 deficiency did not show significant difference between vegetarians and girls on mixed diet. (0.7, CI>95%, p=0.2). This is in contrast to several studies which revealed folic acid deficiency presenting usually in combination most commonly with iron deficiency and less commonly with deficiency of vitamin B12[23][24]. This is best explained by the high bioavailability of dietary folic acid compared to poor absorption of dietary iron after a meal and in the presence of dietary phytates. In addition to this, "methyl trap hypothesis", where long standing vitamin B12 deficiency causes methionine synthetase deficiency causing functional folic acid deficiency in the absence of daily folic acid intake elucidates that though serum folic acid levels were normal in those girls with vitamin B12 deficiency in the present study, functional availability of the same could not be estimated.

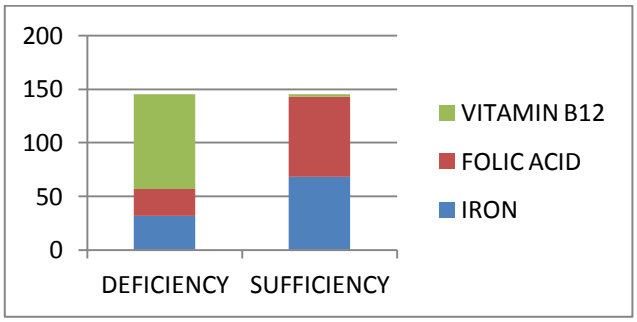

Figure 3: NUTRITIONAL STATUS OF IRON, FOLIC ACID AND VITAMIN B12 AMONG LATE ADOLESCENT GIRLS

Vitamin D deficiency was the most prevalent of all micronutrient deficiencies and detected in 91% of enrolled girls. It was more prevalent among over weight (0.065, CI >95%, p<0.05), obese adolescent girls (0.081, CI >95%, p<0.0001) girls and adolescents who did not meet the minimum requirement of physical activity (0.02, CI >95%,p<0.0001). Nonspecific aches and pains were significantly higher among vitamin D deficient girls (0.05, CI>95%, p<0.05). This is in line with the UNICEF report on hidden hunger among children and adolescents except the nonspecific aches and pains which was significantly higher among vitamin D deficient adolescent girls [12]. Further studies are required to associate these pains to vitamin D deficiency and whether its correction alleviates them.

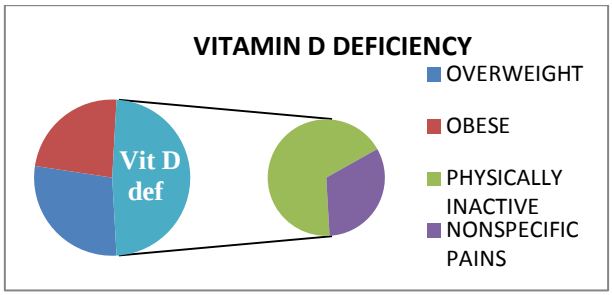

Figure 4: CORRELATION OF VITAMIN D DEFICIENCY TO BMI, PHYSICAL ACTIVITY AND CLINICAL MANIFESTATIONS

Zinc was deficient in 74%. Zinc deficiency significantly correlated with the low dietary micronutrient score (0.04, CI>95%, p<0.0001).This is far higher than urban adolescent girls in Delhi which showed a prevalence of 48.2% in the 11-18 years age group girls [25].

Vitamin C deficiency had a high prevalence of 68% among the enrolled adolescent girls. It was the only deficiency which had a significant correlation with clinical manifestations of swollen, thin gums or bleeding from gums while brushing (009, CI >95%, p<0.05), which were specific to the deficiency. This is in contrast to the study of prevalence of Vitamin C deficiency in adolescent slum girls in Delhi which indicated a prevalence of 6.3% deficiency and 27.6% insufficiency [26]. This may be attributed to loss of plasma vitamin C over time as done in Delhi study and high glucose values or liver dysfunction interfering with the plasma estimates of vitamin C which is overcome when serum samples are used for assay of ascorbic acid.

Several risk factors correlated in the present study with the development of individual micronutrient deficiencies. Of these, statistically significant associations were present between high dietary macro nutrient intake and deficiencies of iron, folic acid, vitamin B12 deficiencies. Strong association between suboptimal micronutrient score in diet and deficiencies of zinc, folic acid and vitamin C was present in the study population. Low physical activity had a positive, statistically significant correlation with vitamin D deficiency irrespective of whether it was indoor or outdoor activity. Overweight and obesity were associated with one to several micronutrient deficiencies and the association was statistically significant in five of the six micronutrients under the study excluding vitamin C. Clinical manifestations were minimal in all of the micronutrient deficient states except vitamin C and vitamin D . Even in these deficiencies of vitamin C and D, the association with clinical symptoms and signs were not significant (p=1.2, p=1.8 respectively).

Characteristics	*Normal micronutrient levels n =21*	*Deficient micronutrient level n =79*	*p value* [a]	*OR 95% (CI)*	*p value* [b]
High carbohydrate in diet	**24 (11,42)**	**15 (8,25)**	**<0.001**	**0.97(0.97,0.98)**	**<0.001**
Low micronutrient score in diet	**-0.46 (-1.48,0.33)**	**1.12(1.04,1.21)**	**0.001**	**1.12(1.04,1.21)**	**0.002**
Overweight	**-0.77 (-1.96,0.3)**	**-0.24 (-0.99,0.56)**	**<0.001**	**0.76(0.72,0.79)**	**<0.001**
Obesity	**-0.65 (-1.63,0.33)**	**0.71 (0.1,0.74)**	**<0.001**	**0.88(0.0.80,1.13)**	**<0.001**
Sub optimal physical activity	**-0.51 (-1.70, 0.4)**	**0.83 (0.2,0.68)**	**0.003**	**0.62(0.69,1.2)**	**0.001**

Values are median (IQR) unless specified. [a] Univariate analysis, [b] Multivariate analysis

Table 2: Risk factors for micronutrient deficiency in adolescent girls

IV. CONCLUSION:

The prevalence of micronutrient deficiency is high in late adolescent girls in the region of karaikal. It is prevalent in middle class and upper class societies also. Obesity and overweight in this social class predisposes these adolescents to such deficiencies. The need for urgent intervention is not only to save these girls from falling prey to dual prongs of obesity induced cardiac morbidity and micronutrient deficiency mediated mental and physical dysfunctions, but also to cut the chain of intergenerational perpetuation of micronutrient deficiencies.

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