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Double or Triple Burden of Malnutrition in Turkish Adolescents: Single Center Experience

Türk Ergenlerde Malnütrisyonun Çoklu Yükü: Tek Merkez Deneyimi

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Abstract: Malnutrition continues to be a health problem, especially in children. The aim of this study was to investigate the prevalence of the double or triple burden of malnutrition in adolescents. This retrospective study was conducted on adolescents admitted for any reason at a tertiary hospital between June 2022 and June 2023. Of the total 1126 cases, 67.3% were normal weight, 16.6% were underweight, %4.1 were stunting, 6.5% were overweight, and 9.6% were obese. It was determined that the obesity rate was significantly higher in late adolescence compared to early adolescence (p = 0.037). At least one micronutrient deficiency was detected in 42.1% of all cases, 34.2% of underweight cases, and 38.1% of obese cases. Any malnutrition was detected in 56.7% of the cases, DBM in 6.3% and TBM in 0.3%. The frequency of DBM and micronutrient deficiency was observed to be high in the adolescents in this study. The increased frequency of obesity and deficiency of vitamin D and vitamin B12 together with age showed that health problems due to the DBM will be reflected in adulthood. The planning of preventative health policies for societal health can be recommended.
Keywords: Adolescents 1, Vitamin B12 Deficiency 2, Vitamin D 3, Obesity 4

Özet: Malnütrisyon, özellikle çocuklarda bir sağlık sorunu olmaya devam etmektedir. Bu çalışmanın amacı, ergenlerde hem ergen popülasyonunda hem de birey içinde ikili veya üçlü malnütrisyon yükünün yaygınlığını araştırmaktır. Bu retrospektif çalışma, Haziran 2022 ile Haziran 2023 arasında üçüncü basamak bir hastaneye herhangi bir nedenle yatırılan ergenler üzerinde yürütülmüştür. Toplam 1126 vakanın %67,3'ü normal kilolu, %16,6'sı düşük kilolu, %4,1'i bodur, %6,5'i fazla kilolu ve %9,6'sı obezdi. Obezite oranının geç ergenlikte erken ergenliğe göre anlamlı derecede daha yüksek olduğu belirlenmiştir (p = 0,037). Tüm vakaların %42,1'inde, düşük kilolu vakaların %34,2'sinde ve obez vakaların %38,1'inde en az bir mikronutrient eksikliği tespit edildi. Vakaların %56,7'sinde herhangi bir yetersiz beslenme, %6,3'ünde DBM ve %0,3'ünde TBM tespit edildi. Bu çalışmada ergenlerde DBM ve mikronutrient eksikliğinin sıklığının yüksek olduğu gözlendi. Obezite ve D vitamini ve B12 vitamini eksikliğinin yaşla birlikte artan sıklığı, DBM'ye bağlı sağlık sorunlarının yetişkinliğe yansıyacağını gösterdi. Toplum sağlığı için koruyucu sağlık politikalarının planlanması önerilebilir
Anahtar Kelimeler: Adölesanlar 1, B12 Vitamini Eksikliği 2, D Vitamini 3, Obezite 4

Ethics Committee Approval: The study was approved by Afyonkasrahisar University Noninterventional Clinical Research Ethical Committee (Decision no: 2024/9 Date: 01/11/2024

Informed Consent: The authors declared that it was not considered necessary to get consent from the patients because the study was a retrospective data analysis.

Authorship Contributions: All authors contributed to the study conception and design. Material preparation, data collection were performed by Hilal Koyuncu, Aysun Soyugüzel and Nur Önen. Analysis were performed by Ayşe Oflu Literature review was done by Hilal Koyuncu, Ayşe Güngör, Ayşe Oflu and Ayşegül Bükülmez. The first draft of the manuscript was written by Hilal Koyuncu , Ayşe Oflu and Aysun Kaya. Ahmet Afşin Kundak, Ayşe Oflu , Hilal Koyuncu and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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1. Introduction

Despite improvements in the availability of food and economic opportunities throughout the world, malnutrition in children remains an important topic. In 2016, the World Health Organization (WHO) renamed the presence of multiple parameters of malnutrition as double burden of malnutrition (DBM) (1). While DBM refers to the coexistence of undernutrition along with overweight, obesity, this definition was later expanded to triple burden of malnutrition (TBM). The term "triple burden of malnutrition" is defined as the coexistence of undernutrition, micronutrient deficiencies, and overnutrition (2).

Incorrect or insufficient nutrition is still one of the most common problems at all ages. Although insufficient nutrition at young ages causes short stature, it increases the risk of obesity at older ages (3). Although conventional wisdom suggests that malnutrition and obesity risk factors are distinct, in fact, each component of the triple burden of malnutrition may be due to poverty (lack of access to nutritious foods); poor dietary choices (lack of knowledge about nutritious foods and healthy diets); and the food supply chain (production and marketing of cheap, low-quality foods) (3-5).

As adolescence is the second most important period of rapid growth in children after infancy, the need for energy, protein and micronutrients increases. The 40% increase in bone mass during adolescence, the gain of 20% of the final adult height, the early onset of puberty with obesity and its short duration show that nutrition is very important in many physical, sexual and psychological development stages of adolescents (4). Malnutrition in this period causes many health problems to be reflected in adulthood. In the WHO 2025 targets to prevent malnutrition, children below the age of 5 years were emphasized (6). However, there are relatively few similar protective measures for adolescents in both family and healthcare policies. Therefore, adolescent nutrition was named a “hidden crisis” by the Lancet Adolescent Health Commission (7).

Data in studies in literature are more related to micronutrient deficiency in adolescents, and undernutrition and obesity have been evaluated separately. There are limited data of the malnutrition burden in this age group (8, 9). Studies of DBM and TBM have mostly been conducted in Africaan and Asian countries , and there are few studies that have reported from Europe, including Türkiye, and central Asia (8, 10). Although these studies were mainly carried out in low-income countries where malnutrition is widespread, we believe that they should also be conducted in our country and other high-income countries with easy access to food. Obesity, a form of malnutrition in itself, is prevalent in developed countries, but is also becoming more common in low-income countries. The risk of DBM/TBM increases during adolescence, a period when the risk of unhealthy nutrition is high, and this risk exists in every region, regardless of geographic location and socioeconomic status. To the best of our knowledge, there is no previous study that has reported the frequency of DBM/TBM in adolescents in Türkiye. The aim of this study was to investigate the prevalence of the DBM or TBM in adolescents.

2. Materials and Method

Study Design

Approval for this retrospective, observational study, conducted in the Paediatric Department of Afyonkasrahisar University, was granted by the Local Ethics Committee (decision no:2024/387, dated:01.11.2024). The study was conducted in accordance with the Helsinki Declaration.

Data Collection

The study included adolescents aged 10-18 years who presented for any reason at the Paediatric Health and Diseases out patient clinic of Afyonkasrahisar University Medical Faculty Hospital between June 2022 and June 2023. Cases whose anthropometric measurements were recorded and whose vitamin D, vitamin B12, iron, ferritin and hemoglobin levels were measured were included in the study. The age, gender, and anthropometric characteristics of the cases at the time of presentation were retrospectively retrieved from the hospital electronic records system. The cases were classified as early adolescence in the 10-14 years and as late adolescence in the 15-18 years. A record was made for each case of any underlying disease in the history, medications continuously used, recurrent infections, hospital admissions, and any eating disorders. Cases with malabsorption syndromes (celiac disease, cystic fibrosis, inflammatory bowel disease), parasitosis; those taking anticonvulsants, metformin, and chemotherapeutic drugs and were currently or had recently taken vitamin supplements within the last 3 months and had received blood and/or blood products transfusion within the last year excluded from study. Cases with missing data

on any of the anthropometric measurements or micronutrient levels were excluded from the study.

Height Z scores according to age and BMI Z scores for age were calculated according to WHO recommendations. BMI Z score according to age of <-2 was accepted as underweight, -2-1 as normal weight, 1-2 as overweight, and >2 as obese. Height for age Z score <-2 accepted stunting (11). In the laboratory tests, the vitamin D level was determined acccording to the Global Consensus Recommendations, evaluated as <12ng/ml deficient, 12-20ng/ml insufficient, and >20ng/ml normal (12). In the determination of the Vitamin B12 level, <200 pg/mL was accepted as deficient, 200-300 pg/mL as insufficient, and >300 pg/mL as normal (13). In cases with hemoglobin levels below 12 mg/dl, if the ferritin level was <12/l, it was considered iron deficiency anemia, and if the vitamin B12 level was <200 pg/mL, it was considered anemia due to B12 deficiency (14, 15). According to the WHO definition, DBM can occur in individuals, households or the population (1). In this context, the proportion of undernutrition components (e.g. underweight, stunting and micronutrient deficiency) and overnutrition components (e.g. overweight and obese individuals) were determined in the whole adolescent population in the study group. Based on these data, DBM in the adolescent population was determined. İndividual DBM was defined as children who were both micronutrient deficient and overweight/obese (1). Using examples from previous studies, TBM was defined as stunting + micronutrient + obesity (16).

Descriptive statistics for the whole sample were generated as follows: Frequency for categorical variables, mean and standard deviation for continuous variables. Chi-square test was used to compare the percentage distributions of categorical data between the groups. The normal distribution of the data was evaluated by the Shapiro-Wilk test. Pairwise comparisons of continuous data were performed with Student's t-test. Bivariate, Spearmen two-tailed correlation test was performed to determine the relationship between BMI and vitamin levels. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) 20.0 package program. Values of $p<0.05$ were considered as statistically significant.

3. Results

It was determined that 1,931 adolescents applied. Researchers excluded 805 cases from the study due to reasons such as missing data, malabsorption, and medication use. This is shown in the flow chart. A total of 1126 cases were evaluated in the age range 10-18 years, with 53.4% females and 46.6% males. The mean age was 13.8±2.5 years and there were 570 (50.3%) in the early- adolescence group and 564 (49.7%) in the late adolescence group. Nutritional status according to BMI was determined as 67.3% normal, 16.6% underweight, 6.5% overweight, 9.6% obesity, and 4.4% stunting. No significant difference was determined in nutritional status according to gender (p=0.213). It was determined that the ratio of obesity in late adolescence is more common than in early adolescence (p=0.037). At least one micronutrient deficiency was determined in 42.1% of all the cases, as 38.1% in obese cases, and in 34.2% of the underweight cases. Any malnutrition was detected in 56.7% of the cases. İndiviual DBM was 6.3% and TBM was 0.3% (Table 1, Table 2). Those with concurrent micronutrient deficiency and underweight were 5.7%. A statistically negative correlation was found between BMI and vitamin D (r:-125 p:0.01) and vitamin B12 (r:-207 p:0.01).

Table 1. Distribution of Determinants of TBM in the Adolescent Population

Determinants of TBM	**N**	**%**
Underweight	187	16.6
Stunting	47	4.1
Overweight	73	6.5
Obesity	108	9.6
MND*		
Anemia	64	5.6
İron deficiency	137	12.2
Vitamin D deficiency	331	29.4
Vitamin B12 deficinecy	89	7.9

**MND: Micrunutrient Deficiency*

Table 2. Distribution of İntra-individual Double and Triple Burden of Malnutrition

Determinants of TBM	N	%
Any malnutrition		
Undernutrition	133	11.8
Overweight/Obesity	110	9.8
MND[1]	340	30.2
Undernutrition+MND	64	5.7
DBM[2]		
Overnutrition+MND	68	6.3
TBM[3]		
Overnutrition+Stunting+MND	3	0.3

MND[1]: Mikronutrient deficiency, DBM[2]: Double burden of malnutrition
TBM[3]: Triple burden of malnutrition

The mean Vitamin D level was determined to be 17.5±8.7 ng/ml (range, 3-62 ng/mml), as 14.8±8.9 ng/ml in females and 20.6±8.9 ng/ml in males, showing a significantly lower level in females (p<0.001). The Vitamin D level was significantly lower in the late adolescence group (16.2±8.6 ng/ml) than in the early adolescence group (18.9±8.7 ng/ml) (p<0.001). Vitamin D was < 20ng/ml in 724 (64.3%) cases, at a deficient level in 393 (34.9%), and insufficient in 331 (29.4%). The frequency of vitamin D deficiency in females and the late adolescence group was determined to be significantly high (p<0.001) (Table 3).

Table 3. Comparison of Nutritional Status by Gender and Adolescence Stage

	Female n(%)*	**Male n(%)***	***p* value**	**Early Adolescent n(%)***	**Late Adolescent n(%)**	***p* value**
BMI for age						
Normal	414(68.9%)	344(65.5%)		381(67.1%)	377(67.6%)	
Thinnes	90(15.0%)	97(18.5%)	0.398	100(17.6%)	87(15.6%)	**0.037**
Overweight	37(6.2%)	36(6.9%)		44(7.7%)	29(5.2%)	
Obesity	60(10.0%)	48(%9.1)		43(7.6%)	65(11.6%)	
Vitamin D deficiency	246(40.8%)	86(16.4%)	**0.000**	129(22.7%)	202(36.2%)	**0.000**
Vitamin B12 deficiency	50(8.6%)	39(7.6%)	0.630	26(4.7%)	63(11.5%)	**0.000**
Anemi	47(7.8%)	17(3.2%)	**0,001**	28(4.9%)	36(6.5%)	0.283
Ferritin						
<15 ng/mL	88(15.3%)	24(4.7%)	**0.000**	30(5.6%)	81(15.1%)	**0.000**
İron						
<40 mg/dl	82(25.5%)	55(20.%)	0,124	70(23.7%)	67(22.3%)	0,670

Vitamin B12 levels in the whole sample were determined to be mean 366.7±142.8 pg/mL (range 57-994 pg/mL), as 362.2±137.3 pg/mL in females and 371.4±148.2 pg/mL in males, with no significant difference between the genders. The Vitamin B12 level in late adolescence (335.7±127.3 pg/mL) was seen to be significantly lower than that of the early adolescence group (398.5±149.1 pg/mL) (p=0.015). Vitamin B12 deficiency was determined in 90 (7.9%) cases and insufficiency in 326 (28.7%). There was no significant difference in the frequency of Vitamin B12 deficency according to gender (p=0.620), but the frequency was significantly higher in the late adolescence group (p<0.001) (Table 3).

The mean Hb value was 13.8±1.3 mg/dl in the whole sample, as 13.4±1.1 mg/dl in females and 14.3±1.3 mg/dl in males. The mean Hb value was sgnificantly lower in females than in males (p<0.001). Anaemia

was determined in a total of 64 (5.6%) cases, at a significantly higher rate in females (n:47, 7.7%) than in males (n:17, 3.2%) ($p<0.001$). No significant difference was determined between the early and late adolescence groups in respect of the frequency of anaemia ($p=0.283$). A low ferritin level was determined in 112 (10.7%) cases. Of the cases with anaemia, this was due to iron deficiency in 42 (66.7%), to iron deficiency and vitamin B12 deficiency together in 17 (27.3%), and to Vitamin B12 deficiency in 4 (6.3%). No gender difference was determined in the distribution of the causes of anaemia ($p=0.312$) (Table 3).

4. Discussion

The study found that one-third of teenagers were underweight or obese, while half suffered from micronutrient deficiencies, known as hidden hunger. The determination of micronutrient deficiency at a very high rate in underweight and obese patients shows a high frequency of DBM. As a deepening of these deficiencies in late adolescence and an increase in obesity will be reflected in adulthood, preventative measures must be taken against the burden of malnutrition in adolescence for the sake of public health. While previous studies in Türkiye have addressed malnutrition and obesity separately, the current study is the first to draw attention to all the burdens of malnutrition.

In this retrospective study, it was found that DBM was quite common both in population and in individuals among adolescents applying to tertiary health institution in Turkey. At least one of undernutrition, overnutrition or micronutrient deficiencies was present in 56.7% of the total population. The individual DBM rate was 6.3%, and the TBM rate was 0.3%. In their review of studies from low- and middle-income countries, Wrottesley and colleagues showed that the determinants of DBM - wasting, stunting, obesity and micronutrient deficiencies - are common throughout the world (8). In the study of Caleyachetty et al., which included 57 low and middle income countries including European countries, underweight in adolescents was 5.5%, obesity was 21.4%; DBM was defined as obesity + stunting and reported as 2% (10). With a similar definition, DBM in Nigeria was stated at the rate of 4%, underweight at 10.2%, and obesity at 11.4%(17). In a previous study in Türkiye that evaluated the nutritional status of early adolescents, the results showed that 8.9% were underweight and 16.9% overweight/obese (18). A study in India that included 16184 adolescents reported rates of 53.4% for DBM and 12.7% for TBM (16). In China, Xiao Hu et al examined 1555 children aged 6-17 years and reported obesity at the rate of 11%, underweight 5% and DBM 26% (19). DBM was determined to be higher in those two studies, but unlike the definition of DBM in other studies, micronutrient deficiency was defined as a separate parameter. We believe that the different definitions used for DBM in the literature cause confusion. This may prevent a standard approach in determining the true prevalence worldwide. There is a need for standardization of malnutrition definitions both within individuals and in communities.

Studies reported in the literature generally indicate that the prevalence of DBM is high in India, Asia and Africaan (8). This is thought to be due to inadequate nutrition in these countries, which can be attributed to factors such as limited access to food, socio-economic issues, and poor hygiene practices. The WHO states that DBM is a significant issue requiring intervention and action. While DBM is not as prevalent in our country as it is in Asian or Africaan countries, we believe it is a health problem requiring action among adolescents. It is concerning that more than half of the study group had at least one nutritional disorder and that this prevalence is increasing. This increase may be explained by adolescents being fed outside of family control, eating more outside due to long school hours, eating less nutritious food due to this freedom and being exposed to low-nutrient 'junk food', Similar to the reduction in stunting under the age of five through health policies in our country, we believe that DBM will also decrease in this age group with government measures. Considerable steps can be taken to improve health and wellbeing, such as BMI screening in schools, mandatory vitamin D prophylaxis in adolescence, mandatory protein-rich nutrition in schools, and increasing social awareness.

As malnutrition is very common as a historical definition, undernutrition comes to mind more often. In 2016, a WHO report stated that 115 million children aged < 5 years were chronically malnourished, and 45% of child deaths were related to undernutrition (1). Nutritional policies have been planned more on undernutrition and have been able to obtain a decrease. Throughout the world in general, the 32.6% rate of stunting in 2000 decreased to 22.2% in 2017 (20). In Türkiye, the rate of stunting in children younger than 5 years has decreased from 5.4% to 1.7% in the last 20 years (21). Studies conducted in Türkiye have reported stunting at 2-7%, and underweight at 4-26% in school age children and adolescents (8). Söbü et al. examined short stature and determined malnutrition

in approximately one-third of patients, and concluded that malnutrition is still a significant cause of short stature (22). Consistent with the literature, the current study results determined stunting at the rate of 4.4% and underweight at 16.6%.

Although undernutrition in children aged <5 years has reduced in the last 20 years, as in Türkiye, there has been a noticeable increase in the frequency of obesity in both developing and developed countries (23, 24). This has arisen because of current climate change, sedentary lifestyles in this digital age, and many food insecurities because of the change in food content. Eating more western style fast food with high fat and carbohydrate content in adolescence, when young people gain individuality and autonomy and acess food on their own, increases the risk of obesity (9). It has been reported that obesity in the 5-19 years age range increased approximately 8-fold between 1975 and 2016 worldwide (25). In 2022, one child in every 4 in Europe was reported to be obese and this rate was 21.4% in developing countries (9). A meta-analysis in Türkiye found that obesity increased from 2.9% to 13.5% between 2000 and 2020 (26). In the current study, obesity was seen in 16.1% of the adolescents and the frequency increased in late adolescence. It is clear that increasing obesity throughout the world in general is also a risk for Türkiye. Action must be taken urgently to prevent complications such as type 2 diabetes, cardiovascular diseases, hyperlipidemia, and hepatosteatosis extending from adolescence into adulthood.

In most of the studies investigating TBM, the micronutrients evaluated included iron, zinc, vitamin A and vitamin D (27, 28). In some studies, only anaemia or any micronutrient deficiency with anaemia was evaluated (27, 28). Based on these sample studies, anemia, vitamin D, and vitamin B12 deficiency were evaluated in our cases based on the available data. As this was a retrospective study, the fact that vitamin A and zinc levels could not be assessed in the cases limits the power of the study. Nevertheless, we believe that all micronutrients are individually important in children.

The increased requirements of the rapid growth rate in adolescence together with increased poor nutritional habits increase the risk of micronutrient deficiency(9). In literature, deficiency of at least one micronutrient varies between 40% and 76.3% (29). Despite preventative measures such as prophylaxis as a health policy, Vitamin D deficiency is extremely common in all regions, including high-income European countries (8, 9). A meta-analysis in south Asian countries reported vitamin D deficiency of 40%, iron deficiency of 14%, and anaemia 25% (29). A study by Ji Naiwen in India, reported 20.6% iron deficiency, 23% Vitamin D deficiency, and 30.9% Vitamin B12 deficiency (16). Studies in Türkiye have reported rates in adolescents of Vitamin D deficiency at 25-56%, anaemia 4-15.8%, and Vitamin B12 deficiency 24.5-69.2% (27, 28). The current study results showed deficiency of at least one micronutrient in 42.1% of the adolescents and this frequency increased significantly in late adolescence. Micronutrient deficiencies were seen in 38.1% of the obese cases and in 34.2% of the underweight cases. The extremely high micronutrient deficiencies in malnourished patients will deepen the negative effects on all systems, including growth and development, cognitive functions, and the immune system, so preventative measures must be taken.

The strength of this study is that it is the first study to reveal the DBM and TBM in Turkish adolescents.

The study has several limitations due to its single-center, retrospective nature. Since it was a single center, the cases had similar socioeconomic and nutritional patterns. İt may not reflect the general population. Furthermore, vitamin A and zinc levels measured in the sample studies could not be examined due to its retrospective nature. Considering the financial burden that will be brought about by field studies to determine the frequency of MND and therefore the frequency of DBM and TBM, although generalization cannot be made, it is quite informative about the frequency of malnutrition in Turkish adolescents. Further large-scale studies are needed to comprehensively investigate the underlying causes of malnutrition and associated factors.

5. Conclusion

There is a need to evaluate the frequency of DBM or TBM in adolescents with studies to be conducted on a national scale. The burden of malnutrition is more striking, especially in late adolescence. It is important to eliminate the existing burden of malnutrition with emergency action plans, as well as the need to develop preventive health policies.

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