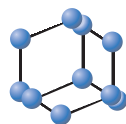


## RESEARCH ARTICLE


**BENTHAM  
SCIENCE**

# Hidden Hunger of Vitamin E among Healthy College Students: A Cross-Sectional Study



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**Abstract: Background:** College students may have a risk of fat-soluble vitamin deficiencies due to unhealthy dietary habits, especially for vitamin A and E. They are important members of the human antioxidant network; deficiencies of these vitamins may increase the risk of many critical diseases.

**Objective:** The current study was undertaken to determine the status of vitamin A and E in college students.

**Methods:** Healthy college students were recruited, and fasting blood samples of them were collected and used for determining serum levels of retinol and  $\alpha$ -tocopherol by the HPLC method.

**Results:** We found that there was no vitamin A deficiency in college students. However, vitamin E deficiency existed in 34.5% of college students, especially in males. All the students had no vitamin E adequacy. In addition, our findings showed that BMI was inversely associated with serum  $\alpha$ -tocopherol, but not serum retinol.

**Conclusion:** These results suggest that vitamin E deficiency in college students should be given more attention, and it is necessary to consider using vitamin E supplements.

## ARTICLE HISTORY

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**Keywords:** Hidden hunger, fat-soluble vitamins, vitamin A, vitamin E, BMI, college students.

## 1. INTRODUCTION

Fat-soluble vitamins, mainly including vitamins A, D, and E, are required for a wide variety of physiological functions. Over the past two decades, deficiencies of these vitamins have been associated with an increased risk of cancer, obesity, diabetes mellitus, and a number of immune system disorders [1-5]. College students are in a period of transition from adolescence to adulthood, in which proper dietary habits and balanced nutritional intake are very important. However, improper dietary habits and lifestyles can cause several health problems. The majority of studies focus on vitamin D, and sufficient results suggest that vitamin D deficiency is prevalent in college students [6-8]. Previously, our group also found that college students had little knowledge and unfavorable behavior about vitamin D, and their consumption frequency of foods rich in vitamin D was low [9].

Vitamins A and E are important members of the human antioxidant network, which has been recognized to be

fundamental to the pathophysiology of various critical illnesses such as acute respiratory distress syndrome, exercise-induced muscle damage, and ischemia-reperfusion injury [10, 11]. The World Health Organization considers the high prevalence of vitamin A deficiency as a serious public health problem, especially in lower socioeconomic developing countries. Preschool-aged children and pregnant women are at high risk of vitamin A deficiency worldwide [12, 13]. Vitamin E deficiency is almost similar to that. The reported prevalence of vitamin E deficiency has ranged from approximately 20% to 90%, and children and the elderly are more vulnerable groups [14, 15]. Although deficiencies of these vitamins are likely to be widespread, few data exist to reveal the extent of young adults such as college students. This study was performed to examine the status of vitamins A and E in college students.

## 2. METHODS

### 2.1. Subjects

The sample size was calculated by using PASS version 11. Based on the  $\alpha$ -tocopherol level, a sample size of 187 from a population of 8000 students, produces a two-sided

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95% confidence interval with a distance from the mean to the limits that are equal to 0.5 when the estimated standard deviation is 3.5. Apparently, healthy college students were invited to voluntarily participate in this cross-sectional study. They were recruited using flyers and posters from Nanjing medical university. Participants who used nutritional supplements and prescription medication had chronic diseases such as kidney disease, malnutrition, or digestion problems were excluded. The purpose, significance, and protocols of the study were fully explained by trained investigators, and the written informed consent was obtained from all participants.

## 2.2. Collection of Blood Samples

From 7 AM to 9 AM, experienced nurses collected blood in the infirmary. A 10-12 h fasting blood samples of each subject were collected into non-anticoagulant vacutainer tubes from an antecubital vein. All blood samples were kept at 4°C for 4h, and centrifuged at 3,000 rpm for 10 min. Serums were obtained and immediately stored at -80 °C until further measurements.

## 2.3. Determination of Vitamins A and E Deficiencies

Concentrations of serum retinol and  $\alpha$ -tocopherol were simultaneously determined by the HPLC method [16]. Retinol and  $\alpha$ -tocopherol in serum were extracted with hexane. Agilent 1260 Infinity (Agilent, CA, USA) was used for HPLC analysis. Chromatography was run with 5 HC-C18 4.6mm $\times$ 150mm column (Agilent, CA, USA). Serum concentrations of vitamins were measured simultaneously by diode array detection at 325 nm (retinol) and 292 nm ( $\alpha$ -tocopherol). Serum retinol below a cut-off of 0.70  $\mu$ mol/L is regarded as vitamins A deficiency, and vitamin E deficiency is defined as serum  $\alpha$ -tocopherol concentration <12 $\mu$ mol/L [17, 18]. Serum  $\alpha$ -tocopherol concentrations of 30 $\mu$ mol/L were classified as adequacy [19, 20].

## 2.4. Statistical Analysis

All data were expressed as means  $\pm$  SD or percentage. Data analyses were performed using IBM SPSS statistics 19. Differences between subgroups were determined by Student's t-test. Pearson's coefficient was used for assessing the correlation between variables. Statistical significance was accepted at  $p < 0.05$  for all tests.

## 3. RESULTS

A total of 171 non-smoking college students participated in the study. 85.4% were female, and most of them were

**Table 1. Demographic characteristics of recruited college students.**

Characteristics	n (%) or Mean $\pm$ SD
Age	20.0 $\pm$ 1.7
17-18	30 (17.5)
19-20	92 (53.8)
21-22	34 (19.9)
$\geq$ 23	15 (8.8)
Gender	-
Male	25 (14.6)
Female	146 (85.4)
Grade	-
1st	53 (31.0)
2nd	57 (33.3)
3rd	35 (20.5)
4th or later	26 (15.2)
Smoking status	-
Yes	0 (0)
No	171 (100)
Ethnic groups	-
Han	164 (95.9)
Other	7 (4.1)
BMI (kg/m <sup>2</sup> )	20.5 $\pm$ 2.2
Underweight	29 (17.0)
Normal	133 (77.7)
Overweight	9 (5.3)
Obesity	0 (0)

Han ethnic. The participants' mean age was 20 years old and more than half of them were between 19 and 20. The mean BMI was within the healthy weight range. 77.7% had normal weight, while 17.0% were underweight and only 5.3% were overweight (Table 1).

To understand vitamin A and E deficiencies in college students, serum levels of vitamin A and E were measured. As for vitamin A, the average serum retinol was 1.76  $\pm$  0.36 $\mu$ mol/L, and the minimum concentration was 0.85 $\mu$ mol/L. Therefore, there was no vitamin A deficiency in college students (Table 2). Interestingly, serum retinol of males was significantly higher than females,  $p < 0.05$  (Fig. 1A). The average serum  $\alpha$ -tocopherol was 13.05 $\pm$ 3.06 $\mu$ mol/L. 34.5% of college students (56% for males and 30.8% for females) were evaluated as vitamin E deficiency, and there was no vitamin E adequacy in our study (Table 2). The serum  $\alpha$ -tocopherol of males were obviously lower than females,  $p < 0.05$  (Fig. 1B).

**Table 2. The status of Vitamin A and E among college students.**

Gender	Vitamin A		Vitamin E		
	Deficiency	Adequacy	Deficiency	Inadequacy	Adequacy
Males	0 (0)	25(100%)	14 (56.0%)	11 (44.0%)	0 (0)
Females	0 (0)	146(100%)	45 (30.8%)	101 (69.2%)	0 (0)
Total	0 (0)	171 (100%)	59 (34.5%)	112 (65.5%)	0 (0)

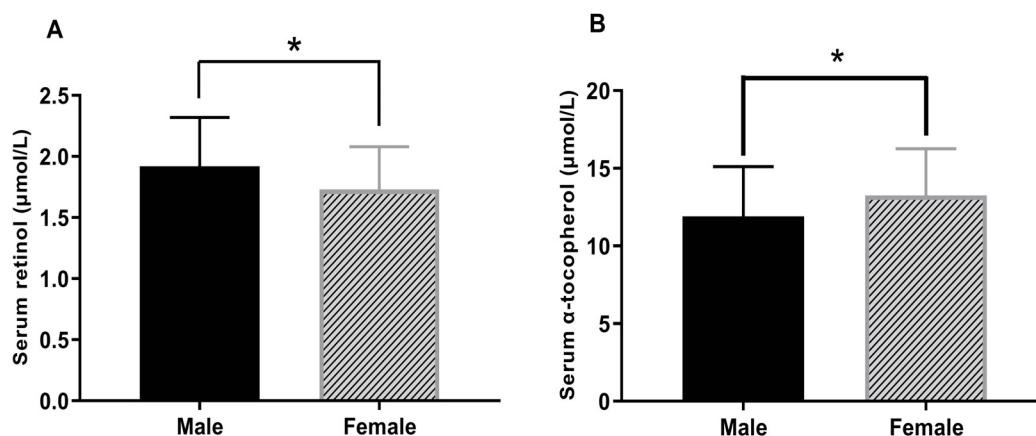


Fig. (1). (A) Serum retinol and (B)  $\alpha$ -tocopherol comparisons between gender-groups. \*significant different between two groups,  $p < 0.05$ .

Correlation analysis showed no correlation between serum retinol and BMI ( $r = -0.016$ ,  $P > 0.05$ ). Conversely, a negative correlation between serum  $\alpha$ -tocopherol and BMI was observed. With the increase in BMI, serum  $\alpha$ -tocopherol gradually decreased (Fig. 2).

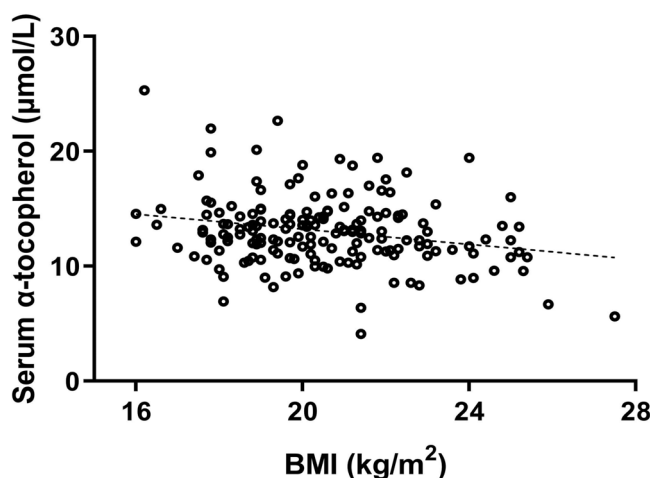


Fig. (2). The scatter diagram of serum  $\alpha$ -tocopherol and BMI. The dotted line indicates a regression line ( $r = -0.238$ ,  $P < 0.05$ ).

#### 4. DISCUSSION

Globally, an estimated two billion people are affected by a chronic deficiency of micronutrients, collectively known as hidden hunger. The term describes the invisible nature of the problem and the lack of evident symptoms of one or more deficiencies [21]. The transition from high school to college or university has been shown to be a critical period for healthy eating. Recent surveys suggest college students do not achieve dietary guidelines and have sub-optimal dietary habits. For instance, they consumed fast foods and soft drinks frequently, skipped breakfast and ate fewer vegetables, fruits, legumes and dairy products [22, 23]. Therefore, it is inferred that college students may have hidden hunger for some nutrients.

It is well known that the prevalence of vitamin A deficiency in children and women is relatively high, but we did not find vitamin A deficiency in college students based on the serum retinol. Our result was consistent with a study in Japan [24], and serum retinol in our group was significantly higher than Japanese college students ( $1.49 \pm 0.44 \mu\text{mol/L}$ ). Also, we found that male students had higher serum retinol than females, and this may be due to more vitamin A intake in male students. Although we had no records of dietary assessment, a study conducted in northern China reported that more than 40% of college students consumed less than the RNI (Recommended Nutrient Intake) of vitamin A [25]. It seems to have a contradiction with our result. The main reason may be listed limitations in their study. In addition, despite a relatively high intake of vitamin A, concentrations of retinol were still low in 30% of in-school adolescents or breastfeeding women [26, 27]. Several studies revealed that there was no significant association of serum retinol levels with total vitamin A intake [24, 28]. When food intake is within the range of general dietary averages, the relationship between blood vitamin levels and food intake of vitamins maybe not necessarily linear [29].

Inadequate vitamin E level may increase the risk of several chronic diseases, such as infection, anemia, and low academic performance [15, 30]. Multiple studies suggest poor overall vitamin E status in developing countries [14]. The  $\alpha$ -tocopherol concentration is the most commonly used biochemical marker of vitamin E status [31]. On the basis of  $\alpha$ -tocopherol concentrations  $< 12 \mu\text{mol/L}$ , 34.5% of college students was vitamin E deficiency. The most recent study in Nigeria has found that the mean of serum  $\alpha$ -tocopherol among female undergraduates was lower than our result, but only 0.6% of younger adults in American were clinically deficient [18]. Moreover, serum  $\alpha$ -tocopherol of males was lower compared with females. It was in accordance with many studies, and those had shown a greater risk of vitamin E deficiency in men than in women [32]. A recent systematic review showed that low vitamin E was harmful to semen quality [33]. Therefore, the status of vitamin E in young men is of great concern. In developing countries, the most common cause is inadequate intake of vitamin E. Although

increasing vitamin E-rich diet can increase plasma  $\alpha$ -tocopherol levels, the extent of dietary modification is difficult in practice [34]. Therefore, supplemental vitamin E appears to be the only means of appreciably raising plasma  $\alpha$ -tocopherol levels.

A number of studies demonstrate high BMI was frequently associated with lower fat-soluble vitamin concentrations [35]. The present study did not show a relation between serum retinol and BMI in young people as well as the same result obtained in elderly people [36]. With regard to the discrepancy of studies, it could be speculated that the inverse relationships were observed in morbidly obese patients and that positive relationships were observed in individuals with a higher prevalence of moderate obesity. In our study, only 5.3% of participants were overweight, and there were no obese students. Nevertheless, we identified a negative correlation between serum  $\alpha$ -tocopherol and BMI. Several other studies have shown consistent results [37, 38]. In addition, evidence from animal and human studies has proved vitamin E may be a promising agent for attenuating metabolic syndrome [39]. As an antioxidant, it protects cell membranes and lipoproteins from oxidative damage by scavenging lipid hydroperoxyl radicals and other reactive oxygen species. Besides, many studies reported the preventive role of vitamin E in cardiovascular disease due to its important effects in modulating signaling pathways and gene expression [40, 41]. Although serum vitamins may be under the influence of many factors, it could be suggested that college students should always maintain a healthy weight.

The strength of the study is that young adults were also confirmed as a key group of vitamin E deficiency in addition to children and the elderly. There are a number of limitations in this study. First, because of the cross-sectional design, the analyses of the relation between vitamins and BMI cannot presume causality. Another important limitation is the small sample size and from one medical university. Furthermore, there are more females in our study due to the features of the medical university in China.

## CONCLUSION

To sum up, our findings indicate that vitamin A status of college students is in good condition. However, a considerable proportion of college students belongs to vitamin E deficiency, especially in males. Although massive studies are focusing on vitamin D, vitamin E deficiency should also attract much attention. Based on this fact, the consumption of supplements could be a better method to achieve ideal vitamin E levels. Thus, it should be encouraged in college students, and nutritional education and appropriate approach should be undertaken to address these problems.

## AUTHORS' CONTRIBUTIONS

Zhongqi Wan, Ming Zhou and Zhong Li conceptualized the study design, Zhongqi Wan, Li Wang, Yinyang Xu, Yuanyuan Wang, Tianyou Zhang, Xinlan Mao, Qiao Li and Yangzhi Zhu carried out the study. Zhongqi Wan, Yinyang Xu and Yuanyuan Wang analyzed the data. Zhongqi Wan

drafted the manuscript, Ming Zhou and Zhong Li reviewed the manuscript. All authors approved the final version submitted for publication.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All study procedures were approved by the Medical Ethics Committee of Nanjing Medical University, Nanjing, China (Reference number: NJMUIRB2019047).

## HUMAN AND ANIMAL RIGHTS

No animals were involved in the study. All human procedures were followed in accordance with the Helsinki Declaration of 1975 as revised in 2013 (<http://ethics.iit.edu/ecodes/node/3931>).

## CONSENT FOR PUBLICATION

Written informed consent was obtained from all students prior to the publication of the study.

## AVAILABILITY OF DATA AND MATERIALS

The datasets used and/or analysed during the current study are available from the corresponding author, [MZ/ZL], on reasonable request.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

## ACKNOWLEDGEMENTS

Declared none.

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