《Original Article》

A study of the distribution range of total thiamine concentration in the blood of university students

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Abstract

Background: Currently, it can be said that there have been striking changes in daily living circumstances and there are also imbalances in dietary patterns like satiation etc and this in turn causes nutritional imbalance. Therefore, this time we paid attention to thiamine (vitamin B_1) deficiency—previously a Japanese national affliction. And we conducted an accurate condition survey of total thiamine concentration in the blood of University Students as a means of nutritional assessment.

Method: The subjects were 328 N University School of Nutritional Sciences first year students aged 18-20 (39 males, 289 females). We conducted the following tests; —anthropometric measurement, blood examination including total thiamine levels and a survey using interview sheets relating to diet and thiamine.

Results: The average ± standard deviation of total thiamine concentration in the blood was 42.8±9.5 ng/ml for males and 39.7±10.2 ng/ml for females and they were nearly within the standard value 21.3~81.9 ng/ml and there was almost a normal distribution. From this result, the number of individuals who had a lower concentration level of total thiamine concentration in the blood than the standard value was 5, all of whom were female. For each anthropometric measurement and blood examination value, the BMI for two out of five people was 18.4, and 17.1 (deemed as lean type) and three out of five people's bone density was 82%, 80% and 80% respectively which is lower than the average value for the same age generation.

Conclusion: The value of total thiamine concentration in the blood was almost in normal distribution. The number of people who had a lower than the standard value of total thiamine concentration was 5, approximately 1.5% of 328 university students. Others were within the standard value.

Key words: thiamine (vitamin B_1), university students, blood examination, nutritional status

Introduction

In recent years, in the middle of a health faddism, there has been increasing interest towards the use of medical examinations and early discovery of illness as a form of secondary prevention. In addition, preliminary prevention such as the improvement of nutrition and lifestyle habits has also gained much attention and the importance of so-called preventative medicine has become a topic of discussion.

On the other hand, the interest towards avitaminosis is decreasing, due to the current belief that vitamin deficiency has become a problem of the past. However, in fact, it can be said that there have been striking changes in daily living circumstances and also in imbalances in dietary patterns e.g. satiation etc. There has also been a prevalence of using processed food, pre-cooked food and dietary supple-

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ments etc and this causes nutritional imbalance. As a result, so-called unidentified clinical syndromes like fatigue, feeling of general malaise, decrease in immunity etc have increased and it has been reported that there is potential avitaminosis [1].

Between 1973 and 1976, thiamine deficiency diseases frequently occurred throughout Japan, there were many young people among patients at that time, especially a lot of sports players aged 15-20. There was speculation on the background reasons behind this such as, these individuals had discontinued thiamine enriched white rice, young people were drinking a lot of soft drinks containing a lot of glucides, and the young were encouraged to participate in more sporting activities [2]. After this period, due to a familiarization of nutritional knowledge combined with an introduction of multi vitamin tablets, the occurrence of thiamine deficiency diseases decreased and it seemed these were temporarily eradicated.

However, in the last few years, reports have shown an indication that the lack of thiamine in female university students has been influenced by diet orientation, missing meals and eating out etc [3]. It can be said that avitaminosis is making a revival.

In this investigation we paid attention to thiamine deficiency—previously a national affliction in Japan. And our purpose was to conduct an accurate condition survey of the total thiamine concentration in the blood among students attending the university students as a means of nutritional assessment. From this we could acknowledge the accurate conditions of the current potential deficiency conditions and considered the relationship between food intake conditions, lifestyle habits and physical status etc, we could gain basic data concerning future healthy dietary habits.

Subjects and method

In July 2008 and 2009 on two occasions, subjects from N University School of Nutritional Sciences who were first year students aged 18-20. The number of subjects was 328 (39 males, 289 females) all of whom agreed to take part in our research. We explained the research content in written form and received certificates of informed consent. This investigation had the approval of the Nagoya University of Arts and Sciences ethics committee.

As an investigation, for anthropometric measurement, we measured height, weight, BMI, body fat percentage, bone density, and blood pressure. For height, weight, body fat percentage, we used Tanita Corporation's TBF-210 and for bone density we used Aloka Corporation's ultrasonic bone evaluator ALOKA AOS-100, and we estimated each using an ultrasonic wave method.

For blood examination, the following were tested; —thiamine, white blood cells, red blood cells, hemoglobin, hermatocrit, MCV, MCH, MCHC, blood platelet count, triglycerides (neutral fat), total cholesterol, HDL cholesterol, LDL cholesterol, total whole protein, albumin, urea nitrogen, uric acid, creatinine, iron, AST, ALT, LDH, ALP, amylase, blood sugar, HbA1c (glycohemoglobin), γGTP and adiponectin. In order to conduct the total thiamine concentration in the blood, we used the HPLC method (high-performance liquid chromatography) and we outsourced to BML.INC.

For the questionnaire survey concerning diet and thiamine, we conducted it by using interview sheets, which were completed by the respondents.

We used the statistical analyzing software SPSS ver15.0J for Windows for statistical analysis. In order to examine the difference in average value we utilized the non-parametric method Mann-Whitney U test and we assigned $p<0.05$ as the significant difference.

Results

Fig. 1 shows the frequency distribution for male university students' total thiamine concentration in the blood. For 39 subjects the average ± standard deviation was 42.8±9.5 ng/ml. All subjects were within the standard value of 21.3~81.9 ng/ml and the distribution was almost normal.

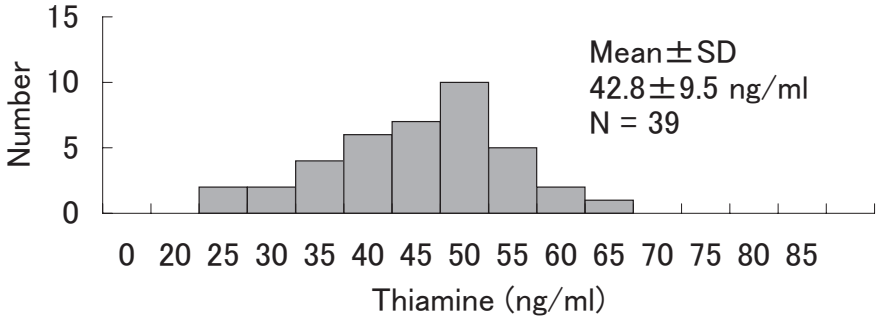

Fig. 1 Histogram of the blood total thiamine level in male students

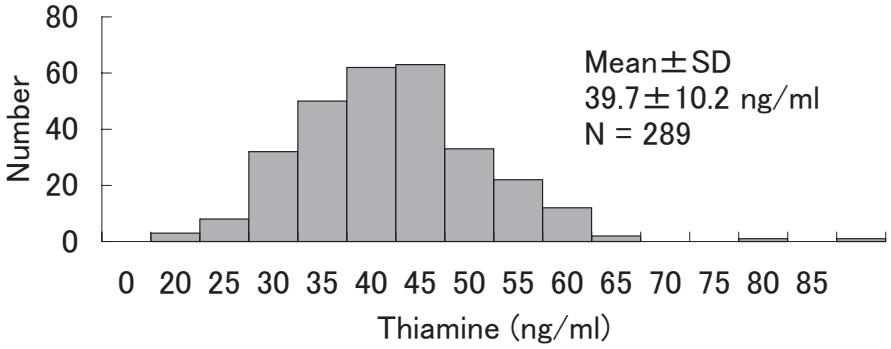

Fig. 2 Histogram of the blood total thiamine level in female students

Table 1 Profiles of subjects for total thiamine in blood (low reference values)

	A	B	C	D	E
Thiamine (ng/ml)	11.4	16.6	19.9	20.8	21.3
Gender	female	female	female	female	female
Age	19	19	19	19	19
Height (cm)	149.1	154.7	159.5	155.4	152.0
Weight (kg)	40.9	56.1	47.4	41.4	48.7
BMI (kg/m^2)	18.4	23.4	18.6	17.1	21.1
%Fat (%)	19.7	31.7	21.7	16.6	27.6
BMD (YAM%)	99	82	95	80	80
SBP (mmHg)	82	93	96	86	118
DBP (mmHg)	58	59	66	59	65

BMI: body mass index, %Fat: percent body fat, BMD: bone mineral density, SBP: systolic blood pressure, DBP: diastolic blood pressure

On the other hand Fig. 2 shows the frequency distribution for female university students' total thiamine concentration in the blood. For 289 subjects the average ± standard deviation was 39.7±10.2 ng/ml. Within this group 283 were within the standard value and 6 were outside the standard value. The distribution was almost normal, the same as males.

For females, there were 5 subjects whose total thiamine concentration in the blood was lower than the standard value. We named these 5 subjects A~E and Table 1-2 shows each of their anthropometric measurements and blood examination values. From the results, we can see that for two out of 5 people's BMI was 18.4 and 17.1 (deemed as lean type) and three out of 5 people's bone density was 82%, 80% and 80% respectively which is lower than the aver-

Table 2 Hematological parameters of subjects for total thiamine in blood (low reference value)

	A	B	C	D	E
WBC (/mm^3)	5450	3370	5470	5200	8990
RBC (10^4/mm^3)	406	402	460	430	572
Hgb (g/dl)	12.3	12.3	14.1	11.4	13.0
Hct (%)	38.8	37.6	42.9	36.0	41.0
MCV (fl)	96	94	93	84	72
MCH (pg)	30.3	30.6	30.7	26.5	22.7
MCHC (%)	31.7	32.7	32.9	31.7	31.7
PLT (10^4/mm^3)	20.7	18.1	24.4	29.1	22.1
TG (mg/dl)	84	47	65	37	44
T-CHO (mg/dl)	158	193	202	143	150
HDL-CHO (mg/dl)	73	93	76	60	71
LDL-CHO (mg/dl)	77	80	118	78	70
TP (g/dl)	7.5	7	7.2	6.7	7.7
Alb (g/dl)	4.9	4.5	4.8	4.2	4.7
BUN (mg/dl)	20.0	10.5	10.0	10.6	10.6
UA (mg/dl)	4.3	3.9	4.0	4.8	5.6
CRE (mg/dl)	0.5	0.6	0.7	0.6	0.8
SI (μg/dl)	52	111	66	37	112
AST (IU/L)	20	16	16	20	19
ALT (IU/L)	17	10	13	7	10
LDH (IU/L)	225	162	158	139	176
ALP (IU/L)	197	235	161	206	247
AMY (IU/L)	96	107	118	58	91
Glc (mg/dl)	94	84	95	90	94
HbA1c (%)	5.6	4.8	5	5.2	5.3
γGTP (IU/L)	17	14	20	8	17
Adi (μg/mL)	17.0	14.6	13.3	17.8	11.4

WBC: white blood cell, RBC: red blood cell, Hgb: hemoglobin, Hct: hematocrit, MCV: mean corpuscular volume, MCH: mean corpuscular hemoglobin, MCHC: mean corpuscular hemoglobin concentration, PLT: platelet, TG: triglyceride, T-CHO: total cholesterol, HDL-CHO: high-density lipoprotein cholesterol, LDL-CHO: low-density lipoprotein cholesterol, TP: total protein, Alb: albumin, BUN: blood urea nitrogen, UA: uric acid, CRE: creatine, SI: serum iron, AST: aspartate aminotransferase, ALT: alanine aminotransferase, LDH: lactate dehydrogenase, ALP: alkaline phosphatase, AMY: amylase, Glc: glucose, HbA1c: hemoglobin A1c, γGTP: γ-glutamyl transpeptidase, Adi: adiponectin

Table 3 Mean of profiles in low and normal thiamine level

	Mean±SD		
	Low thiamine level (n=5)	Normal thiamine level (n=284)	Significant probability
Thiamine (ng/ml)	18.0 ± 4.1	40.1 ± 9.9	0.000***
Height (cm)	154.1 ± 3.9	158.3 ± 5.4	0.079
Weight (kg)	46.9 ± 6.2	50.7 ± 6.9	0.221
BMI (kg/m^2)	19.7 ± 2.5	20.2 ± 2.3	0.567
%Fat (%)	23.5 ± 6.1	24.5 ± 9.3	0.687
BMD (YAM%)	87.2 ± 9.1	96.1 ± 10.3	0.061
SBP (mmHg)	95 ± 14	107 ± 11	0.032*
DBP (mmHg)	61 ± 4	66 ± 8	0.104

BMI: body mass index, %Fat: percent body fat, BMD: bone mineral density, SBP: systolic blood pressure, DBP: diastolic blood pressure

* $p<0.05$ *** $p<0.001$

The non-parametric method Mann-Whitney U test

Table 4 Mean of hematological parameters in low and normal thiamine level

	Mean±SD		
	Low thiamine level (n=5)	Normal thiamine level (n=284)	Significant probability
WBC (/mm^3)	5696 ± 2038	6179 ± 1429	0.415
RBC (10^4/mm^3)	454 ± 70	453 ± 30	0.372
Hgb (g/dl)	12.6 ± 1.0	13.3 ± 1.1	0.084
Hct (%)	39.3 ± 2.7	40.8 ± 2.8	0.177
MCV (fl)	87.8 ± 10.0	90.3 ± 5.1	0.922
MCH (pg)	28.2 ± 3.5	29.5 ± 2.2	0.597
MCHC (%)	32.1 ± 0.6	32.7 ± 1.1	0.085
PLT (10^4/mm^3)	22.9 ± 4.2	23.5 ± 5.2	0.744
TG (mg/dl)	55.4 ± 19.0	71.3 ± 36.5	0.300
T-CHO (mg/dl)	169.2 ± 26.6	174.8 ± 30.5	0.666
HDL-CHO (mg/dl)	74.6 ± 11.9	65.0 ± 11.9	0.081
LDL-CHO (mg/dl)	84.6 ± 19.0	99.7 ± 26.7	0.110
TP (g/dl)	7.2 ± 0.4	7.5 ± 0.3	0.128
Alb (g/dl)	4.6 ± 0.3	4.6 ± 0.2	0.838
BUN (mg/dl)	12.3 ± 4.3	12.0 ± 2.7	0.690
UA (mg/dl)	4.5 ± 0.7	4.3 ± 0.8	0.543
CRE (mg/dl)	0.6 ± 0.1	0.6 ± 0.1	0.942
SI (μg/dl)	75.6 ± 34.3	90.9 ± 39.2	0.398
AST (IU/L)	18.2 ± 2.0	17.0 ± 3.7	0.157
ALT (IU/L)	11.4 ± 3.8	12.2 ± 6.4	0.948
LDH (IU/L)	172.0 ± 32.4	173.3 ± 24.4	0.697
ALP (IU/L)	209.2 ± 33.8	196.9 ± 50.7	0.367
AMY (IU/L)	94.0 ± 22.7	82.2 ± 24.2	0.185
Glc (mg/dl)	91.4 ± 4.6	86.7 ± 7.4	0.055
HbA1c (%)	5.2 ± 0.3	5.1 ± 0.2	0.368
γGTP (IU/L)	15.2 ± 4.5	15.4 ± 4.2	0.635
Adi (μg/mL)	14.8 ± 2.6	11.1 ± 4.4	0.026*

WBC: white blood cell, RBC: red blood cell, Hgb: hemoglobin, Hct: hematocrit, MCV: mean corpuscular volume, MCH: mean corpuscular hemoglobin, MCHC: mean corpuscular hemoglobin concentration, PLT: platelet, TG: triglyceride, T-CHO: total cholesterol, HDL-CHO: high-density lipoprotein cholesterol, LDL-CHO: low-density lipoprotein cholesterol, TP: total protein, Alb: albumin, BUN: blood urea nitrogen, UA: uric acid, CRE: creatine, SI: serum iron, AST: aspartate aminotransferase, ALT: alanine aminotransferase, LDH: lactate dehydrogenase, ALP: alkaline phosphatase, AMY: amylase, Glc: glucose, HbA1c: hemoglobin A1c, γGTP: γ-glutamyl transpeptidase, Adi: adiponectin
* $p<0.05$
The non-parametric method Mann-Whitney U test

age value (100%) for the same age generation. As a reference, from the remaining 284 female subjects there were 65 subjects (approximately 23% of the total) with a BMI of below 18.5. There were 77 subjects with a bone density measurement of below 80% and 89% (approximately 27% of the total).

In addition, Table 3-4 shows the average ± standard deviation. One table was for 5 subjects whose total thiamine concentration in the blood was lower than the standard value and the other table was for the remaining 284 female subjects. Results showed that the average value for systolic blood pressure of the 5 subjects, who were below the standard value, was significantly lower than the other female subjects.

Discussion

Currently, a number of inspection institutes have agreed that the standard value for the lower limit of total thiamine concentration in the blood is under 20 ng/ml, therefore in clinical settings it is rare to diagnose thiamine deficiency. In this investigation, results showed that the number of people who had a

lower standard value for total thiamine concentration in the blood was 5 which was approximately 1.5% of the total for both males and females. However, conversely, various literature has reported that there are people who show symptoms of deficiency diseases despite their total thiamine concentration in the blood being within the standard value. Due to this, there are some who feel that the standard value lower limit is 30 ng/ml [1) 4)]. As a reference, in this investigation the number of those lower than 30 ng/ml was 47 out of 328 males and females which is as much as approximately 14% of the total. From this it is difficult to deny that the potential of thiamine deficiency remains.

In addition, we showed each anthropometric measurement and blood examination values of 5 females whose total thiamine concentration in the blood was lower than the standard value 21.3 ng/ml. Results showed there were people who showed low values for BMI and bone density, it could be suggested that there is the possibility that accompanying low values for thiamine concentration in the blood cause low nutrient condition.

As well as this, in the questionnaire surveys concerning diet and thiamine responses showed that all five had no habit to intake unpolished (whole) rice or brown rice for regular meals. Generally, particular good sources supplying thiamine are unpolished rice, brown rice and pork etc [5)]. In this investigation, we indicate that people who have no habit to intake unpolished rice or brown rice for their everyday meals may have the possibility of lower levels of thiamine concentration.

Conversely, we compared the average values of 5 subjects whose total thiamine concentration in the blood were lower than the standard value and the remaining 284 female subjects. Results showed that, the average value for systolic blood pressure of the 5 subjects (below the standard value) was significantly lower than the other female subjects. However, we were unable to see any significant feature common in the subjects which could lead to a lack of thiamine. We need to continuously review the relationship between thiamine, physical condition and lifestyle habits.

From now, it is important to know the relationship between various causes and thiamine nutritional status. For instance the influence of carrying out exercise on thiamine is an issue worth watching. Thiamine mainly works as a co-enzyme of a carbohydrate metabolic enzyme and a deficiency brings subjective symptoms like whole body feeling of malaise, fatigue, palpitation and shortness of breath etc, so it is an important nutrient for maintaining bodily functions. It has been said that when we exercise, energetic metabolism becomes active and this increases the necessary quantity of thiamine and if there are inadequate levels of thiamine for the consumption of glucose, there can be no smooth metabolism from pyruvic acid to acetyl-CoA. The increased production of lactic acid from pyruvic acid leads to an accumulation of lactic acid which causes fatigue [6) 7) 8)].

Currently, the necessary amount of thiamine can be determined as a standard of energy/1000kcal [9)]. When we exercise it is often recommended that we redeem an increased amount of energy intake by consuming meals which are well balanced including increasing both staple and side dishes [5)] however, experimental data supporting this argument is extremely low.

Conversely, in recent years, the most crucial assignment has been preserving elderly people's health in our upcoming ageing society in Japan. Elderly people's lifestyles are extremely varied; there are healthy old people, but also many old people with some type of disease. It has been reported that among elderly people with thiamine deficiency diseases, there were many who had the following type of health problems previously. These include, over-consumption of alcohol (polyposia) and bad nutrition, diabetes and gastrectomy etc [10) 11)].

In addition, there has been the problem of elderly people lacking nutritional intake like vitamins. For example, it has been reported that for long term hospitalized elderly people the intake amount of

thiamine was extremely low, and at the same time, nutritional conditions of thiamine in the blood were extremely bad [12]. The cause of this is that the amount of elderly people's food intake is low as in when they fail to finish hospital meals etc and this report says that we need to reconsider the nutritional care for elderly hospitalized patients.

As a countermeasure for elderly people's health especially lifestyle diseases, we should emphasize prevention rather than care. Among the various types of prevention, preliminary prevention which is dissociated from its cause is most effective. And it has been considered that diet has the highest impact on preliminary prevention. Therefore, having an adequate intake of minor components like vitamins etc has become an essential condition to prevent elderly people's vitamin deficiency and helps in the preservation of health.

From this, as of now, it is necessary to investigate exercise or elderly people's lack of nutritional intake etc. We hope that the consideration of general university students' nutritional conditions of thiamine in this paper will be future basic data.

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和文抄録

大学生における全血総ビタミン B_1 濃度分布範囲の検討

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要旨

背景：現在、日常生活環境･習慣の急激な変化や、飽食などによる食生活パターンの顕著な変化と乱れが指摘され、栄養のアンバランスがもたらされている。そこで今回、かつて日本人の国民病とされてきたビタミン B_1 欠乏に注目し、栄養評価としての大学生の全血総ビタミン B_1 濃度の実態調査を行った。

方法：N 大学管理栄養学部生 1 年生18～20歳の328名（男性39名、女性289名）を対象とし、身体測定、全血総ビタミン B_1 を含む血液検査、食生活やビタミン B_1 に関する問診票による調査を行った。

結果：全血総ビタミン B_1 濃度の平均値±標準偏差は、男性が42.8±9.5 ng/ml、女性が39.7±10.2 ng/ml であり、ほぼ基準値21.3～81.9 ng/ml 内で、かつほぼ正規分布していた。このうち全血総ビタミン B_1 濃度が基準値以下の者は 5 名であり、いずれも女性であった。それぞれの身体測定値および血液検査値において 5 名中 2 名の BMI が18.4、17.1とやせ型であり、5 名中 3 名の骨密度が同年代の平均値と比べて82%、80%、80%と低い値を示した。

結論：大学生328名において全血総ビタミン B_1 濃度が基準値以下の者は 5 名（全体の約1.5%）であり、その他はほぼ基準値内で、かつほぼ正規分布していた。

索引用語：ビタミン B_1、大学生、血液検査、栄養状態

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