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RESEARCH ARTICLE

Prevalence of Biochemical Thiamine Deficiency in a Non-large Urban Population of Individuals with Obesity: A Retrospective Study

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Abstract

Background: Previous studies of individuals with obesity in large urban populations identified biochemical or clinical thiamine deficiency in 15.5% to 29% of individuals. The prevalence of biochemical thiamine deficiency in a non-large urban, obese population is not well defined.

Methods: Consecutive patients with obesity (n=400) had been seen in gastroenterology clinic. Individuals (n=23) are excluded from this study because of specific diagnoses. Whole blood thiamine was completed in 130 individuals who had complaints of dysphagia, nausea & vomiting, constipation, abdominal distension, or symptoms of peripheral neuropathy.

Results: Men comprised 84% of the 130 subjects with 83% identified as white men and 17% as black men. There were 64 individuals (49%) with type 2 diabetes. Four individuals (3%) have biochemical thiamine deficiency of whom two (50%) have type 2 diabetes. Two thiamine deficient individuals have dysphagia as a complaint, one has nausea/vomiting, and one has peripheral neuropathy.

Conclusions: Despite the high percentage of individuals with type 2 diabetes and enrollment of patients with symptoms consistent with thiamine deficiency, there was a low prevalence of biochemical thiamine deficiency in individuals with obesity in this non-large urban population. Potential explanations for this result may include dietary thiamine intake differences, a higher rate of thiamine supplementation, or lower body mass index. A whole blood thiamine level is unlikely to be useful when screening for thiamine deficiency, but supplemental thiamine may be helpful in determining whether a patient with a suggestive gastrointestinal symptom has thiamine deficiency.

Keywords: Vitamin B1; Micronutrient; Biochemical Marker; Deficiency, Vitamin B; Body Size.

1. Introduction

Obesity represents a Body Mass Index ≥ 30 kg/m^2, while overweight represents a Body Mass Index ≥ 25 kg/m^2 per the World Health Organization [1]. From 1980 to 2019, there was a continued worldwide rise in the prevalence of obesity so that obesity now includes 12.2% of men and 15.8% of women [2]. One of the concerns resulting from this rise in obesity is that micronutrient deficiencies that may promote disease development have been frequently identified in individuals with obesity [3-6].

Among the vitamin micronutrient deficiencies, thiamine deficiency is the most serious because thiamine pyrophosphate is the required substrate for initiation of the Krebs cycle [7, 9]. Thiamine deficiency can therefore lead to symptoms of multiorgan

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dysfunction that can be difficult to elucidate [8-9]. In a previous study of individuals with obesity in a large urban population, our group identified a16.5% prevalence of clinical thiamine deficiency [8]. This finding was in agreement with previously reported 15.5% to 29% prevalence of biochemical thiamine deficiency in individuals with obesity in large urban populations [9-11].

The importance of the linkage of obesity with type 2 diabetes mellitus is further supported by the finding of thiamine deficiency in individuals with type 2 diabetes mellitus [12]. Hyperglycemia-driven impaired uptake of thiamine in the kidneys [13] and increased clearance of thiamine [14] are mechanisms that have been proposed to explain lower blood thiamine levels in patients with type 2 diabetes mellitus.

The dearth of information, with regards to the prevalence of biochemical thiamine deficiency in obese individuals in a non-large urban population, and the linkage of obesity with type 2 diabetes mellitus have been used to design this present study.

Our hypothesis is that individuals with obesity who have both a symptom suggesting thiamine deficiency and type 2 diabetes in a non-large urban population have a higher prevalence of biochemical thiamine deficiency. In this retrospective study, we examine the prevalence of biochemical thiamine deficiency in individuals who have a symptom suggesting thiamine deficiency and either have been diagnosed with type 2 diabetes mellitus or have not been diagnosed with type 2 diabetes mellitus.

2. Methods

2.1 Study Population

All procedures performed in studies using human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Approval for human studies was obtained from the Salem VA Medical Center Institutional Review Board on September 28, 2021.

The Institutional Review Board decided that this was an exempt protocol and granted a waiver of informed consent for this research study. This is a single center, retrospective study of consecutive non-large urban patients with obesity (n=400) who were seen in gastroenterology clinic. Individuals (n=23) who have a diagnosis of Celiac disease, who did not complete a whole blood thiamine level, who have had prior stomach surgery or bariatric surgery, or who first exhibited their symptom during Persian Gulf exposure have been excluded from this study. Whole blood thiamine determination was completed in 130 individuals who described symptoms suggestive of thiamine deficiency [8-9],which included dysphagia, nausea and vomiting, constipation (as defined in this study as 3 or fewer bowel movements per week), abdominal distension/bloating, or peripheral neuropathy (which included complaints of paresthesias or weakness).

2.2 Data Collection

In this study, for all patients identified as having had a whole blood thiamine level, the following data were collected: status of the diagnosis of type 2 diabetes mellitus, symptoms suggestive of thiamine deficiency, use of a daily multivitamin or daily thiamine supplement, age, sex, weight, body mass index, and racial background.

2.3 Measurement of Whole-Blood Thiamine

Patients with symptoms suggestive of thiamine deficiency had been offered measurement of fasting whole-blood thiamine concentration. Determination of whole-blood thiamine concentration was completed by high performance liquid chromatography with fluorescence detector [15].

Normal whole blood thiamine in this assay is defined by a whole blood thiamine level>/= 78 nmol/L. In evaluation of whole-blood thiamine concentrations, a measurement that was less than the lower limit of the reference range was accepted as being consistent with biochemical thiamine deficiency.

2.4 Statistical Analysis

A power analysis could not be performed due to the retrospective organization of our present study. We were unsure of what the effect size would be. Statistical analysis was performed using StatView for Windows, SAS Institute Inc., Cary, NC, USA. Descriptive statistics were calculated for all variables.

3. Results

3.1 Patient Population

The demographics of the patient population are summarized in Table 1. Men comprised 109 (84%) of the 130 subjects. Ninety men (83%) identified themselves as white and nineteen (17%) as black, while sixteen women identified themselves as white (76%) and five as black (24%). There are 64 individuals (49%) with type 2 diabetes. A daily multivitamin was being taken by 26 individuals (20%), while a daily thiamine supplement was being taken by 5 individuals (4%).

Table 1. *Demographics of 130 Individuals with Obesity*

	MEAN	STANDARD DEVIATION	RANGE
AGE	60.3 Years Old	11.9	28 to 86 Years Old
BODY MASS INDEX	36.1 kg/m^2	5.1	30.1 to 61.8 kg/m^2
WEIGHT	245 lbs.	40	165 to 441 lbs.

3.2 Patient Symptoms

As seen in Table 2, a small fraction of the patients had more than one symptom suggestive of thiamine deficiency. Symptoms of peripheral neuropathy (paresthesias or weakness) were the most commonly reported symptoms, while dysphagia was the most commonly reported gastrointestinal symptom.

Table 2. *Symptoms Suggestive of Thiamine Deficiency*

SYMPTOM	NUMBER OF PATIENTS	% OF TOTAL NUMBER
PERIPHERAL NEUROPATHY	79	61%
DYSPHAGIA	39	30%
NAUSEA AND VOMITING	13	10%
ABDOMINAL DISTENSION	22	17%
CONSTIPATION	26	20%

3.3 Biochemical Thiamine Deficiency

Four individuals (3%) have biochemical thiamine deficiency. Two of these patients (50%) have type 2 diabetes. Two individuals with biochemical thiamine deficiency have dysphagia as a complaint, one has nausea/vomiting, and one has a symptom of peripheral neuropathy (paresthesias). Oral thiamine supplements were recommended for all 4 patients who were then referred back to their Primary Care Providers for follow-up.

4. Discussion

The result of this study did not support our hypothesis that individuals with obesity who have both a symptom suggesting thiamine deficiency and type 2 diabetes in a non-large urban population have a higher prevalence of biochemical thiamine deficiency.

Despite the high percentage of individuals with type 2 diabetes and enrollment of patients with symptoms consistent with thiamine deficiency, there was only a 3% prevalence of biochemical thiamine deficiency in individuals with obesity in this specificpatient population. This present result was quite different compared to reports in large urban populations of 15.5% to 29% prevalence of biochemical or clinical thiamine deficiency.

Our finding suggests that a whole blood thiamine level is unlikely to be useful when screening for thiamine deficiency in patients with gastrointestinal symptoms that suggest thiamine deficiency. Based on our previous study of clinical thiamine deficiency, prescribing supplemental thiamine may be helpful in determining whether a patient with a suggestive gastrointestinal symptom has sub-clinical thiamine deficiency [8].

The most common complaint in this present study were symptoms of peripheral neuropathy (paresthesias or weakness) while the most common gastrointestinal complaint was dysphagia. These were not surprising findings due to the high prevalence (49%) of type 2 diabetes mellitus in this patient population and the known high frequency of peripheral neuropathy in diabetes. In clinical settings, thiamine deficiency has generally only been considered when an individual with alcohol dependence presents with a gait disorder orophthalmo-psychiatric symptoms.

Gastrointestinal symptoms suggesting thiamine deficiency are not commonly considered and could be overlooked. Subclinical thiamine deficiency in at risk patients, such as obese individuals or individuals with alcoholic cirrhosis, could present with symptoms that are vague, chronic in nature, or previously evaluated by using endoscopy. Thiamine deficiency should therefore be considered in at risk individuals who present with gastrointestinal symptoms.

In this study, we attempted to identify an increase in the prevalence of thiamine deficiency by studying individuals with obesity who did and who did not have type 2 diabetes mellitus. Prior studies have supported a linkage between type 2 diabetes and the presence of thiamine deficiency [12, 16]. A decrease in plasma thiamine concentrations of 75% in type 2 diabetic patients has been reported [16]. As a potential mechanism to explain this finding, renal clearance of thiamine was reported to be increased16-fold in individuals with type 2 diabetes as compared to normal volunteers [16]. It is not clear why we did not identify any increase in the prevalence of biochemical thiamine deficiency in obese individuals with type 2 diabetes mellitus.

Potential factors that might reduce the identification of biochemical thiamine deficiency include the patients' dietary intake of thiamine, the patients' intake of vitamin supplements, the Body Mass Index of the patients, and the use of whole blood thiamine as a marker for biochemical thiamine deficiency.

We have not yet attempted to use food diaries to try to estimate dietary intake of thiamine because our primarily rural population may prepare their own meals rather than purchasing ultra-processed foods. Review of our patients' medical records revealed that a daily multivitamin was being taken by 26 individuals (20%), while a daily thiamine supplement was being taken by 5 individuals (4%).

Therefore, about one-fourth of our patients were receiving daily supplements containing thiamine. In our previous study of clinical thiamine deficiency in a large urban population, we reported that there was a significant statistical relationship between thiamine deficiency and Body Mass Index [8]. The mean Body Mass Index in this present study was 36.1 kg/m^2(which corresponds to Class II Obesity, on average).

It has been previously suggested that urinary thiamine excretion and whole blood thiamine concentration may not be reliable measurements of thiamine status [17]. Since thiamine activity is mainly intracellular, whole blood thiamine levels may not reflect marginal thiamine deficiency. In addition, underlying disorders (e.g. protein malnutrition) might alter results obtained using an assay. Other assays to examine the potential presence of biochemical thiamine deficiency, such as functional enzymatic assays, have not yet been validated in all patient populations.

This study has additional limitations which include the enrollment of a large percentage of older, white men in this study. This study may therefore not be applicable to all non-large urban patient populations. It also has the usual limitations related to its organization as a retrospective study, including the utilization of an inferior level of evidence when compared to a prospective study.

5. Conclusion

The result of this study did not support our hypothesis that individuals with obesity who have both a symptom suggesting thiamine deficiency and type 2 diabetes in a non-large urban population have a higher prevalence of biochemical thiamine deficiency. Potential explanations for the present result may include differences in dietary thiamine intake, a higher rate of thiamine supplementation, or lower body mass index. Our finding suggests that a whole blood thiamine level is unlikely to be useful when screening for thiamine deficiency in patients with gastrointestinal symptoms that suggest thiamine deficiency. Prescribing supplemental thiamine may be helpful in determining whether a patient with a suggestive gastrointestinal symptom has sub-clinical thiamine deficiency.

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