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Original Research

Hubungan antara Status Kontrol Glikemik, Vitamin D dan Gizi pada Anak Diabetes Melitus Tipe 1

Relationship between Glycemic, Vitamin D and Nutrition Status Control in Children with Type 1 Diabetes Mellitus

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ABSTRAK

Di beberapa negara barat kasus DM tipe-1 adalah 5-10% dari kasus diabetes, dan lebih dari 90% penderita diabetes pada anak dan remaja adalah DM tipe-1. Vitamin D berperan penting dalam membangun dan memelihara mineralisasi tulang. Defisiensi vitamin D dapat menyebabkan penekanan bone turnover sehingga menyebabkan gangguan kecepatan tinggi badan. Kontrol glikemik yang buruk berupa HbA1c yang tinggi dapat menyebabkan berat dan tinggi badan tidak naik secara adekuat. Penelitian ini bertujuan untuk membuktikan hubungan antara status kontrol glikemik(HbA1c), status vitamin D (25(OH)D), dan status gizi pada anak DM tipe-1. Desain penelitian berupa studi *cross-sectional* dilakukan pada 28 subjek penelitian yaitu anak DM tipe 1 usia 1-18 tahun yang menjalani rawat jalan di Poli Endokrinologi Rumah Sakit Umum dr. Saiful Anwar Malang. Kriteria eksklusi yaitu menderita penyakit autoimun lain, infeksi berat, gangguan hati, gangguan fungsi ginjal dan anemia. Variabel yang diukur status gizi, kadar HbA1c dan 25(OH)D. Untuk mengetahui perbedaan rerata kadar 25(OH)D dan HbA1c berdasarkan status gizi digunakan uji beda Kruskal wallis, dan uji korelasi Spearman. Dari 28 subjek didapatkan 68% anak dengan status gizi baik, 64% anak dengan kontrol metabolik buruk dan 61% anak dengan defisiensi/insufisensi 25(OH)D. Tidak terdapat hubungan yang bermakna antara status gizi, kontrol glikemik, dan vitamin D.

Kata Kunci: Diabetes melitus tipe 1, HbA1c, status gizi, status kontrol glikemik, status vitamin D

ABSTRACT

In some western countries, type-1 diabetes cases are 5-10% of diabetes cases, and more than 90% of diabetics in children and adolescents are type 1 DM. Vitamin D plays an important role in building and maintaining bone mineralization. Vitamin D deficiency can cause bone turnover suppression, thus causing height growth disorders. Poor glycemic control in the form of high HbA1c can cause weight and height not to increase adequately. This study aimed to prove the relationship among control glycemic status (HbA1c), vitamin D status (25(OH)D), and nutritional status in children with type-1 DM. The study design was a cross-sectional study conducted on 28 research subjects, namely children with type 1 DM aged 1-18 years who underwent outpatient care at the Endocrinology Polyclinic of Dr. Saiful Anwar General Hospital Malang. The exclusion criteria were suffering from other autoimmune diseases, severe infections, liver disorders, impaired kidney function, and anemia. Variables measured were nutritional status, HbA1c, and 25(OH)D levels. To find out the differences in the mean levels of 25(OH)D and HbA1c based on nutritional status, Kruskal wallis test and Spearman correlation test were used. Of the 28 subjects 68% of children were found with good nutritional status, 64% of children with bad metabolic control, and 61% of children with 25(OH)D deficiency/insufficiency. There is no significant relationship between nutritional status, glycemic control, and vitamin D.

Keywords: *Control glycemic status, HbA1c, nutrition status, type 1 diabetes mellitus, vitamin D status*

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INTRODUCTION

Type 1 diabetes mellitus (DM) is one of the chronic diseases that until recently could not be cured (1,2). This disease is a chronic disease with disrupted metabolism of carbohydrate, fat, and protein due to insulin deficiency as a result of autoimmune pancreatic beta cell destruction (3).

The incidence of type 1 DM varies greatly among countries and within a country. In several western countries, type 1 DM cases are 5-10% of all diabetes cases, and more than 90% of diabetics in children and adolescents are type 1 diabetes mellitus. The highest incidence is in Finland that is 43/100,000 and the lowest incidence is in Japan at 1.5-2/100,000 among children below 15 years old (2,3). The incidence of type 1 diabetes is higher in Caucasians compared to other races. It is estimated that throughout the world 80,000 children aged below 15 years will develop type 1 diabetes mellitus. Until 2014, the national registry data of type 1 diabetes mellitus in children from the Board of Central Indonesian Medical Association revealed 1021 cases (4). At Dr. Saiful Anwar Hospital (RSSA) Malang from 2011 to 2016, there were 60 type 1 diabetes mellitus patients aged 1-18 years (5).

The etiology of multifactorial type 1 DM includes genetic factors, environment, and immune system. The mechanism of β cell destruction is still under debate, but it is clear that the involvement of the immune system, i.e. macrophages and T cells, and cytokines is very big. Inflammatory factors, reactive oxygen species, and autoimmune reactions appear as pathogenic effectors of type 1 DM (6-9).

Vitamin D deficiency can increase the risk of developing autoimmune diseases including type 1 DM due to the loss of vitamin D modulation to the immune system and inflammatory reactions in diabetes (6,10,11). In vitro studies have shown that vitamin D is immunosuppressive or as an immunomodulator while studies on experimental models of autoimmune diseases, including type 1 DM, show that vitamin D is protective. Other observational studies also showed a positive correlation among vitamin D level, insulin sensitivity, and pancreatic beta cell function (11). In the skeleton, vitamin D has a very important role in building and maintaining bone mineralization. Bone growth requires calcium and $1,25(OH)_2$ D to build optimal bone osteoblastic formation (12).

The involvement of genetic factors, environment, and autoimmune process is a mechanism that plays a role in the occurrence of type 1 DM. The interaction between genetic factors and environment triggers an immune response in a form of an autoimmune process. Vitamin D is a hormone that is synthesized in the body and acts on various organs through vitamin D receptor (VDR). Most people with type 1 DM experience vitamin D deficiency, because of either lacking UV exposure or inadequate vitamin D intake. A low 25(OH)D level can affect the immune system in various ways, thus resulting in pathogenic immune response and triggering pancreatic β cell destruction. In the process of pancreatic β cell destruction, there are infiltrations to Langerhans islands by inflammatory cells through selective and specific destruction of pancreatic β cells thus causing insulitis and decreased insulin levels (7-9). If the insulin level drops, hyperglycemia will occur which, if chronic, results in increasing HbA1c as an indicator of glycemic control. In uncontrolled type-1 DM, a disruption of nutritional status occurs. Insulin deficiency in type-1 DM will reduce glucose uptake by muscles, soft tissue, splanic tissue, and there will be an increase in glycogenolysis and gluconeogenesis, reduced amino acid uptake and protein synthesis, resulting in less muscle nitrogen fulfillment. Protein catabolism also increases, so clinically muscle mass in the peripheral tissue decreases resulting in weight loss (4).

Children with diabetes are at risk of developing growth disorders due to the disease process or its complications. Poor metabolic control can result in impaired growth (weight and height do not adequately increase) and late development of puberty (Mauriac syndrome) (4,13). A study in India showed children with type 1 diabetes aged 4-16 years had a lower height velocity than healthy children (14). Growth monitoring needs to be done in children with diabetes so that adequate management can be carried out, thus they can achieve optimal final height according to the general population (4).

Glycemic control is associated with microvascular and macrovascular complications. Good glycemic control can improve the life quality of patients with type 1 diabetes. A high level of HbA1c indicates poor glycemic control. Vitamin D status is one of the factors associated with glycemic control in children and adolescents with Type 1 DM (15). Poor metabolic control can result in impaired nutritional status and growth. Vitamin D has an important role in bone growth. This study was conducted to determine the relationship among vitamin D status (25 (OH) D), glycemic control status, and nutritional status in children with type 1 DM.

METHOD

This study was an analytical observational study with a cross-sectional design that measured vitamin D level (25(OH)D), HbA1c, and nutritional status (based on body weight and height) in children with type 1 DM. The population of this study was type 1 DM children who underwent outpatient care at the Endocrinology Clinic of Dr. Saiful Anwar General Hospital Malang from October 2017 to December 2017 and routinely got insulin therapy and have not received vitamin D supplementation therapy.

In accordance with the calculation, the minimum sample size was 13 samples (16), in this study 28 samples were involved. Sample inclusion criteria included type 1 DM classified, aged between 2 to 18 years, and parents agreed to take part in the study. Patients with type 1 diabetes mellitus who suffer from other autoimmune diseases, severe liver disorders, kidney function disorders, and anemia were not included in this study. Type 1 DM patients were determined based on one of the following criteria, i.e. (1) hyperglycemia symptoms including polyuria, polydipsia, weight loss, and random blood plasma glucose level >200 mg/dl (11.1 mmol/L), (2) fasting blood glucose (> 8 hours) ≥126 mg/dl (≥7.0 mmol/L), (3) in patients with asymptomatic, random blood glucose level was > 200mg/dl or fasting blood glucose level was higher than normal with more than one examination of impaired

glucose tolerance tests. This research was approved by the Ethics Commission of Saiful Anwar Hospital Malang No. 4000/01/K.3/302/2018.

Vitamin D level was the 25(OH)D level that was measured in plasma using the enzyme-linked Immuno Assay (ELISA) method. Serum 25(OH)D level was classified into: normal > 30ng/ml, insufficiency 21-29ng/ml, and deficiency < 20ng/ml. HbA1c was glucose bound to hemoglobin (glycated hemoglobin) which served to see the average blood glucose level in 3 months. The examination was measured by using Bio-Rad D-10™ at the Clinical Pathology Central Laboratory RSSA Malang. The following criteria were used to group the HbA1c levels: <7.5% (good metabolic control), 7.5% -9% (suboptimal metabolic control), and >9% (poor metabolic control).

Measurement of Weight, Height, and Nutritional Status

The weight of the children was measured using a standing scale. Before weighing, an inspection was carried out to ensure the device was balance (the needle showed the number 0). The children were weighed in a standing position without shoes and with minimal clothing. Height measurement of the children was carried out in a standing position without assistance; height was measured using a stadiometer. In measuring height, the children were measured without footwear or socks and with minimal clothing, when measured, the child must stand upright, both feet were touching each other, heels, buttocks and back of the head touched the stadiometer and stared forward at a flat level. Weight was measured in kilograms, and height was measured in centimeters, and then plotted on the CDC or WHO curve according to the age of the patient.

Nutritional status was determined based on body weight and height, for ages below 5 years WHO chart was used, and ages above 5 years were using CDC charts. Subjects were called malnutrition if BW/BH -3 SD up to -2 SD according to WHO or 70-90% BW/BH according to CDC, good nutrition if -2SD up to +2SD according to WHO or BW/BH 90 -110 % according to CDC, over nutrition if BW/BH +2SD up to +3SD or BW/BH >110-120% according to CDC, and obesity if BW/BH +3SD or BW/BH >120% according to CDC. Subjects with BW/BH >110% were analyzed further by measuring body mass index (BMI) with a formula of BW (kg)/BH^2 (meter) and plotted to BMI charts according to age and sex.

Examination of HbA1c and 25(OH)D levels

Examination of HbA1c level using whole blood sample was examined by Bio-Rad D-10™ device using a high-performance liquid chromatography (HPLC) method. Examination of vitamin D level (25 (OH) D) using plasma samples by the Enzyme-linked Immuno Assay (ELISA) method was carried out at the Clinical Pathology Laboratory in Saiful Anwar Hospital Malang. The kit used was the Alegria Human Vitamin D kit catalog number ORG 270 in ng/mL unit.

Statistical analysis

Statistical analysis was using the SPSS version 17. Data from research results were presented in a form of frequency distribution tables. The mean difference between vitamin D and HbA1c levels based on nutritional status was carried out using the Kruskal-Wallis test because the data were not normally distributed. Spearman rank correlation analysis was used to test the correlation between nutritional status and vitamin D status and nutritional status with glycemic control status.

RESULTS

Table 1 shows the comparison of the gender ratio of male to female was 3: 4. The most age group (57%) was >12-18 years while the age group of 5-12 years was 12 people, the mean age was 12.64±3.19 years, and approximately half were in puberty. Clinically most subjects had good nutrition, experienced insufficiency and deficiency of vitamin D, and poor glycemic control.

Table 1. Characteristics of research subjects (n = 28)

Sample characteristics	n (%)
Gender, n	
Male	12 (43)
Female	16 (57)
Age	
2-<5 years	0
5-12 years	12 (43)
>12 –18 years	16 (57)
Age, mean (SD), years	12,6 (3,19)
Nutritional Status, n	
Good nutrition	19 (68)
Malnutrition	7 (25)
Over nutrition	2 (7)
Status vitamin D ((25()H)D), n	
Deficiency	11 (39)
Insufficiency	6 (21)
Sufficiency	11 (39)
Glycemic control Status, n	
Good	7 (25)
Suboptimal	3 (11)
poor	18 (64)
Frequency of independent blood sugar monitoring, n	
1-2x/day	28
>2x/ day	0
Status of puberty, n	
Not yet Puberty	13 (46)
Puberty	15 (54)
Dosage of insulin/kgBW (IU) , mean (SD), IU	1,1(0,3)
Level of GDP (mg/dL) , mean (SD), mg/dl	146(76.1)
Level of GDS (mg/dL) , mean (SD), mg/dl	122 (52.1)

Table 2 shows nearly the same HbA1c levels in different nutritional statuses with the lowest level in over nutritional status. Vitamin D levels in the three groups of nutritional status were also almost the same as the lowest level in malnutrition status. Statistically, there were no differences in HbA1c or vitamin D levels in subjects with type 1 DM in children with three different nutritional statuses.

Table 2. Differences in levels of HbA1c, vitamin D (25 (OH) D) in nutritional status

Variable	Nutritional Status			p
	Good nutrition	Malnutrition	Over nutrition	
Vitamin D (25(OH)D)	24,61 ± 12,32	23,72 ± 16,19	24,00 ± 12,02	0,989
HbA1c	10,43 ± 2,92	10,74 ± 4,18	9,70 ± 2,26	0,995

Subjects with good nutritional status were found in almost the same proportion in all three conditions of vitamin D status (Table 3). Those who have stated that they had less or more nutritional status had not experienced insufficiency. The Spearman rank correlation test confirmed that there was no significant correlation between nutritional status and vitamin D status (r = 0.079, p = 0.689).

Table 3. Relationship between nutritional status and vitamin D status

Variable	Vitamin D (25(OH)D) Status			Total	r	p-value
	Deficiency	Insufficiency	Sufficiency			
Nutritional Status						
- Good nutrition	7	6	6	19		
- Malnutrition	3	0	4	7	0,079	0,689
- Over nutrition	1	0	1	2		
Total	11	6	11	28		

Correlation test found no significant correlation between nutritional status and vitamin D status with glycemic control status (Table 4). Most of the subjects showed poor glycemic control even with good nutritional status. The proportion of subjects with vitamin D deficiency and sufficiency was balanced.

Table 4. Relationship between nutritional status and vitamin D with glycemic control status

Variable	Glycemic control status			Total	r	p-value
	good	suboptimal	bad			
Nutritional Status						
- Good nutrition	5	1	13	19		
- Malnutrition	2	1	4	7	-0,062	0,752
- Over nutrition	0	1	1	2		
Vitamin D Status						
- Deficiency	3	2	6	11		
- Insufficiency	1	0	5	6	0,062	0,755
- Sufficiency	3	1	7	11		
Total	7 (25%)	3 (11%)	18 (64%)	28		

DISCUSSION

This study identified 28 subjects of children with type 1 diabetes mellitus, most of whom were females with the highest age range of 13-18 years. In this study, 28 children with type I diabetes mellitus were identified as the subjects of the study. The age characteristics of subjects were in the age range of 7-17 years with a mean age of 12 years. This is in line with the previous epidemiology that the peak incidence of type 1 DM is 5-7 years old and at the age of 10-14 years or puberty (2.8). Based on gender distribution, the females were higher than males (4: 3). This is consistent with data from a study in the United States that the highest incidence is in the age range of 9-12 years, and girls are twice as many as boys (17). In contrast, data from IDF in 2011 stated that men were 1.5 times higher than women. ISPAD data in the same year stated that gender differences in the incidence of type 1 DM in some countries were not different (3). The existence of this difference is caused by differences in population, race, and number of research subjects (18).

Nutritional Status and Glycemic Control

In this study, most subjects had good nutritional status (68%), and there was no relationship between nutritional status and glycemic control status and vitamin D status. Research in Brazil also showed 59% of patients with type 1 diabetes were in good nutrition, 1% in malnutrition, and 40% in over nutrition (19). While the research in RSSA Malang in the period 2005-2009 found 27 type 1 DM children, most of whom were moderately malnourished (20). In type 1 DM, a decrease in insulin secretion that occurs is a result of autoimmune disease, not because of a decrease in insulin sensitivity as in other types of DM, so that nutritional status does not have a direct effect (21). Diabetic children with adequate insulin therapy and improved metabolic control will experience weight gain. Too much weight gain indicates excess diet above their needs and the possibility of excessive insulin doses (22).

In this study 54% of 28 subjects had experienced puberty, the average dose of insulin used in this study was 1.14 ± 0.26 IU/kg/day. There were two children with more nutritional status with an insulin dose range of 0.5-1 IU/kg/day. More nutritional status in this study can be caused by excess diet above the needs of children, but the number of diets that can affect children's nutritional status was not examined in this study. Onset, peak work, and the length of work of insulin are the determining factors in the management of DM patients. Insulin dose adjustment aims to achieve optimal metabolic control, without increasing the risk of hypoglycemia and without neglecting the life quality of patients both short and long terms. During the "honeymoon" period, the total daily insulin dose is <0.5 IU/kgBW/day, children before puberty (excluding the "honeymoon" period) in the dose range of 0.7-1 IU/kgBW/day. During puberty, the need for insulin increases into above 1 IU up to 2 IU/kgBW/day. In adolescence, the need for insulin increases because of the work of sex steroid hormones, increased amplitude, and frequency of growth hormone secretion, all of them are anti-insulin hormones (4). Children with type 1 diabetes have a lower height velocity than healthy children, one risk factor of growth failure is the younger the age when diagnosed (Parthasaray). The duration of illness and HbA1C level affect height velocity (14).

Vitamin D status

Vitamin D status in this study sample was dominated by abnormal level of 25(OH)D, both deficiencies as much as 39% and insufficiency as much as 21% of the 28 subjects. There was no significant differences in the 25(OH)D level in the nutritional status group. Research by Hasan also identified vitamin D deficiency in children with type 1 DM was as much as 91.67%, and obtained no significant correlation between serum vitamin D, serum calcium, phosphorus, anthropometric status, duration of diabetes, mean of HbA1c, insulin dose, and sunray exposure (23). A cross-sectional study in the Netherlands showed that 60-84% of patients with type 1 DM had vitamin D deficiency (10). A study in America, of the 128 type 1 DM patients, revealed 15% of patients with 25(OH)D deficiency, 61% with insufficient 25(OH)D level, and 24% sufficient 25(OH)D level (15). Another study in Saudi Arabia, North India, and Australia reported that children with type 1 DM had low level of $25(OH)D_3$ compared to the normal

population (11,24). Research conducted in Indonesia also found similar results that type 1 DM patients experienced vitamin D deficiency and insufficiency. One study conducted in RSSA Malang found 90% of children with type 1 DM had low level of 25(OH)D_3 (25). Based on nutritional status, there were two patients with over nutrition (BMI >110) with a BMI >25. In these patients, one of the vitamin D level was in a deficiency state, and the other one was insufficiency. In obese patients there is a decrease in vitamin bioavailability due to the presence of vitamin D sequestration in fat tissue (26).

Vitamin D deficiency is influenced by genetic factors and environmental factors. Indonesia as a tropical country located on the equator with sunray exposure obtained throughout the year, thus it makes Indonesia sufficient for vitamin D synthesis (27). Decreased synthesis of vitamin D is caused by the use of sunscreen, dark skin pigments, age, season, latitude that is away from the equator, the amount of sunray exposure duration, closed dressing choice, and lesions on the skin. Decreased bioavailability of vitamin D can be caused by malabsorption and obesity. Increased catabolism of vitamin D can be triggered by the use of drugs such as anticonvulsants and glucocorticoids. Decreased synthesis of vitamin D can be due to liver disorders. Loss of vitamin D through urine can occur in nephrotic syndrome. The presence of chronic kidney disease can reduce the vitamin D synthesis. In children, the most common cause of vitamin D deficiency is breastfeeding without vitamin D supplementation, lack of sunray exposure, and a diet lacking vitamin D (26,28).

In this study, low vitamin D level could be because of a lack of sunray exposure and a lack of vitamin D diet. This study did not examine how long the amount of sunray exposure was and did not measure the type of diet containing vitamin D among the subjects. The most genetic contribution of locus DM type 1 is the HLA class II gene located on chromosome 6p21.3. The HLA-DR and HLA-DQ locus in the class II region have a very strong risk of the occurrence of type 1 DM (29). The presence of a polymorphism in VDR (Vitamin D receptor) is associated with a number of diseases, one of which is diabetes (30). The presence of VDR polymorphism causes vitamin D not to be captured by receptors even though the levels are normal. In addition, certain genetic influences and different environmental influences in each patient can also affect vitamin D levels in patients.

Individuals who are deficient in vitamin D have a higher risk of developing autoimmune disorders (31). Suppression in bone turnover is a major characteristic of bone disorders associated with type 1 DM and vitamin D deficiency. The states of hyperglycemia, hypoinsulinemia, autoimmune inflammation, a low level of insulin-like growth factor-1, and low vitamin D level are thought to be associated with bone turnover suppression. Risk factors of a decrease in bone mineralization in type 1 DM include: the younger the age at the time of diagnosis, poor glycemic control, diabetes complications, decreased kidney function, low BMI, and insulin doses (32).

HbA1c levels

This study showed no significant difference in HbA1C levels between nutritional status groups. In this study, of 28 study subjects, only seven children were in good metabolic control while the other 18 children were in poor metabolic control (HbA1c> 9%). HbA1c examination is used to describe long-term glucose control, describing the condition of 8-12 weeks before, because half-life of erythrocytes is 120 days (33).

The possibility that can cause a high HbA1c level is the relationship between the limited availability of insulin and a lack of independent blood sugar monitoring. Insulin storage may affect the effects of insulin, such as storing insulin in the freezer or exposure to insulin in direct sunray (34). From several studies, there was a significant correlation between independent monitoring and glycemic control. Blood glucose levels should be measured several times per day to avoid hypoglycemia and hyperglycemia, as well as adjusting insulin doses. Preprandial, postprandial, and midnight blood glucose levels are indispensable for adjusting insulin doses (4). In this study the frequency of blood glucose monitoring was 1-2 per day in all study samples, this indicates a lack of monitoring.

A retrospective study of the effect of type 1 DM on growth by Korcan et al. showed a negative correlation of HbA1C with height at three years after diagnosis (35). Studies in Iran showed that in the early onset of type 1 DM, 44.6% experienced KAD, the mean of HbA1C was 8.89%. Significant differences in SDS weight were only seen in patients with good and bad metabolic controls. Poor metabolic control can reduce growth in height and slightly affect body weight (36). A cohort study in Mexico 2016 showed 50% who faced growth failure. The results of multivariate analysis of factors associated with failure to grow was HbA1c level in the first year of diagnosis (37).

In this study, there was no significant correlation between vitamin D status (25(OH)D) and HbA1c status. Study by Branco et al. also proved that there was no relationship between HbA1c and 25(OH)D level but vitamin D status differed significantly between sexes (38). Even, previous research showed a negative correlation which meant that the higher the level of 25(OH)D, the lower the level of HbA1c. This study was conducted in three months without the intervention of vitamin D administration (39).

In DM type 1, there is an imbalance between pro-inflammatory cytokines and anti-inflammatory cytokines. At the APC level, vitamin D inhibits the surface expression of the MHC class II complex and co-stimulatory molecules, and also the production of IL-12, which directs the polarization of T cells from Th1 phenotype towards Th2. Furthermore, vitamin D has an indirect immunomodulatory effect on the level of T cells, through inhibition of Th1 inflammatory cytokines, namely IL-2 and IFN-γ, and stimulates the production of Th2 cytokines, namely IL-4, IL5, and IL10. Simultaneously, the immunomodulatory effects of vitamin D lead to the protection of target tissues such as beta cells (40). In this study, no inflammatory or anti-inflammatory cytokines were examined to determine the effect on vitamin D ((25(OH)D) and glycemic control (HbA1c).

The limitation of this study is to examine the levels of HbA1c and vitamin D and nutritional status in one measurement, serial measurements are needed in order to find out more about the relationship between research variables. This study was conducted only in the population

of type 1 DM children, and there was no control of healthy children. HbA1c level is influenced by a number of factors including levels of iron, vitamin B12, and folic acid that were not examined in this study. The complicating factors that may arise in this study also have not been controlled as ideal as possible, for example, low vitamin D diet factors, exposure to sunray, ethnicity/race, body surface areas, and drugs that can affect vitamin D status in the research subjects who might have a role in the occurrence of vitamin D deficiency which were not examined in this study. IGF-1 level measurement is needed to determine the relationship with bone growth that affects the child's height.

The results of the study illustrate that in children with type 1 DM there is a considerable amount of deficiency and is dominated by poor glycemic control despite having good nutritional status.

There are no significant differences in HbA1c and vitamin D levels based on nutritional status in type 1 DM children. There is no relationship between vitamin D status and nutritional status of glycemic control with vitamin D status in type 1 DM children. Further studies need to be conducted using healthy control groups, periodic monitoring, and considering the influence of environmental factors.

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