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ORIGINAL ARTICLE

# The Relationship of Carbohydrate, Vitamin D, Zinc Consumption and Physical Activity with Fasting Blood Glucose Level in Type 2 Diabetes Mellitus Patients during COVID-19 Pandemic

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ABSTRACT

**Background:** One of the concurrent illnesses linked with COVID-19 is Diabetes mellitus (DM). DM patients must follow a diet plan and engage in physical exercise to reduce illness complications and enhance immunity during COVID-19 pandemic. This study aimed to determine relationship of carbohydrates, vitamin D, zinc consumption and physical activity with fasting blood glucose levels in Type 2 Diabetes Mellitus (T2DM) patients during COVID-19 pandemic.

**Methods:** a cross-sectional study was undertaken in three health centers of Bantul Health Center, Bambanglipuro Health Center, and Pajangan Health Center. Members of the Chronic Disease Management Program (PROLANIS) were among the responders with T2DM. Semi Quantitative Food Frequency Questionnaire (SQ-FFQ) and Short Form International Physical Activity Questionnaire (SF-IPAQ) were completed to measure the degree of physical activity to figure out eating habits. Fasting blood sugar and Glucose Oxidase-Peroxidase Aminoantipyrine blood samples (GOD-PAP) were also determined.

**Results:** The consumption of carbohydrates and physical activity were both linked to fasting blood glucose levels ($p$<0.05). T2DM patients with low vitamin D consumption habits had 1.3 times greater risk of experiencing abnormal fasting blood glucose level (OR=1.292). Carbohydrate consumption, vitamin D, zinc, and physical activity had contribution as much as 16.2% to affect the occurrence of abnormal fasting blood glucose level.

**Conclusion:** As in T2DM patients with low vitamin D consumption habits, a higher risk of experiencing abnormal fasting blood glucose level was noticed. So health planning issues are needed for vitamin D consumption in T2DM patients during COVID-19 pandemic.

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## Introduction

In 2019, the virus Severe Acute Respiratory Syndrome Coronavirus (SARS-Cov-2) infected almost 150,000 people, resulting in thousands of deaths practically everywhere in the world (1, 2). Patients with comorbidities such as hypertension, diabetes mellitus (DM), coronary artery disease, and cerebrovascular disease have a significant death rate when they have Coronavirus Disease 2019 (COVID-19). According to research conducted in China, DM patients with COVID-19 had a three-fold greater mortality rate than COVID-19 patients overall, which was 7.3% vs. 2.3%. In Italy, COVID-19 patients had a death rate of 7.2 percent (3).

Diabetes mellitus is caused by a decrease in the secretion or action of the hormone insulin, which results in an increase in blood glucose levels. Insulin is a hormone generated by the pancreas that transports glucose from the blood stream to the body cells, where it is used as an energy source (4). Diabetes mellitus is one of the concomitant disorders associated with COVID-19. Coronavirus has been shown to attach to Angiotensin Converting Enzyme 2 (ACE2) in the pancreas, damaging it and inducing rapid hyperglycemia, which contributes to high mortality (5).

According to COVID-19 data in Indonesia on August 8, 2021, there were 3.666.031 people with DM comorbidities (37.2%) and those who died with DM (10.1%), the most in the country (6). In 2018, the prevalence rate of diabetes in the 15-year-old age group was 2.0%, according to the Basic Health Research Data (RISKESDAS) (7). DM sufferers in DIY Province are rated second in the country (3.1%). In the same year, 3.28% of people in Bantul Regency had diabetes (8).

Diet program is an action that DM patients must undertake to avoid disease complications and boost immunity during the COVID-19 pandemic (9). According to research conducted before, there are still many DM patients who are not compliant in the execution of the diet program, as many as 60%, while only 40% are obedient in the implementation of the diet program (10). In the pandemic, elevated glucose levels played a significant role in the development of DM problems, necessitating patient care. In pandemic situations, elevated glucose levels can make DM patients more susceptible to infection. High blood glucose levels contribute to reduced neutrophil activity, making patients with T2DM's immune systems vulnerable to infection (11).

Adequate nutritional intake is very much needed during this pandemic, so that it can control blood glucose levels and maintain the immunity of people with T2DM. The immune system in the body must remain optimal in order to have a good impact on the body. One way to increase the body's immune response is to consume foods that contain specific substances that function to modulate and improve the body's immune response called immunonutrients. Nutrients included in immunonutrients include carbohydrate, vitamin D, and zinc. Micronutrient deficiencies have a negative impact on immune function and may decrease resistance to infection (12-16).

There was a considerable increase in the number of daily hours that research participants sat without undertaking any physical activity during the COVID-19 lockdown. We noticed a considerable decrease in the average minutes per week spent walking during the regional restriction or lockdown compared to the preceding time. Bernard *et al.* found that physical activity can lower the risk of T2DM by reducing fat cells in the body and stabilizing blood sugar levels (17). Drug therapy, educational lifestyle, dietary intake, and physical activity are four pillars of T2DM management that have been shown to reduce blood glucose levels and avoid acute and chronic illnesses (18, 19).

## Materials and Methods

A cross-sectional study was conducted in three health centers in Bantul district, Yogyakarta, namely Bantul Health Center, Bambanglipuro Health Center, and Pajangan Health Center. Data collection was carried out from June to August 2021. Ethical approval was provided from Research Ethics Committee of the Faculty of Medicine, Sebelas Maret University (No: 34/UN27.06.6.1/ KEP/EC/2021 with Protocol ID: 01/02/ 04/41). Also, a research permit was taken from the Bantul District Health Office (No: 070/2035). A written informed consent was prepared from all participants prior to data collection.

T2DM patients who were Chronic Disease Management Program (PROLANIS) members at the Community Health Center in Bantul Regency were the participants in this study. The sampling technique was multi-stage random sampling method. In a first-stage research, three health centers from 27 health centers in Bantul Regency were selected using a random sampling procedure. The selected health centers were Bantul Health Center, Bambanglipuro Health Center, and Pajangan Health Center that had a total population of 225 T2DM patients. In the second-stage research, proportional random sampling was utilized to enroll T2DM responders in the three health community centers. The research sample size was obtained using the Kothari formula for estimating the number of samples, with a minimum

total sample size of 105 participants (20). A total of 40 participants were gathered from Bantul Health Center, 35 participants from Bambanglipuro Health Center, and 30 participants from Pajangan Health Center for this study.

The study was carried out during the COVID-19 Pandemic; hence it was conducted once for each health community center. Respondents arrived in three shifts, according to the invitation, and were gathered in the hall of their individual health community center. The health protocol required researchers, enumerators, and other health workers to wear protective attire, gloves, and double masks. The subject's characteristics, food consumption habits (carbohydrate, vitamin D, and zinc), physical activity, and fasting blood sugar were the key data obtained. Food consumption habits were determined by filling out the Semi Quantitative-Food Frequency Questionnaire (SQ-FFQ) and keeping track of what they ate in the last month. We used the Short Form International Physical Activity Questionnaire (SF-IPAQ) to determine the degree of physical activity. This allowed to classify the levels of physical activity based on the amount of time spent conducting moderate physical activity and walking, as well as the amount of time spent sitting per week. The SF-IPAQ questionnaire was validated in 14 locations across 12 countries and was internationally standardized with a high level of validity (r=0.40) and reliability (0.70-0.87) (21).

This questionnaire consisted of 7 questions based on the patient's physical activity during the last week. Assessment of the data from the IPAQ questionnaire using the IPAQ scoring protocol guide was undertaken with the help of the IPAQ automatic report, so that data on physical activity was obtained, namely Metabolic Equivalents of Task (MET) as a unit. The results of the data from the assessment in the form of MET scores were as follows: walking=3.3 MET, moderate activity=4.0 MET, and high activity=8.0 MET which were multiplied by intensity in minutes and days, and then were added up (21).

An interview was carried out by a trained enumerator using the criteria of a graduate of applied science in nutrition. Laboratory professionals measured fasting blood sugar using the technique and collected Glucose Oxidase-Peroxidase Aminoantypirin blood (GOD-PAP). SPSS software (IBM SPSS Statistics for Windows, Version 16, Chicago, IL, USA) was used for statistical analysis. The relationship between carbohydrate, vitamin D, zinc consumption, physical activity, and fasting blood sugar levels was determined using the Chi-Square test and Fisher's Exact test. The multivariate analysis used logistic regression. A $p<0.05$ was considered statistically significant.

## Results

The majority of respondents were women (63.8%) and the oldest age group was 46-65 years old (66.7%) as seen in Table 1. Non-communicable and other chronic diseases became more common after the age of 40. The majority of the respondents had a high school education (30.5%) and did not have an employment work (60%). The fasting blood sugar level of 55.2% of T2DM respondents was abnormally high. Table 2 shows a relationship between carbohydrate consumption and T2DM ($p<0.05$, OR=0.425), which means that T2DM patients who consumed inadequate carbohydrate consumption had a 0.425 times greater risk of increasing or decreasing fasting blood glucose levels. As Table 3 demonstrates, Participants engaged in moderate physical activity were 71%, while 54.4% of participants experienced a normal moderate physical activity, while 45.6% were abnormal for the moderate physical activity. Table 4 illustrates the relationship between carbohydrate, vitamin D, zinc consumption and physical activity with fasting blood glucose level revealing that T2DM patients with low vitamin D consumption habits, had a higher risk (1.292 times greater risk) of experiencing abnormal fasting blood glucose level, as the largest OR value was for vitamin D (1.292). Then the risks were zinc, physical activity and carbohydrates, respectively. So Nagelkerkel value was 0.162 which means that carbohydrate,

**Table 1:** Characteristics of the study subjects.

| Variable | Subjects (n=105) | |
|---|---|---|
| | n | % |
| Gender | | |
| a. Women | 67 | 63.8 |
| b. Man | 38 | 36.2 |
| Age | | |
| a. Adult (26-45 years old) | 6 | 5.7 |
| b. Elderly (46-65 years old) | 70 | 66.7 |
| c. Seniors (>65 years old) | 29 | 27.6 |
| Education | | |
| a. No School | 10 | 9.5 |
| b. Elementary School | 28 | 26.7 |
| c. Junior High School | 18 | 17.1 |
| d. Senior High School | 32 | 30.5 |
| e. University | 17 | 16.2 |
| Employment | | |
| a. Work | 42 | 40 |
| b. Does Not Work | 63 | 60 |
| Fasting Blood Glucose Level | | |
| a. Normal | 47 | 44.8 |
| b. Not Normal | 58 | 55.2 |

**Table 2:** The relationship between carbohydrate, vitamin D, and zinc consumption with fasting blood glucose level.

| Variable | Fasting blood glucose level | | | | Total | | OR | *p* value |
|---|---|---|---|---|---|---|---|---|
| | Normal | | Not normal | | | | | |
| | n | % | n | % | n | % | | |
| Carbohydrate | | | | | | | | |
| Inadequate | 28 | 38.4 | 45 | 61.6 | 73 | 100 | 0.426 | 0.045[1*] |
| Adequate | 19 | 59.4 | 13 | 40.6 | 32 | 100 | | |
| Vitamin D | | | | | | | | |
| Inadequate | 42 | 44.2 | 53 | 55.8 | 95 | 100 | 0.792 | 0.750[2] |
| Adequate | 5 | 50.0 | 5 | 50.0 | 95 | 100 | | |
| Zinc | | | | | | | | |
| Inadequate | 43 | 43.9 | 55 | 56.1 | 98 | 100 | 0.586 | 0.698[2] |
| Adequate | 4 | 57.1 | 3 | 42.9 | 7 | 100 | | |

[1]Chi-Square, [2]Fisher's Exact, *Significance $p<0.05$. OR: Odds ratio

**Table 3:** The relationship between physical activity with fasting blood glucose level.

| Variable | Fasting blood glucose level | | | | Total | | *p* value |
|---|---|---|---|---|---|---|---|
| | Normal | | Not normal | | | | |
| | n | % | n | % | n | % | |
| Physical activity | | | | | | | |
| Light | 4 | 21.1 | 15 | 78.9 | 19 | 100 | 0.020[1*] |
| Medium | 37 | 54.4 | 31 | 45.6 | 68 | 100 | |
| Heavy | 6 | 33.3 | 12 | 66.7 | 18 | 100 | |

[1]Chi-Square, *Significance at $p<0.05$.

**Table 4:** The relationship between carbohydrate, vitamin D, zinc and physical activity with fasting blood glucose level.

| Variable | *p* value | OR | CI 95% | | Nagelkerkel R Square |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| Carbohydrate | 0.049* | 0.394 | 0.156 | 0.994 | 0.162 |
| Vitamin D | 0.740 | 1.292** | 0.284 | 5.874 | |
| Zinc | 0.986 | 0.984 | 0.162 | 5.985 | |
| Physical Activity | 0.331 | 0.731 | 0.361 | 1.411 | |

*$p<0.05$, **The Highest OR value. OR: Odds ratio

vitamin D, zinc, and physical activity contributed as much as 16.2% in influencing the occurrence of abnormal fasting blood glucose level.

## Discussion

In our study, the majority of responses were female and in the 46-65 years old age group. Non-communicable and chronic diseases were more prevalent after the age of 40 years. The majority of the respondents had a high school education and did not have employment work. Yunieswati *et al.* have also shown that farmers older than 40 years were more health-conscious, ate a balanced diet, exercise regularly, avoided a sedentary lifestyle, and limited their sugar, salt, and fat consumption (22). Other researchers have reported the fasting blood sugar level in several T2DM patients to be abnormally high (55.2%). COVID-19 severity and greater mortality appeared to be linked to the presence of DM and the degree of hyperglycemia (23, 24). One of the key factors influencing the severity and death of Covid-19 patients was shown to be diabetes (25). In a meta-analysis by Kumar *et al.*, diabetes was shown to be significantly associated to the risk of dying from COVID-19, with an odds ratio of 1.90 (95% CI: 1.37-2.64; p0.01). With an odds ratio of 2.75 (95% CI: 2.09–3.62; p0.01), diabetes was also connected to a higher severity of COVID-19, including a higher chance of ARDS, a longer ICU stay, and the necessity for invasive ventilation (26). Persistent systemic inflammation, increased coagulation activity, a reduced immune response, and the risk of SARSCoV-2 inflicting direct injury to the pancreas were all linked to diabetes and COVID-19 (27). Changes in ACE2 receptor expression, immune cell deregulation, alveolar malfunction, endothelial dysfunction, and increased systemic coagulation all led to a higher risk of morbidity and death. Old age, diabetes, and other comorbidities were found to be significant

predictors of morbidity and death among COVID-19 patients (28).

In was shown that patients with T2DM had a carbohydrate deficiency (81%) and ate 1-2 and 1-3 rice balls weighing 50-100 grams. As carbohydrate consumption should be 45-65% of total energy needs; ingestion of more than 130 g per day is not suggested (29). Hypoglycemia can also be caused by a lack of carbohydrate ingestion. In contrast to the findings of Ruiz-Roso *et al.*,which involved potential health consequences, especially on patients with Type 2 Diabetes Mellitus (T2DM there was a considerable increase in the average weekly food intake of T2DM sufferers during regional restriction or lockdowns, including dairy products, vegetables, snacks, and sweet foods, compared to before the pandemic. Snack foods, particularly sweet foods, were consumed 5 times per week or 2.9% before the regional restriction or lockdown and climbed to 5.7 % during the restriction or lockdown. Sugary foods and high-carbohydrate snacks could affect T2DM metabolic regulation (30).

In our study, the findings revealed that T2DM patients with low vitamin D consumption had a higher risk times greater risk of experiencing abnormal fasting blood glucose level. Vitamin D deficiency has been demonstrated to be linked to obesity, and obesity has been linked to an increased risk of T2DM (31). In patients with T2DM and hypovitaminosis D, vitamin D supplementation was illustrated to improve glycemia and insulin secretion. This notion has been strengthened by the discovery of vitamin D receptors (VDR) and vitamin D-binding protein (DBP) in pancreatic tissue, as well as a relationship between certain allele variations in the VDR and DBP genes and glucose tolerance and insulin production. Vitamin D's impact on T2DM was thought to be mediated not only via influencing plasma calcium levels, which regulate insulin synthesis and secretion, but also by direct action on beta cell function in the pancreas (32).

Vitamin D is necessary for glucose-induced insulin release, enhances resistance, and has anti-inflammatory effects. In most epidemiological studies, low vitamin D levels have been associated to an increased risk of insulin resistance and T2DM. The majority of randomized controlled trials (RCTs) in healthy or pre-diabetic persons, have found no evidence for vitamin D to have any effect on insulin resistance or diabetes incidence. Vitamin D had a modest effect on glycemic control and insulin resistance in people with T2DM. While these findings urge further research, there is currently insufficient evidence to recommend vitamin D supplementation for the prevention or treatment of T2DM (33). Vitamin D's protective effects are mediated through the immune system and calcium homeostasis. Vitamin D, on the other hand, appears to have a direct effect on beta cells, making them more resistant to the cellular stress found in T1DM and T2DM (34).

In our study, 98% of participant consumed adequate zinc and 7% were inadequate consumers for zinc. Zinc was shown to help T2DM patients with antioxidant defense by acting as a cofactor for the enzyme superoxide dismutase, modulating glutathione metabolism and metallothionein expression, competing with iron and copper in cell membranes, and inhibiting nicotinamide adenine dinucleotide dinucleotide phosphate-oxidase. In these people, zinc lowered prolonged hyperglycemia, which increased oxidative stress (34). Given that aging is linked with a steady decline in zinc status in the body owing to numerous causes, including lower food consumption, decreased nutrient absorption efficiency, and medication usage, this group of people had a greater incidence of zinc insufficiency (35, 36).

In our study, the participants engaged in a moderate physical activity (71%). It has been found that the majority of the individuals have walked or cycled more frequently. During the regional restrictions, most of the participants went about their business as usual; and the epidemic had little effect on them. Regular physical activity was demonstrated to have numerous health benefits, and its potential to boost metabolic health and immunological defense may be especially important during the pandemics (37, 38). We must attempt to maintain suggested levels of physical activity during the COVID-19 pandemic to assist increase immunity and prevent the negative effects of inactivity and social isolation on immune systems and metabolism. Adults with T2DM should break up their sitting time with light exercise every 30 minutes to reduce sedentary time, according to the physical activity guidelines. The recommendations below meant to supplement, rather than replacing, a weekly exercise routine that included at least 150 minutes of combined aerobic and strength training (39).

Our results of multivariate analysis between carbohydrate consumption habits, vitamin D, zinc, and physical activity denoted to a relationship with the occurrence of abnormal fasting blood glucose level. The most dominant variable was vitamin D revealing that T2DM patients who had low vitamin D consumption habits had a greater risk of experiencing abnormal fasting blood glucose level, followed by zinc, physical activity and carbohydrates. Nutritional management in T2DM patients has been one crucial component in controlling blood glucose level and

preventing infection during a pandemic (40). Drug therapy, educational lifestyle, dietary intake, and physical activity were reported as four pillars of T2DM management that can reduce blood glucose level and avoid acute and chronic illnesses (18, 19). T2DM has been a comorbid of COVID-19 infection, so infection prevention requires activating the host immune response and eating a well-balanced diet to boost immunity that has been compromised by malnutrition, lack of physical activity, and stress, all of which can lead to COVID-19 infection (18, 19).

## Conclusion

The consumption of carbohydrates and physical activity were shown to be linked to fasting blood glucose level and T2DM patients with low vitamin D consumption habits had a greater risk of experiencing abnormal fasting blood glucose level. It seems that to control blood sugar and avoid infection with COVID-19, T2DM patients require nutritional care. So health planning issues are needed for vitamin D consumption in T2DM patients during COVID-19 pandemic.

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## Conflict of Interest

None declared.

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