Original Research

The Indonesian Journal of Public Health
Vol 18. No. 3 December 2023
p- ISSN 1829-7005 e- ISSN 2540-8836

# A PILOT STUDY ON DIABETIC PATIENTS AT MALANG COMMUNITY HEALTH CENTER REGARDING THE APPLICATION OF THE T-PLATE MODEL CONCEPT

**Dwipajati**
Diploma 3 Program in Nutrition Department,
Politeknik Kesehatan Kemenkes Malang, Malang, Indonesia
Correspondence address: Dwipajati
Email: dwipajati@poltekkes-malang.ac.id

## ABSTRACT

**Introduction:** Diabetes mellitus is a comorbidity that is often found in Covid-19 patients with a 3.9-fold risk of death. Data from the Malang City Health Office shows an increase in the number of diabetes patients by 1.2% each year. In Indonesia, 3J (right amount, type, and eating time) has become the principle of diabetes diet therapy, but in practice, it is still challenging to apply independently. **Aims:** Investigating the T-Plate Model as a simple eating guide for people with diabetes mellitus. **Methods:** This pilot study included 18 diabetic patients at some Primary Health Care who were 50–70 years old and had a BMI more than 23 kg/m2. The participant was split into two groups, with nine people in the (C) group eating according to the T-Plate Model, and others in the (T) group eating according to the T-Plate Model after eating fruit. After a 3-month treatment period, BMI, blood pressure, carbohydrate, and fiber consumption were assessed. Mean BMI and blood pressure were examined using paired sample t-tests (p 0.05). **Results:** Both groups' BMIs fell into the category of obesity level 1 before to treatment periods: C group (26.09+3.13 kg/m2) and T group (27.15+ 4.15). We discovered significant blood pressure and BMI variations in the T group at the end of intervention periods (p 0.05). Nevertheless, systolic blood pressure was different in the C group (p 0.05). **Conclusions:** It may be inferred that using the T-Plate Model with the addition of fruit initially can lower blood pressure and BMI.

**Keywords**: T-Plate Model, fruit before meal, diabetes patients

## INTRODUCTION

The majority of cases of diabetes mellitus, or type 2 diabetes, are currently prevalent in the global community. According to WHO data (2021), at least 1.5 million deaths in 2019 were related to diabetes mellitus, putting it the ninth most common cause of death. Meanwhile, the International Diabetes Federation (IDF) said that there had been a global increase of 10.5%, where as many as 44.7% of adults experience glucose intolerance. In addition, the IDF estimates that by 2045 we can easily find 1 in 8 adults with diabetes mellitus. According to Indonesia's Basic Health Research (Riskesdas) findings, the incidence of diabetes dramatically increased from 6.9% in 2013 to 8.5% in 2018 (Indonesian Ministry of Health, n.d.). This rising tendency was observed in the 55 to 64 and 65 to 74 age groups, with an increase of 1.5 and 1.8%, respectively. Health profile data from East Java (2021) reported that Malang City was included in 10 cities with a number of >= 20,000 people with diabetes. This is consistent with the Head of the Malang City Health Office's Report in the 2021 Malang City Health Profile, which shows an increase in the number of DM sufferers during the COVID-19 pandemic from 2020 to 2021 was 1.76%, where previously there was only increased 0.7% from 2019 to 2020 (Malang Head of Health Service, n.d.).

Having diabetes in the family, being overweight or obese, living a sedentary lifestyle, exercising infrequently, consuming large amounts of sugar and fat, having high blood pressure, and sleeping irregularly can all lead to metabolic

**Cite this as:** Dwipajati, (2023). A Pilot Study on Diabetic Patients at Malang Community Health Center Regarding The Application of The T-Plate Model Concept. The Indonesian Journal of Public Health, 18(3), 540-551. https://doi.org/10.20473/Ijph.v18i3.2023.540-551


Received 24 November 2022, received in revised form 10 September 2023, Accepted 12 September 2023, Published online: December 2023.Publisher by Universitas Airlangga

problems that can alter blood glucose levels (Al Mansour, 2019; Ismail, Materwala and Al Kaabi, 2021). Diabetes patients are more likely to develop significant and potentially fatal consequences, such as heart attacks, strokes, renal failure, blindness, and lower limb amputations, when their blood sugar levels are not under control. Therefore WHO, IDF, ADA (American Dietetic Association), and Perkeni (Persatuan Endokrinologi Indonesia) have recommended pillars of diabetes mellitus management to suppress the growth and development of diabetes mellitus.

The pillar focuses on lifestyle and dietary modifications, medication adherence, and participation in educational activities. Dietary modification is a critical pillar of successful diabetes therapy management. The dietary modification refers to the 3J principle which is right in amount, type and eating time. Preliminary survey in Malang City showed that 70% of diabetics received health services at the health center still have difficulty measuring food (food portion) according to their individual energy needs, have difficulty measuring food (food portion) according to their individual energy needs, have difficulty choosing groups of food ingredients, and are confused about choosing the right snack. In addition, based on Riskesdas 2018 data, Indonesian adults' daily fiber choosing groups of food ingredients, and are confused about choosing the right snack. In addition, based on Riskesdas 2018 data, Indonesian adults' daily fiber intake is still below the recommended daily fiber intake of 20-25 g/day.

Based on the above conditions, easy and simple eating techniques are needed to help diabetic patients measure their food (food portions). The concept of the T-Model Plate, which is known as an effort to overcome overweight and obesity conditions, is a modification in eating proportion where ½ part of the plate contains vegetables, ¼ part contains carbohydrates and the remaining ¼ part contains side dishes. Fiber has a known positive effect on health. Both soluble and insoluble fiber are essential for diabetics.

By delaying stomach emptying, soluble fibers such fructooligosaccharide (FOS), pectin, -glucans (found in wheat and barley grains), galactomannan gums, alginates, and psyllium may slow down the absorption of glucose (Perry and Wing, 2016). Meanwhile, insoluble fiber such as cellulose, some hemicellulose, resistant starch, and lignin will ferment in the intestine and produce short chain fatty acids (SCFA) (Zhao et al., 2018). It is hoped that by applying the T model plate concept, fiber intake in diabetes patients will increase so that glycemic control is achieved. As a result, This study's objective was to investigate the T-Plate Model as a straightforward dietary therapy for diabetes mellitus.

## METHODS

An experimental group with a pre-posttest control group was used in this investigation and randomized control trial study design. Our research was carried out in three Primary Health in Malang City (Kedung Kandang, Mulyorejo and Ciptomulyo). The three Primary Health are among the top five areas in Malang with regard to the increasing number of diabetes patients per year with low coverage of health services, which is why we choose this spot. The Kedung Kandang Health Center is on Malang City's western edge; the Ciptomulyo Health Center is in the city's center; and the Mulyorejo Health Center is on Malang City's eastern edge, close to Malang Regency.

We used sample random sampling with criteria such as the age range of 50-70 who took part in the aging program activities at the health facility, non-insulin therapy, not following other therapy, had BMI above 23 $kg/m^2$ and light physical activity. A number of 18 diabetic patients who satisfied the inclusion criteria and were willing to follow this therapy were separated into two groups by randomizing the member of group. Having comorbidities that hindered memory, not having a complete food recall data, and having insufficient blood chemistry data were the exclusion criteria.

Nine diabetes patients in the C group were eating according to the T-Plate Model, while the remaining patients in the T group were eating fruit first and then utilizing the T- Plate Model. Diabetes patients who satisfied the inclusion criteria and were willing to follow this therapy were separated into two groups. Before starting the program, the nutrition statue, blood pressure, and body fat of all diabetes patients who will be following the diet will be assessed. We used a mercury tensimeter to measure blood pressure and Body Composition Monitor Model HBF-375 Karada Scan to measure body composition.

The past 24 hours' worth of food consumption will also be noted. The task of keeping track of food intake will fall to enumerators who have a nutrition diploma. A quick introduction to diet therapy utilizing a T-style plate will thereafter be given to each participant. Information on the food therapy, which each group will follow for the following three months, will be given as part of the ongoing diet therapy.

Our enumerator team will keep a 24-hour food diary during the intervention period. We will gather recall data three times, on two working days and one holiday, at least once every week. Technically, we will choose the participant's food intake information from Monday through Friday on weekdays. On weekends and holidays, we will record the amount of food consumed. Two techniques will be used to obtain information on food intake: home visits and video calls or text messages with accompanying pictures. We use two different techniques to minimize bias of food intake.

All participants will be brought back to the health center on the final day of the intervention to have their height, weight, and HbA1c assessed once more. Participants will also take part in a final educational session that contains the findings of a three-month food intake monitoring program. If a participant's diet is determined to be incompatible with the dietary therapy for people with diabetes mellitus, suggestions for altering it will be given to them as well. The HbA1c test results will thereafter be disclosed at least a week after the final meeting of this activity.

Excel will be used to recapitulate the complete collection of data. The dietary history data will be presented before and after the dietary intervention. The participant's food intake during the intervention will be examined as a point of change. Before and after diet therapy, information on changes in height, weight, and HbA1c levels will be presented.

SPSS for Windows: Statistical Product and Service Solutions series 25 was used to evaluate and report mean and standard deviation for all acquired data. The Shapiro-Wilk test was used to determine the normality of the data, the Mann-Whitney U test for normally distributed data and an independent t-test for typically skewed data were used to evaluate participant characteristic data. Wilcoxon and Paired Samples t-Tests, two types of tests, were utilized to examine BMI, blood pressure, body fat, and nutritional intake, including carbohydrates and fiber. A p-value of 0.05 or lower was deemed significant. With the letter number No.:488 / KEPK- POLKESMA/ 2019, the Poltekkes Kemenkes Malang ethics committee determined that this study was ethically eligible.

## RESULT

Table 1 lists specific of participant characteristics. There were 18 volunteers who regularly took anti-hyperglycemic medications and had type 2 diabetes. Participants' average ages range from 55 to

60 years old, with the T group having the oldest mean age (60 ± 6.16). Most of them are women (two men and the others were women) who do not work. In addition, all of them had an increase in blood pressure categorized as grade 1 hypertension but did not take anti-hypertension medicine. The findings of the interviews revealed that none of the patients had ever received nutrition education, particularly about eating habits. Furthermore, all responders only engaged in light to moderate activity.

**Table 1.** Relationship of Demographic Characteristics with Independence of Elderly

| Variable | C (n=9) | T (n=9) | p-*value* |
|---|---|---|---|
| Age (years) | 55.89 ± 4.57 | 60.00 ± 6.16 | 0.13[a] |
| Weight (kg) | 59.10 ± 8.97 | 65.93 ± 11.70 | 0.17[a] |
| Height (cm) | 151.33 ± 4,86 | 155.62 ± 6.80 | 0.18[a] |
| Systolic blood pressure (mmHg) | 139.30 ± 18.47 | 134.44 ± 11.30 | 0.34[a] |
| Diastolic blood pressure (mmHg) | 83.40 ± 9.49 | 81.67 ± 12.25 | 0.85[a] |
| Body Fat (%) | 37.70 ± 4.64 | 35.63 ± 7.78 | 0.48[b] |
| BMI (kg/m$^2$) | 26.09 ± 3.13 | 27.16 ± 4.15 | 0.63[b] |
| HbA1c | 9.40 ± 1.88 | 8.07± 0.92 | 0.06[a] |
| Diabetes History | 8.40 ± 1.35 | 5.78 ± 4.29 | 0.69[a] |
| Recall 24 hours: | | | |
| Energy (Cal/day) | 1083.58 ± 102.96 | 706.89 ± 153.28 | 0.00 [*a] |
| Carbohydrate | 152.96 ± 43.62 | 101.76 ± 21.38 | 0.08[a] |
| Fiber | 8.54 ± 1.07 | 3.86 ± 1.28 | 0.10[b] |

*) Statistical test paired sample t test, significant p <0.05
[a] different in control group; [b] different in treatment group

The findings of the interviews revealed that none of the patients had ever received nutrition education, particularly about eating habits. Furthermore, all responders only engaged in light to moderate activity. In body composition result, we found that both groups had high body fat, which was above 30% with the highest body fat percentage in group C. In addition, based on BMI calculations, the results showed that the treatment group had an average BMI that was higher than the control group, which was 27.16 ± 4.15 and 26.09 ± 3.13, respectively.

On blood examination related to glycemic control, it was found that both the control and treatment groups had glycemic control that had not reached the PERKENI recommended glycemic target of <7%. The interview results also revealed that the control and treatment groups' means+SD indicated that they had been dealing with diabetes for 5 to 10 years, with the longest duration of diabetes in the control group (8.40 + 1.35).

Furthermore, the eating history study using 24-hour food recall found that the average energy intake up to group C was higher than the control group (1083.58 + 102.96). The outcomes of statistical analyses revealed a sizable variation in the amount of energy consumed between two groups. The treatment group's average carbohydrate intake was lower than that of the control group (101.76 + 21.38). In addition, fiber intake in both groups was still far from Perkeni's recommendation of 25-30 g per day, Although the treatment group's fiber intake was lower than that of the control group, respectively 3.86 + 1.28, and 8.54 + 1.07. After 3 months of the intervention period, it was found that several variables measured before the intervention period changed. The difference in the results before and after the intervention is presented in Table 2.

Based on the table below some of the variables monitored in both groups during the intervention tended to decrease. We observed reductions in body fat, systolic and diastolic blood pressure, carbohydrate intake, and fiber intake in group C. A rise in BMI was seen in this group, though. While in group T there was a decrease in BMI, body fat, systolic and diastolic blood pressure and carbohydrate intake. Interestingly, we noted an increase in fiber intake in this group.

**Table 2.** The Mean △ Some Variable Both of Group After Intervention Periods

| Variable | Group | |
|---|---|---|
| | C | T |
| △ BMI | 0,27 | -0,04* |
| △ BF | -0,48 | -0,93 |
| △ SBP | -16,33* | -10,67 |
| △ DBP | -5,11 | -1,67 |
| △ Energy | 14,77 | 74,01 |
| △ CH | -49,59* | -16,32 |
| △ Fiber | -0,27 | 2,04 |

*) Statistical test paired sample t test, significant p <0.05. △ result post-pre. -) mean decrease.

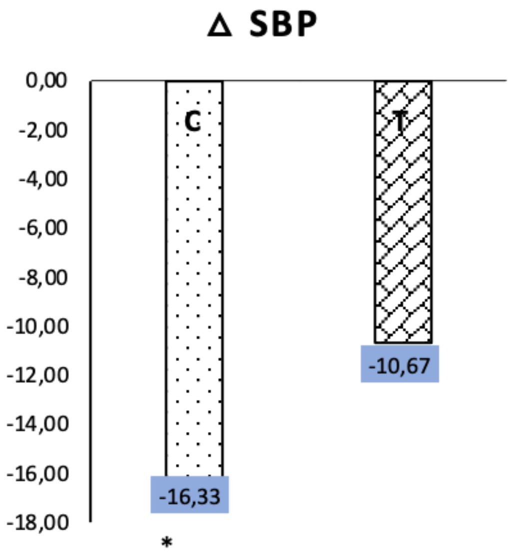


**Figure 1.** The mean △ systolic blood pressure of both groups after intervention.

On the last day of the intervention, we recorded specific changes in the variables we measured, some of which are presented in the figure below. Systolic blood pressure decreased in both group C and group T (Figure 1). The mean systolic blood pressure in C group significantly decreased became 125.11+11.36 with an average systolic blood pressure of 77.56+6.89.

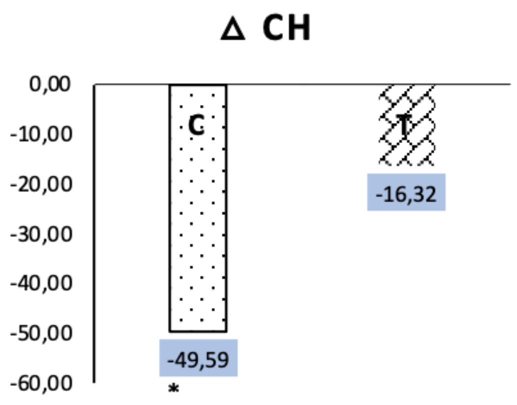


**Figure 2.** The mean △ carbohydrate intake of both groups after intervention

In addition, we found a downward trend in carbohydrate intake in both groups (Figure 2). Especially in group C, there was a significant decrease in carbohydrate intake compared to before the intervention. The amount of decrease in carbohydrate intake in group C was 49.59 g, while in group T it was only 16.32 g. These results are based on the average 24-hour recall results during the ongoing therapy period. The results of the recall are carried out on two working days and one day off for three months.

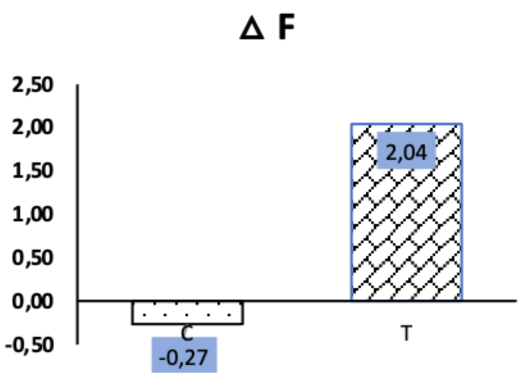


**Figure 3.** The mean △ fiber intake of both groups after intervention.

Besides that, in fiber intake we found differences between the two groups. In Figure 3, it can be seen that group C's fiber intake decreased slightly after the intervention period. However, this was inversely proportional to fiber intake in the T group. A trend of increasing fiber intake was seen in group T where there was an increase of at least 2 g after three months. Between the two groups, there was no statistically significant difference in the amount of fiber consumed (p>0,05).

In this study, we also observed changes in BMI in both groups. During the 3-month intervention period, we noted that group C experienced no significant reduction in BMI. Meanwhile, a significant decrease in BMI occurred in group T (Figure 4). The decrease in BMI in group T was supported by the trend of decreasing carbohydrates and increasing fiber intake. This was also accompanied by an increase in total energy intake in group T. The results of fiber consumption in the intervention group are directly linked to this condition. The intervention group's BMI improved as intake was increased for three months.

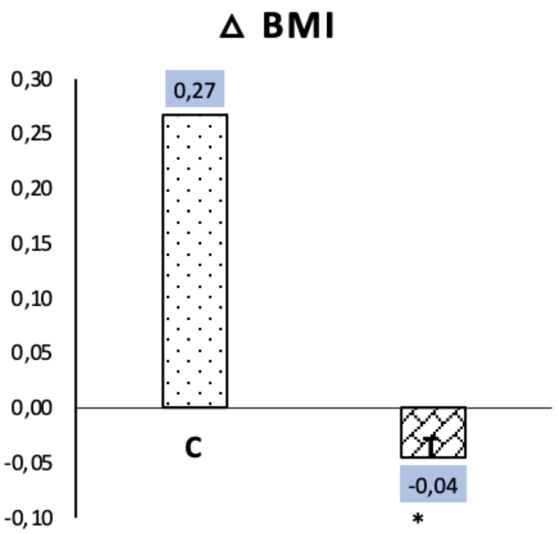


**Figure 4.** The mean △ BMI of both groups after intervention.

## DISCUSSION

We explored whether patients with diabetes mellitus could use the T plate model.. All of the participants in our study were diabetes mellitus type-2 with hypertension grade 1. Considering this condition, nutritional statue rises, becoming obese according to the 2014 Minister of Health Regulation Number 41 cutoff threshold. Similar conditions were also found in diabetic patients in Lajur, India, where nearly 30% of diabetics also had hypertension (Bansode and Prasad, 2022). Argano et al. (2022) also found similar condition that hypertension was the first comorbid disease in elderly diabetes mellitus patients who were treated in the internal medicine ward (57.1%).

Patients with diabetes mellitus who are elderly are more likely to develop hypertension. Inversely, it is generally observed that insulin resistance puts hypertensive patients at the risk of developing diabetes mellitus (Mancusi et al., 2020). Insulin resistance and obesity go together to the combined occurrence of diabetes mellitus and hypertension. Additionally, both of them have the same risk factors, including obesity, dyslipidemia, atherosclerosis, vascular inflammation, and remodeling of the arteries (Petrie, Guzik and Touyz, 2018). Insulin resistance and chronic hyperglycemia both contribute significantly to the development of vascular problems. This is made more severe by the lack of measures to reduce diabetes mellitus risk factors that can be modified, such as obesity, sedentary lifestyle, and unhealthy diets which can increase the risk of intestinal dysbiosis, inflammatory reactions, and ROS that lead to macro-microvascular complications (Galicia-Garcia et al., 2020).

Furthermore, we found that they had lived with type-2 diabetes for <10 years and had low glycemic control. This is consistent with several research from various nations, including Qatar, China, and Turkey, which likewise revealed the cut points for adult men and women's body fat percentages aged >= 40 years ranging between 25-35% and 35-45% (Li et al., 2017; Bahat et al., 2020; Bawadi et al., 2020). Obesity risk may be increased by an excessive buildup of body fat (ABG), as measured by the percentage of body fat above the cutoff limit (Macek et al., 2020).

Bae et al. also published the results of the other trial, which involved diabetic individuals in the US with BMI > 25 kg/m2 and HbA1c values > = 7% (Bae et al., 2016). Increased plasma free fatty acid (FFA) levels in obese individuals are known to result in peripheral (muscle) insulin resistance. (Sobczak, Blindauer and Stewart, 2019; Henderson, 2021). By secreting unesterified fatty acids, adipose tissue participates in the metabolism and production of hormones, glycerol, and other molecules like leptin, cytokines, adiponectin, and proinflammatory agents (NEFAs). Unesterified fatty acids (NEFAs), which are released more often from adipose tissue in obese patients, have an impact on the pancreatic ß cells' ability to secrete insulin (Algoblan, Alalfi and Khan, 2014; Chobot et al., 2018).

According to a 24-hour food recall, we documented that they had a low intake of energy, carbohydrates, and fiber. This means that it has not been able to meet the daily fiber needs according to Indonesian Endocrinology Association (PERKENI) recommendations (Soelistijo, 2019. This is in line with the results of RISKESDAS 2018, that Indonesian adults' average intake of vegetables and fruit is still < 5 servings a day or the equivalent of 8-10 g of fiber only. Recent research conducted by Susilowati, Rachmat and Larasati (2020) in Central Bogor Regency also shows a similar situation where type 2 diabetes with controlled glycemic levels can only consume 152.9 g and 131.69 g of vegetables and fruit per day.

Meanwhile, people with diabetes mellitus with uncontrolled glycemic levels were only able to consume vegetables and fruit of 116.2 g and 102.40 g, respectively. WHO (2020) recommends at least adults can consume 250 grams of vegetables and 150 grams of fruit per day (Kalmpourtzidou, Eilander and Talsma, 2020). A recent meta-analysis study found that people with diabetes mellitus whose daily fiber intake is increased by 10–40 g has better glycemic control (Silva et al., 2013; Mao et al., 2021)

Our study recorded that some of the variables monitored in both groups during the intervention tended to decrease. When the intervention time is over, we noted a similar pattern of decreases in body fat, blood pressure, and energy intake variables. In addition, we also noted a trend of increasing energy intake. Then there are also differences in changes that are contrary to the two groups, which include BMI and fiber intake. First, focusing on dietary food record, we analyze that carbohydrate intake in diabetes patients only reaches 25-30% of Perkeni's recommended carbohydrate intake of the total daily energy requirement. When in fact, people with diabetes mellitus can consume carbohydrates 45-65% of the total daily energy needs with a note still considering the type of carbohydrates.

According to our data, there is a positive association between a patient's systolic blood pressure and the amount of carbohydrates and fiber they consume. Numerous studies on the impact of restricting carbohydrate intake on blood pressure have not produced encouraging results, according to a meta-analysis study. (Choi et al., 2022). Li et al. (2021) found that intake of high-quality carbohydrates or those containing high fiber and substitution of plant products possibly prevent the emergence of new instances of hypertension by consuming low-quality carbs. According to Abbanezhad et al. (2020), a diet heavy in monounsaturated fatty acids was superior to one high in carbs for decreasing SBP and DBP. Increased fiber consumption has been linked to lower systolic and diastolic blood pressure, according to prospective studies by 4.3 mmHg and 3.1 mmHg in adults with hypertension, respectively (Reynolds et al., 2022). By comparing several scientific studies that have been conducted regarding carbohydrate intake, fiber intake and blood pressure, we can conclude that the intake of fiber-rich foods can affect blood pressure.

The second part of the study that we found was the change in BMI. Some people with diabetes mellitus who applied fruit consumption before using the T model plate experienced a decreased BMI. Meanwhile, people with diabetes mellitus who only applied for the T model plate experienced an increase in BMI. Changes in carbohydrate and fiber intake in patients with diabetes mellitus encourage this opposite condition. A decrease in BMI is followed by a decrease in carbohydrate intake and an increase in fiber for people with diabetes mellitus. Burger et al. (2012) reported that increasing fiber intake among diabetes patients can decrease the mortality. An experimental study with an RCT design conducted by (Miketinas et al. (2019) showed that changes in fiber intake in adults after energy reduction therapy are strong predictors of weight loss programs.

The physical and chemical properties of fiber can provide a satiety effect because the satiety effect, especially soluble fiber, can delay gastric emptying and prolong transit time in the intestine so that it impacts the release of the satiety hormone (Hervik and Svihus, 2019; Giuntini, Sardá and de Menezes, 2022). In addition, the consumption of fiber in foodstuffs can affect intestinal motility by increasing the volume and weight of feces so that the consistency and frequency of stools also increase (Rebello, Greenway and Dhurandhar, 2014; Müller, Canfora and Blaak, 2018). When -glucan, lupine kernel fiber, rye bran, whole rye, or high fiber mixed meals are employed, a number of studies have demonstrated a decrease in intake and body weight, according to Clark and Slavin ( 2013). This is consistent with our discovery that obese people may experience weight loss after increasing their fiber intake by 2 grams per day for three months.

Applying a T-plate diet and consuming fruit before meals can contribute to efforts to increase fiber intake for diabetics. Increasing fiber intake through daily intake of vegetables and fruit not only improves the glucose response of people with diabetes mellitus but can prevent the development of impaired glucose tolerance in adult (McRae, 2018; Kimura et al., 2021). Modification of fruit consumption before using the T-style plate and the application of the T-plate diet without modification appeared to be successful but not significant. This may occur as a result of the adaptation process of the body's metabolic system in type-2 diabetes mellitus patients where previously fiber consumption was very low.

The benefits of our research include the opportunity to experiment with the eating aids suggested for obese individuals in order to get closer to the fundamentals of eating in accordance with a typical diabetes diet. Also, we collected samples from a variety of locations in order to explain the food habits of diabetic patients in Malang. Our study's flaw is that women continue to dominate the sex proportion, but the sample size is still quite tiny.

## CONCLUSIONS

The application of the eating model using the T-plate model alone can decrease blood pressure and reduce carbohydrate intake. Meanwhile, dietary modification by consuming fruit before using the T-plate model can increase fiber intake and reduce BMI. Future research can refer to special eating aids intended for diabetic patients. Meal aids that help diabetic patients apply the principles of the diabetes mellitus diet in a simple and easy way. Besides that, further research can also be carried out which raises the effect of various foods that contain fiber that can be eaten before main meals to increase fiber intake in a day.

## REFERENCES

Abbasnezhad, A., Falahi, E., Gonzalez, M.J., Kavehi, P., Fouladvand, F.

and Choghakhori, R., 2020. Effect of different dietary approaches compared with a regular diet on systolic and diastolic blood pressure in patients with type 2 diabetes: A systematic review and meta-analysis. *Diabetes Research and Clinical Practice*, 163, p.108108. https://doi.org/10.1016/j.diabres.2020.108108

Al Mansour, M.A., 2019. The Prevalence and Risk Factors of Type 2 Diabetes Mellitus (DMT2) in a Semi-Urban Saudi Population. *International Journal of Environmental Research and Public Health*, 17(1), p.7. https://doi.org/10.3390/ijerph17010007

Algoblan, A., Alalfi, M. and Khan, M., 2014. Mechanism linking diabetes mellitus and obesity. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, p.587. https://doi.org/10.2147/DMSO.S67400

Argano, C., Natoli, G., Mularo, S., Nobili, A., Monaco, M.L., Mannucci, P.M., Perticone, F., Pietrangelo, A. and Corrao, S., 2022. Impact of Diabetes Mellitus and Its Comorbidities on Elderly Patients Hospitalized in Internal Medicine Wards: Data from the RePoSi Registry. *Healthcare*, 10(1), p.86. https://doi.org/10.3390/healthcare10010086

Bae, J.P., Lage, M.J., Mo, D., Nelson, D.R. and Hoogwerf, B.J., 2016. Obesity and glycemic control in patients with diabetes mellitus: Analysis of physician electronic health records in the US from 2009–2011. *Journal of Diabetes and its Complications*, 30(2), pp.212–220. https://doi.org/10.1016/j.jdiacomp.2015.11.016

Bahat, G., Kilic, C., Topcu, Y., Aydin, K. and Karan, M.A., 2020. Fat percentage cutoff values to define obesity and prevalence of sarcopenic obesity in community-dwelling older adults in Turkey. *The Aging Male*, 23(5), pp.477–482. https://doi.org/10.1080/13685538.2018.1530208

Bansode, B. and Prasad, J.B., 2022. Burden of comorbidities among diabetic patients in Latur, India. *Clinical Epidemiology and Global Health*, 13, p.100957. https://doi.org/10.1016/j.cegh.2021.100957

Bawadi, H., Hassan, S., Shanbeh Zadeh, A., Sarv, H., Kerkadi, A., Tur, J.A. and Shi, Z., 2020. Age and gender specific cut-off points for body fat parameters among adults in Qatar. *Nutrition Journal*, 19(1), p.75. https://doi.org/10.1186/s12937-020-00569-1

Burger, K.N.J., Beulens, J.W.J., van der Schouw, Y.T., Sluijs, I., Spijkerman, A.M.W., Sluik, D., Boeing, H., Kaaks, R., Teucher, B., Dethlefsen, C., Overvad, K., Tjønneland, A., Kyrø, C., Barricarte, A., Bendinelli, B., Krogh, V., Tumino, R., Sacerdote, C., Mattiello, A., Nilsson, P.M., Orho-Melander, M., Rolandsson, O., Huerta, J.M., Crowe, F., Allen, N. and Nöthlings, U., 2012. Dietary Fiber, Carbohydrate Quality and Quantity, and Mortality Risk of Individuals with Diabetes Mellitus. *PLoS ONE*, 7(8), p.e43127. https://doi.org/10.1371/journal.pone.0043127

Chobot, A., Górowska-Kowolik, K., Sokołowska, M. and Jarosz-Chobot, P., 2018. Obesity and diabetes-Not only a simple link between two epidemics. *Diabetes/Metabolism Research and Reviews*, 34(7), p.e3042. https://doi.org/10.1002/dmrr.3042

Choi, J.H., Cho, Y.J., Kim, H.-J., Ko, S.-H., Chon, S., Kang, J.-H., Kim, K.-K., Kim, E.M., Kim, H.J., Song, K.-H., Nam, G.E., Kim, K.I., and Committee of Clinical Practice Guidelines, Korean Society for the Study of Obesity (KSSO), Committee of Clinical Practice Guidelines and Committee of Food and Nutrition, Korean Diabetes Association (KDA), Policy Committee of Korean Society of Hypertension (KSH), Policy Development Committee of National Academy of Medicine of Korea (NAMOK), 2022. Effect of carbohydrate-restricted diets and intermittent fasting on obesity, type 2 diabetes mellitus, and hypertension management: consensus statement of the Korean Society for the Study of obesity, Korean Diabetes Association, and Korean Society of Hypertension. *Clinical Hypertension*, 28(1), p.26. https://doi.org/10.1186/s40885-022-00207-4

Clark, M.J. and Slavin, J.L., 2013. The Effect of Fiber on Satiety and Food Intake: A Systematic Review. *Journal of the American College of Nutrition*, 32(3), pp.200–211. https://doi.org/10.1080/07315724.2013.791194

Galicia-Garcia, U., Benito-Vicente, A., Jebari, S., Larrea-Sebal, A., Siddiqi, H., Uribe, K.B., Ostolaza, H. and Martín, C., 2020. Pathophysiology of Type 2 Diabetes Mellitus. *International Journal of Molecular Sciences*, 21(17), p.6275. https://doi.org/10.3390/ijms21176275

Giuntini, E.B., Sardá, F.A.H. and de Menezes, E.W., 2022. The Effects of Soluble Dietary Fibers on Glycemic Response: An Overview and Futures Perspectives. *Foods*, 11(23), p.3934. https://doi.org/10.3390/foods11233934

Henderson, G.C., 2021. Plasma Free Fatty Acid Concentration as a Modifiable Risk Factor for Metabolic Disease. *Nutrients*, 13(8), p.2590. https://doi.org/10.3390/nu13082590

Hervik, A.K. and Svihus, B., 2019. The Role of Fiber in Energy Balance. *Journal of Nutrition and Metabolism*, 2019, pp.1–11. https://doi.org/10.1155/2019/4983657

I. S. Sobczak, A., A. Blindauer, C. and J. Stewart, A., 2019. Changes in Plasma Free Fatty Acids Associated with Type-2 Diabetes. *Nutrients*, 11(9), p.2022. https://doi.org/10.3390/nu11092022

Indonesian Ministry of Health, n.d. *Indonesia Basic Health Research 2018*.

Ismail, L., Materwala, H. and Al Kaabi, J., 2021. Association of risk factors with type 2 diabetes: A systematic review. *Computational and Structural Biotechnology Journal*, 19, pp.1759–1785. https://doi.org/10.1016/j.csbj.2021.03.003

Kalmpourtzidou, A., Eilander, A. and Talsma, E.F., 2020. Global Vegetable Intake and Supply Compared to Recommendations: A Systematic Review. *Nutrients*, 12(6), p.1558. https://doi.org/10.3390/nu12061558

Kimura, Y., Yoshida, D., Hirakawa, Y., Hata, J., Honda, T., Shibata, M., Sakata, S., Uchida, K., Kitazono, T. and Ninomiya, T., 2021. Dietary fiber intake and risk of type 2 diabetes in a general Japanese population: The Hisayama Study. *Journal of Diabetes Investigation*, 12(4), pp.527–536. https://doi.org/10.1111/jdi.13377

Li, Q., Liu, C., Zhang, S., Li, R., Zhang, Y., He, P., Zhang, Z., Liu, M., Zhou, C., Ye, Z., Wu, Q., Li, H. and Qin, X., 2021. Dietary Carbohydrate Intake and New-Onset Hypertension: A Nationwide Cohort Study in China. *Hypertension*, 78(2), pp.422–430. https://doi.org/10.1161/HYPERTENSIONAHA.120.16751

Li, Y., Wang, H., Wang, K., Wang, W., Dong, F., Qian, Y., Gong, H., Xu, G., Li, G., Pan, L., Zhu, G. and Shan, G., 2017. Optimal body fat percentage cut-off values for identifying cardiovascular risk factors in Mongolian and Han adults: a population-based cross-sectional study in Inner Mongolia, China. *BMJ Open*, 7(4), p.e014675. https://doi.org/10.1136/bmjopen-2016-014675

Macek, P., Biskup, M., Terek-Derszniak, M., Krol, H., Smok-Kalwat, J., Gozdz, S. and Zak, M., 2020. Optimal cut-off values for anthropometric measures of obesity in screening for cardiometabolic disorders in adults. *Scientific Reports*, 10(1), p.11253. https://doi.org/10.1038/s41598-020-68265-y

Malang Head of Health Service, n.d. *Malang City Health Profile in 2021*.

Mancusi, C., Izzo, R., di Gioia, G., Losi, M.A., Barbato, E. and Morisco, C., 2020. Insulin Resistance the Hinge Between Hypertension and Type 2 Diabetes. *High Blood Pressure & Cardiovascular Prevention*, 27(6), pp.515–526. https://doi.org/10.1007/s40292-020-00408-8

Mao, T., Huang, F., Zhu, X., Wei, D. and Chen, L., 2021. Effects of dietary fiber on glycemic control and insulin sensitivity in patients with type 2 diabetes: A systematic review and meta-analysis. *Journal of Functional Foods*, 82, p.104500. https://doi.org/10.1016/j.jff.2021.104500

McRae, M.P., 2018. Dietary Fiber Intake and Type 2 Diabetes Mellitus: An Umbrella Review of Meta-analyses. *Journal of Chiropractic Medicine*, 17(1), pp.44–53. https://doi.org/10.1016/j.jcm.2017.11.002

Miketinas, D.C., Bray, G.A., Beyl, R.A., Ryan, D.H., Sacks, F.M. and Champagne, C.M., 2019. Fiber Intake Predicts Weight Loss and Dietary Adherence in Adults Consuming Calorie-Restricted Diets: The POUNDS Lost (Preventing Overweight Using Novel Dietary Strategies) Study. *The Journal of Nutrition*, 149(10), pp.1742–1748. https://doi.org/10.1093/jn/nxz117

Müller, M., Canfora, E. and Blaak, E., 2018. Gastrointestinal Transit Time, Glucose Homeostasis and Metabolic Health: Modulation by Dietary Fibers. *Nutrients*, 10(3), p.275. https://doi.org/10.3390/nu10030275

Perry, J.R.. and Ying, W., 2016. A Review of Physiological Effects of Soluble and Insoluble Dietary Fibers. *Journal of Nutrition & Food Sciences*, [online] 06(02). https://doi.org/10.4172/2155-9600.1000476

Petrie, J.R., Guzik, T.J. and Touyz, R.M., 2018. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. *Canadian Journal of Cardiology*, 34(5), pp.575–584. https://doi.org/10.1016/j.cjca.2017.12.005

Rebello, C., Greenway, F.L. and Dhurandhar, N.V., 2014. Functional foods to promote weight loss and satiety: *Current Opinion in Clinical Nutrition and Metabolic*

*Care*, 17(6), pp.596–604. https://doi.org/10.1097/MCO.0000000000000110

Reynolds, A.N., Akerman, A., Kumar, S., Diep Pham, H.T., Coffey, S. and Mann, J., 2022. Dietary fibre in hypertension and cardiovascular disease management: systematic review and meta-analyses. *BMC Medicine*, 20(1), p.139. https://doi.org/10.1186/s12916-022-02328-x

Silva, F.M., Kramer, C.K., de Almeida, J.C., Steemburgo, T., Gross, J.L. and Azevedo, M.J., 2013. Fiber intake and glycemic control in patients with type 2 diabetes mellitus: a systematic review with meta-analysis of randomized controlled trials. *Nutrition Reviews*, 71(12), pp.790–801. https://doi.org/10.1111/nure.12076

Soelistijo, S.A.,2019. *Pedoman Pengelolaan dan pencegahan Diabetes Melitus Tipe 2 Dewasa Di Indonesia*. PB Perkeni.

Susilowati, A., Rachmat, B. and Larasati, R.A., 2020. HUBUNGAN POLA KONSUMSI SERAT DENGAN KONTROL GLIKEMIK PADA DIABETES TIPE 2 (T2D) DI KECAMATAN BOGOR TENGAH [RELATIONSHIP OF FIBER CONSUMPTION PATTERNS TO GLYCEMIC CONTROL IN TYPE 2 DIABETES (T2D) IN CENTRAL BOGOR SUB-DISTRICT]. *Penelitian Gizi dan Makanan (The Journal of Nutrition and Food Research)*, 43(1), pp.41–50. https://doi.org/10.22435/pgm.v43i1.3083

Zhao, L., Zhang, F., Ding, X., Wu, G., Lam, Y.Y., Wang, X., Fu, H., Xue, X., Lu, C., Ma, J., Yu, L., Xu, C., Ren, Z., Xu, Y., Xu, S., Shen, H., Zhu, X., Shi, Y., Shen, Q., Dong, W., Liu, R., Ling, Y., Zeng, Y., Wang, X., Zhang, Q., Wang, J., Wang, L., Wu, Y., Zeng, B., Wei, H., Zhang, M., Peng, Y. and Zhang, C., 2018. Gut bacteria selectively promoted by dietary fibers alleviate type 2 diabetes. *Science*, 359(6380), pp.1151–1156. https://doi.org/10.1126/science.aao5774