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Dietary Intake and Health Status in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study

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ABSTRACT

Despite the positive effects of physical activity on type 2 diabetes mellitus (T2DM) management, the lack of adequate evidence on the effects of dietary intake has raised concerns. This study aimed to assess dietary intake and its effect on glycaemic control among active and inactive patients with T2DM. A cross-sectional observational study was conducted on patients with T2DM. Dietary food intake and physical activity were assessed using a validated questionnaire through face-to-face interviews. The daily consumption of fruit and vegetables was significantly higher in active patients compared with inactive patients ($p = 0.00$). Significantly higher daily rice consumption ($p = 0.00$) and lower dietary non-starch polysaccharide (NSP) intake ($p < 0.01$) were reported among inactive patients compared with active patients. The results also revealed a significantly higher glycated haemoglobin (HbA1c) level (8.37$\pm$ 1.51% vs 8.015$\pm$ 1.50%; p=0.02) and BMI (34.95$\pm$6.06 kg/m2 vs 31.72$\pm$5.62 kg/m2; $p = 0.00$) among inactive patients compared with active patients. A positive correlation was found between physical activity and NSP intake. The study found that a variety of lifestyle modifications, including increased physical activity and fruit and vegetable consumption, could help manage glycaemic control in patients. The study further found that carbohydrate-rich NSPs may help lower BMI levels in patients with T2DM.

KEYWORDS
Dietary intake, glycaemic control, lifestyle, physical activity

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1. Introduction

Type 2 diabetes mellitus (T2DM) is a chronic disease affecting almost 366 million people worldwide, and this number is expected to increase to 552 million by 2030 (Whiting *et al.*, 2011). The International Diabetes Federation has confirmed that Saudi Arabia is among the top 10 countries, both regionally and globally, in terms of having the highest diabetes rates among adults aged 20–79 (Boutayeb *et al.*, 2014; Ogurtsova *et al.*, 2017). Diabetes leads to various long-term complications that negatively affect individuals' quality of life and potentially their lifespan, with harmful effects on both the individual and society (Glasgow *et al.*, 1997). It is well established that high blood glucose levels will increase the risk of diabetes complications and mortality (Seshasai *et al.*, 2011).

Studies conducted in Saudi Arabia have shown that most patients with T2DM have poor glycated haemoglobin (HbA1c) control, which may accelerate the progression of diabetes (Alzaheb and Altemani, 2018). According to previous reports, the prevalence of poor control of HbA1c in patients with T2DM in the Tabouk and Najran regions of Saudi Arabia is 75% and 85%, respectively (Alzaheb and Altemani, 2018; Al-Qahtani, 2020). A previous study conducted in Saudi Arabia has suggested that T2DM patients have poor dietary habits (Sami *et al.*, 2020). However, some previous studies are limited due to having investigated dietary habits alone, without assessing physical activity. Dietary fibre is reported to exert an important effect on human health, including reducing blood glucose and blood cholesterol levels and modulating gut microbiota (Alarifi *et al.*, 2018). These changes may also decrease body weight and reduce appetite (Hobden *et al.*, 2015). To achieve glycaemic control among people with T2DM, all possible associated risk factors of poor glycaemic control should be considered.

This observational study therefore aims to assess dietary intake and its effect on glycaemic control of active and inactive T2DM patients.

2. Materials and Methods

2.1. Study Design:

In this cross-sectional study, patients with T2DM were recruited from the diabetes clinic at the Ministry of National Guard Health Affairs, Al Ahsa, Saudi Arabia. Using convenience sampling, all Saudi patients with T2DM who attended the diabetes clinic between November 2018 and March 2019 were screened for enrolment. The inclusion criteria were patients with T2DM on oral or injectable medication, aged over 20 and under 80. The exclusion criteria were the presence of chronic kidney or liver disease and the use of medications that affect diabetes control (e.g. glucocorticoids and pregnancy-related medications). All patients were required to provide written informed consent, and the study protocols were approved by the Institutional Research Board, Ministry of National Guard Health Affairs (IRB, Ref. No. IRBC/0666/19). Blood pressure, height and weight were initially recorded upon arrival at the clinic. Patients' electronic medical records available at the time of the interview were reviewed, and data were collected for the following variables: body mass index (BMI), fasting blood glucose (FBG), random blood glucose (RBG), HbA1c, triglyceride (TG), total cholesterol (TC), high-density lipoprotein (HDL) and low-density lipoprotein (LDL) levels.

A validated questionnaire (Al-Mssallem, 2018; Al-Mssallem *et al.*, 2019) was used, to collect data from patients through face-to-face interviews on their physical activity and amount of dietary intake. Physical activity was assessed, and patients were assigned as active or inactive, based on the intensity, duration and frequency of their physical activity (Al-Nozha *et al.*, 2007).

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2.2. Statistical Analysis:

Descriptive statistics were reported using the Statistical Package for Social Sciences (SPSS software, version 26, IBM Corp.© Copyright IBM Corporation), by calculating the means and standard deviations for laboratory test results, food items and total nutrient consumption for active and inactive patients, along with proportions of major nutrients for every food item. A Student's t-test with a two-tailed significance level of 5% ($p < 0.05$) was used to compare laboratory test measures, food items, and nutrient consumption between active and inactive patients. The correlations between food items and laboratory test measures and between laboratory test measures and nutrient consumption among active and inactive patients were assessed using the Pearson correlation test.

3. Results

3.1. Characteristics of Participants:

This study included 404 patients with T2DM who were categorised into active (n = 144) and inactive (n = 260) patients. As shown in Table 1, the mean age was 55.84±8.84 years for inactive participants and 54.26±10.97 years for active participants. A significant difference was found between the two groups in terms of their weight, which was significantly higher ($p = 0.03$) for inactive patients, with a value of 88.64±16.61 kg, compared with 84.97±16.40 kg for active patients. Consequently, the inactive group had a significantly higher ($p = 0.00$) BMI of 34.95±6.06 kg/m2 compared with 31.72±5.62 kg/m2 for active patients. Moreover, inactive patients had a significantly higher ($p = 0.02$) HbA1c level of 8.37±1.51 than active participants (8.01±1.50) (Table 1). However, no differences in blood levels of the lipids TC, LDL, HDL and TG were observed between groups ($p > 0.05$). Interestingly, obesity and morbid obesity were dominant among inactive patients, where the percentages were approximately double and four times (for obesity and morbid obesity, respectively) that in active patients (Figure 1). Moreover, active patients had a significantly lower weight and consequently lower BMI than inactive patients ($p < 0.05$ and $p < 0.01$, respectively).

Interestingly, a positive correlation between dietary non-starch polysaccharide (NSP) intake and physical activity ($r = 0.226$, $p < 0.01$) was observed.

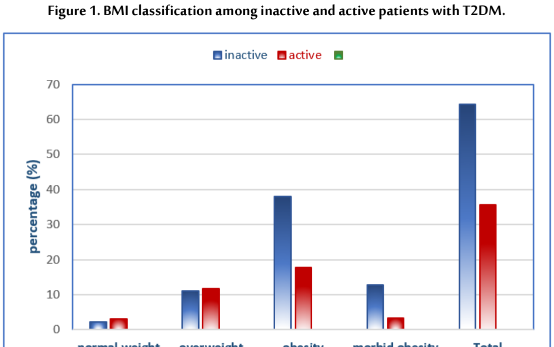
Table 1. Descriptive characteristics of the study participants (mean±SD)

Measurement	Inactive (n=260)	Active (n=144)	p value
Age (years)	55.84±8.84	54.26±10.97	0.11
Height (m)	159.15±8.45	163.61±9.46	0.00
Weight (kg)	88.64±16.61	84.97±16.40	0.03
BMI (kg/m2)	34.95±6.06	31.72±5.62	0.00
DBP (mmHg)	71.83±10.01	73.89±11.35	0.06
SBP (mmHg)	138± 18.72	139.88± 17.36	0.32
FBG (mmol/L)	9.86± 3.73	9.51± 3.50	0.35
RBG (mmol/L)	11.14± 4.31	11.35± 4.28	0.64
HbA1c (%)	8.37± 1.51	8.015± 1.50	0.02
TG (mmol/L)	1.68± 0.91	1.62± 0.96	0.55
TC (mmol/l)	4.46± 0.94	4.30± 0.88	0.1
HDL (mmol/L)	1.05± 0.24	1.03± 0.25	0.31
LDL (mmol/L)	2.73± 0.82	2.64± 0.77	0.28

1- DBP, diastolic blood pressure; SBP, systolic blood pressure.

2- Values are expressed as mean±SD

Figure 1. BMI classification among inactive and active patients with T2DM.



3.2. Dietary Food Intake:

The reported dietary food intake of the inactive and active groups is presented in Table 2. The consumption of fruit and vegetables reached 4.76±0.19 portions/day among active patients and was significantly higher ($p = 0.00$) than the amount consumed by inactive patients (3.69±0.11 portions/day). Similarly, the consumption of milk and milk products was also significantly higher among active patients, with a value of 1.70±0.07 portions/day compared with 1.48±0.05 portions/day in inactive patients ($p = 0.01$). On the other hand, the consumption of rice was significantly lower among active patients than among inactive patients ($p = 0.00$). However, the active group consumed more fish than the inactive group ($p = 0.01$).

Table 2. Dietary food intake (mean±SE) among inactive and active patients with T2DM

Food intake (portions/day)	Inactive (n = 260)	Active (n = 144)	p value
Fruits and vegetables	3.69±0.11	4.76±0.19	0.00
Milk and milk products	1.48±0.05	1.70±0.07	0.01
Meat	0.26±0.01	0.22±0.01	0.08
Chicken	0.57±0.02	0.59±0.02	0.64
Fish and seafood	0.10±0.00	0.13±0.01	0.01
Egg	0.27±0.02	0.29±0.02	0.68
Rice	10.05±0.22	8.90±0.30	0.00
Pasta and whole grains	0.82±0.04	0.87±0.08	0.55
Bread	4.58±0.09	4.52±0.12	0.69
Legumes	0.65±0.05	0.82±0.08	0.08
Fast food	0.14±0.01	0.13±0.02	0.51
Confectionery	0.45±0.05	0.41±0.04	0.67

3.3 Nutrients Intake:

Table 3 compares the energy and macronutrient intake between inactive and active participants. No significant differences in the total daily intake of protein, fat, available carbohydrates or overall energy were found. However, the intake of NSPs was significantly higher in the active group than in the inactive group, reaching 32.32±0.97 g/day compared with 27.22±0.60 g/day ($p = 0.00$).

Table 3. Energy and macronutrient intake (mean±SE) among inactive and active patients

Energy and nutrients	Inactive (n = 260)	Active (n = 144)	p value
Available carbohydrates (g)	305.27±4.28	300.47±6.45	>0.05
Proteins (g)	65.25±1.29	66.54±1.75	>0.05
Fats (g)	47.93±0.87	46.90±1.14	>0.05
Non-starch polysaccharides (g)	27.22±0.60	32.32±0.97	<0.01
Total energy intake (calories)	1988.71±29.07	1988.22±41.96	>0.05

4. Discussion

This cross-sectional study assessed dietary intake between active and inactive patients with T2DM. Active patients consumed significantly more fruit and vegetables and less rice than inactive patients. The study also identified that the sources of protein in the patients' daily intake were milk and milk products, meat, chicken, fish and eggs. However, significant differences were found between the two groups of patients in their intake of fish and milk and milk products ($p < 0.05$). The differences between the two groups' intake of meat, chicken and eggs were not, however, significant ($p > 0.05$). As a result of this variation in the source of protein in patients' diets, the intake of protein was not significant ($p > 0.05$). This result indicates the effective roles of both eating habits and an active lifestyle in improving glycaemic control.

Previous data has shown a negative association between HbA1c levels and physical activity in patients with T2DM (Alramadan *et al.*, 2018; Alzaheb and Altemani, 2018). Moreover, poorly controlled HbA1c levels have been associated with adverse effects in patients with diabetes (Alramadan *et al.*, 2018). A possible explanation is that physical activity may reduce intra-abdominal fat, which is a known risk factor for insulin resistance and potentially reduces body fat stores (Nakanishi *et al.*, 2020). Therefore, increasing physical activity is an effective strategy for glycaemic control and reducing the risk of T2DM (Ansari, 2009). In general, poor glycaemic control among patients with diabetes has been reported in previous studies conducted in other regions of Saudi Arabia, including Jizan, Tabouk, and Al Ahsa (Khan *et al.*, 2012; Badedi *et al.*, 2016; Alzaheb and Altemani, 2018). Another United Arab Emirates' (UAE) study of patients with diabetes found that only 31% had an HbA1c level of less than 7% (Al-Kaabi *et al.*, 2008). Similarly, Alramadan *et al.* (2018) reported that only 24.1% of patients with T2DM met the recommended target for HbAc1 levels (< 7%). High blood glucose levels increase the risk of diabetes complications and mortality (Seshasai *et al.*, 2011). The American Diabetes Association (ADA) (2017) guidelines recommend performing exercise for at least 150 min/week to improve HbA1c levels (ADA., 2017). The beneficial effect of physical activity on T2DM relates to it increasing insulin sensitivity, and it can prevent the progression of T2DM during the initial stages, before insulin therapy is required (Sampath Kumar *et al.*, 2019). During an exercise session, contracting skeletal muscle increases glucose uptake into the cells, which increases blood flow in the muscle and transports glucose into the muscle cell (Evans *et al.*, 2019). It can also reduce glucose storage of adipose tissue (Honkala *et al.*, 2020).

Another factor that affects the health of patients with T2DM is obesity. In this study, the prevalence of obesity and morbid obesity was 72%. Most patients were inactive, among whom the percentages of obesity and morbid obesity were approximately double and four times, respectively, the values observed in inactive patients (Figure 1). Moreover, active patients had a significantly lower weight and, consequently, lower BMI than inactive patients ($p < 0.05$ and $p < 0.01$, respectively). Similar studies conducted in Saudi Arabia have reported that the prevalence of a lack of physical activity among patients with T2DM (70.5%) did not meet the recommended time and length of physical activity (Alzaheb and Altemani, 2018). In another study, only 26.4% of patients met the recommended physical activity levels (Mohamed *et al.*, 2020), and 28.7% of patients with T2DM were obese (Memish *et al.*, 2014).

Our findings likewise indicate a higher intake of fruit and vegetables in active patients than in inactive patients. The consumption of fruit and vegetables is considered a healthy dietary habit among patients with T2DM. Reports emphasise that the consumption of at least 26 g of fruit and vegetables a day lowers the risk of developing diabetes by 18% (Du *et al.*, 2017), which is similar to our results. Poor glycaemic control is associated with a lower intake of fruit and vegetables (Alramadan *et al.*, 2018). Similarly, a seven-year prospective study conducted in China concluded that consumption of fresh fruit and vegetables lowers the risk of diabetic complications by 12% (Du *et al.*, 2017). Another study conducted in Saudi Arabia, shows that patients with T2DM consumed low fruit and vegetable intake (Sami *et al.*, 2020). The current guidelines for people with diabetes recommend eight to ten servings of fruit and vegetables per day (American Diabetes Association, 2017).

Based on this study, a restriction of the amount of starchy staple foods may be very important, as it was found to be correlated with BMI, which is consistent with a previous study conducted in the UAE (Al-Kaabi *et al.*, 2008). In the present study, rice consumption was significantly higher among inactive patients than among active patients.

NSPs play a crucial role in health improvement. NSP intake was significantly higher in active patients than in inactive patients. A significant weak positive correlation between NSPs and physical activity was also observed in this study ($r = 0.13$, $p < 0.01$). NSP-rich foods are digested and absorbed more slowly than other food types due to their role in increasing the viscosity of the gastrointestinal tract, improving post-meal satiety and decreasing subsequent hunger (Lovegrove *et al.*, 2017). Studies have suggested that NSPs may prevent and control diabetes and micro- and macrovascular complications. A previous study conducted in the Netherlands found that a high intake of NSPs is related to a lower BMI. One of the benefits of NSPs is that they enhance the composition of the gut microbiota towards a balanced microbiome; this modulation may help maintain weight, by controlling appetite (Hobden *et al.*, 2015; Alarifi *et al.*, 2018). Additionally, one possible explanation for the significant correlation between physical activity and NSPs is that the increase in consumption of fruit and vegetables and NSP-rich food by active patients may improve their attitude towards exercise. A large body of evidence from studies of the brain–gut axis explains the relation between ingested food and mood/behaviour changes.

Lifestyle and environmental factors are the leading causes of extreme increases in the incidence of T2DM. Additional investigations are required to further determine the causes of increased rates. The link between obesity and T2DM may be difficult to prove. Also, the existence of limited health care plans may be a contributing factor. Physical activity remarkably improves abnormal glucose tolerance. A healthy diet and physical exercise are critical in T2DM management. Patients with T2DM may prevent disease progression during the initial stages, before insulin therapy is required. In Saudi Arabia, the increasing number of patients with T2DM who have poor control of their HbA1c levels should be managed properly. Health care providers should develop effective methods to raise the awareness of patients about the importance of maintaining their HbA1c levels. Physical activity and regular exercise are essential for improving the quality of life of patients with diabetes.

The cross-sectional approach used to examine the association between physical activity and HbA1c and obesity, was a limitation of this study, as no follow-up study was undertaken, to identify other new cases of the disease. However, the study has given an overview of T2DM disease, and it is acknowledged that follow-up studies are needed to investigate the link between physical activity and dietary intake of Saudi individuals with diabetes. Dietary habits may be included in future research, in terms of exploring food choices that affect dietary intake.

5. Conclusion

In conclusion, the critical finding of this study was that patients with T2DM could achieve normal ranges of blood glucose levels by modifying their lifestyle, including increasing their intake of fruit and vegetables and practising daily physical activity. Healthy eating habits and regular exercise are fundamental contributors to T2DM management and overall health, in addition to required medication. Additionally, the need for regular follow-up visits and measurements of body weight and other anthropometric parameters as essential indicators of being overweight or obese is emphasised. Further studies are needed to devise a health care system that supports patients by improving these services and evaluating the system. In conclusion, this study provides an overview of the dietary habits of T2DM people in Saudi Arabia.

Biographies

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