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Design and Psychometrics of Diabetes Knowledge Questionnaire

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Abstract

Background: Due to the important role played by knowledge in controlling and managing diabetes in most educational interventions, the assessment of the individuals' levels of knowledge is regarded as a key variable when planning the given interventions.
Objectives: This study aimed to design and evaluate the psychometric properties of the Diabetic Knowledge Questionnaire for Iranian diabetic patients.
Methods: This cross-sectional study was conducted from March 2020 to May 2021 in Yazd, to examine 400 type 2 diabetes mellitus (T2DM) by adopting the simple random sampling method. Exploratory factor analysis was carried out to evaluate the validity, and 2 methods of test-retest and internal consistency were used to evaluate the reliability. Data were analyzed using SPSS 20 and Amos 21 software.
Results: The questionnaire's items were classified into 6 factors based on factor analysis method; that is, a total of 27 questions with the dimensions of general, hypoglycemia, complications, nutrition, physical activity, and insulin were included. Questions 1 to 24 were allocated to patients with oral therapy, and questions 25 to 27 were allocated to patients under insulin therapy. These factors altogether accounted for 78% of the total variance. The internal correlation coefficient (ICC) for the knowledge questionnaire as a whole was 0.85, which demonstrated an acceptable level of reliability. Also, Pearson correlation coefficient of reliability between test times (test-retest) was found to be 0.92.
Conclusions: The instrument was a valid scale designed to assess the awareness of patients with T2DM about various aspects of the disease. However, it was suggested that further studies should be conducted to investigated the patients with type 1 diabetes mellitus (T1DM) as well as patients with different age groups and education levels.

Keywords: Diabetes, Knowledge, Psychometrics

1. Background

Diabetes mellitus is recognized as a major public health concern worldwide, especially in developing countries, due to its high prevalence, severity, and associated complications (1, 2). According to the International Diabetes Association, in 2019, 1 out of every 11 people aged 20 - 79 has diabetes, which is equivalent to 463 million people, and it is estimated that the number of people with diabetes will reach more than 552 million by 2030 (3, 4). Problems with diabetes can be decreased with early detection and proper management, including lifestyle modifications, regular exercise, a healthy diet, weight control, and medication (5). Studies have shown that knowledge plays a central role in diabetes control, and knowledge of medications, diet, physical activity, home blood glucose monitoring, as well as foot care is essential in the management of diabetes (6).

A previous study has revealed that patients with metabolic syndrome and have inadequate knowledge of the disease fail to adhere to necessary lifestyle changes as well as pursue the required treatment (7). People who are not well aware of their illness do not properly understand the risk of disease-related complications and, therefore, have poor motivation for making behavioral changes to the treatment (8).

One of the most important challenges to deal with type 2 diabetes mellitus (T2DM) in developing countries is the adherence to drug treatment in order to prevent complications. In fact, patients' knowledge of diabetes, education level, and duration of diabetes are recognized as compliance predictors (9).

Due to the significant role of knowledge in controlling and treating the diabetes in most educational interventions, the assessment of the individuals' levels of knowl-

edge is regarded as a key variable when planning the given interventions. In other words, assessment is a complement to education; however, conducting accurate assessment requires effective tools (10). Therefore, it is essential to develop a valid tool capable of assessing people's knowledge of diabetes and intervention efficacy.

The first tool is Diabetes Awareness Test (DKT) which was designed by the Michigan Diabetes Education and Research Center in 1981. This questionnaire consists of 38 questions in 5 domains (i.e., carbohydrates, basics, blood glucose, food exchange, and insulin management) and has been widely used by diabetes researchers and educators (11). In 1984 and in Australia, a three-part scale was designed based on the literature reviews and the experts' knowledge to assess diabetic patients' knowledge. The questionnaire has 45 questions (i.e., one-third of these items are multiple-choice, one-third are true/false, and the rest are open-ended questions). Validation of this tools has been measured and accepted for the Australian population (12). Another tool, Diabetes Knowledge Questionnaire (DKQ), including 60 items in English, was first designed in 2000, but its concise English and Spanish versions (24 items) were validated later (13). Validity of this questionnaire for Portuguese population has been evaluated and confirmed twice, and it has been used to investigate the patients with type 1 and type 2 diabetes (14).

2. Objectives

Due to the lack of a questionnaire assessing diabetes knowledge standard in Iran as well as the lack of some items considered by the researcher in the previous questionnaires (including physical activity and complications of diabetes), this study aimed to design and evaluate the psychometric properties of the DKQ in Iranian diabetic patients.

3. Methods

3.1. Sample

This cross-sectional study was conducted from March 2020 to May 2021, in Yazd, to explore 400 T2DM using simple random sampling method. First, 2 public clinics and 2 private clinics were randomly selected from among diabetes clinics in Yazd. Then, patients from these clinics who were willing to participate in the study and met the inclusion criteria were selected. Inclusion criteria included age 30 - 65 years, having no cognitive disorder, as well as reading and writing ability. To implement factor analysis, the minimum sample size is determined by factors and not by variables; to implement exploratory factor analysis, 10 or 20 samples are required for each factor; however, the minimum sample size 200 is acceptable (15). In order to meet the minimum sample size, therefore, 400 T2DM (i.e., 200 under insulin therapy and 200 under oral therapy) were selected using simple random sampling method.

3.2. Instrument

Initial questionnaire was developed by the research team (i.e., a health educator, a community and preventive medicine specialist, a nutritionist, and 2 endocrinologists) and based on the literature review (the above-mentioned previous questionnaires and FDA guidelines) and expert panel's recommendation. This questionnaire, including 34 multiple choice items, explored 6 dimensions, namely glucose monitoring, diet, physical activity, complications, and insulin. Experts evaluated the questionnaire in terms of consistency with scientific texts as well as appropriate words and grammar choices.

3.3. Content Validity

Content validity index (CVI) and content validity ratio (CVR) were calculated in order to evaluate content validity. The questionnaire was sent to 13 experts in endocrinology, nutrition, exercise physiology, and health education, who were requested to rate the questions in terms of their necessity, simplicity, clarity, and relevance. Each item with CVI $>$ 0.79 and CVR $>$ 0.8 was accepted based on the number of experts (16). Finally, face validity was assessed by 30 patients who were not included in the study sample. They confirmed that the questions and answers were clear.

3.4. Reliability

The reliability of the instrument was assessed adopting 2 methods: Test re-test and internal consistency measurement with a one-month interval. The intraclass correlation coefficient (ICC) was calculated using test re-test. The Cronbach's alpha coefficient was used to measure the internal consistency of each item in each subscale. To this end, 30 diabetic patients not included in the study sample were asked to complete the questionnaire twice at one-month intervals.

3.5. Structural Validity

After the confirmation of the questions regarding content validity and reliability, the construct validity of the questionnaire was evaluated by adopting exploratory factor analysis. Factor analysis enables researchers to come up with a distinct pattern among the many variables and the complex relationships among them. Finally, 400 diabetic patients (oral and insulin therapy) completed the questionnaire.

4. Results

The mean age of participants in this study was 53.98 ± 10.80. As for the gender of participants, 239 (60.1%) were females and 164 (39.9%) were males.

4.1. Content Validity

The CVI results indicated that all questions scored above 0.8 and, therefore, were considered appropriate. The CVR results revealed that all questions were equal to or greater than the number in the Lawshe table (0.62). This indicated that essential and important questions were used in this tool (Table 1) (16).

4.2. Construct Validity

Exploratory and confirmatory factor analysis were used to evaluate the validity of the structure. For the data related to this questionnaire, the Kaiser-Meyer-Olkin (KMO) value was 0.89, which indicated that the suitability of the data reduced a number of key factors. The value of Bartlett's test of sphericity was obtained at the error level of less than 0.001, which was indicative of a sufficient correlation between variables or questions and factors (Table 2).

Exploratory factor analysis was adopted to analyze the items in the questionnaire by using Varimax method (Table 3). According to Table 3, 6 factors with a specific value greater than 1 were extracted, which included 0.82 total variance. Item 3 was removed due to having a common load on 3 factors; items 11 and 18 were removed due to having a negative factor load from a theoretically incorrect point of view. Therefore, items 3, 11, and 18 were generally removed in factor analysis. Finally, 6 factors were obtained implementing the exploratory factor analysis. The first factor included questions 1, 2, and 4, which were referred to as general knowledge questions; the second factor included the expressions 5, 6, 7, and 8, which were called hypoglycemia knowledge; the third factor included the items 9, 10, 12, 13, and 14, which were termed the knowledge of diabetes complications; the fourth factor included the expressions 15, 16, and 17, which were called nutrition knowledge; the fifth factor included the expressions 19, 20, 21, 22, 23, and 24, which were named physical activity knowledge; and finally, the sixth factor included phrases 25, 26, and 27, which were referred to as insulin knowledge. The results of this analysis are shown in Table 3.

According to the scree plot diagram in Figure 1, the six factors in the second factor analysis had a specific value higher than 1, and this number of the extracted factors confirms the number of sub-tests made by the developer of the questionnaire.

Table 3 shows the extracted factors along with the factor load, the percentage of variance, and the correlation of each item with the total score of the questionnaire.

Confirmatory factor analysis was also performed to examine the six-factor model of the knowledge questionnaire. The fit indices of the 6-factor model of the questionnaire are reported in Table 4.

According to this table and regarding the knowledge questionnaire, the root mean square error (RMSEA) was less than 0.08, the goodness-of-fit index (GFI) was 0.91, and the relative chi-square (1.21) was less than 3, based on which the model 6 factors were confirmed. Since the factor loads of all items in the questionnaire were greater than 0.4 and t-values were greater than 1.96, the model obtained from the exploratory analysis was confirmed.

Figure 2 shows all the path coefficients and covariances between the latent (standardized) factors. As shown in this figure, all coefficients were within a reasonable range; in other words, none of the standardized path coefficients had a value greater than 1, and all factor loads were greater than 0.4 (see Figure 2). Therefore, the exploratory model obtained from exploratory factor analysis was confirmed.

4.3. Reliability

The internal correlation coefficient (icc) for test-retest relative reliability of the questionnaire's total score was 0.85, which had an acceptable level of reliability. Furthermore, Pearson correlation coefficient of reliability between test times (test-retest) was calculated to be 0.92. The results of this reliability for all six factors are given in Table 2. The results statistically showed that both correlation coefficient and internal correlation tests had high coefficients, and there was significant reliability between the measures in all subscales ($P < 0.05$) (Table 5).

In addition, Cronbach's alpha coefficient index was used to estimate the internal consistency of this questionnaire, and the value of 0.9 was accepted for the whole instrument (Table 6).

5. Discussion

According to our study findings, the DKQ had content validity, form, and structure, as well as internal consistency, reliability, and good stability; therefore, this questionnaire may have assessed the state of knowledge of diabetic patients with a minimum literacy by spending 10 - 15 minutes to complete. According to the researchers, gaining sufficient knowledge about this chronic disease is the cornerstone of empowering people to self-manage diabetes and, thus, to control the disease (17). In order to check the content validity in this study, the CVR and CVI were calculated, which led to the elimination of 8 questions and

Table 1. Content Validity Index and Content Validity Ratio of Diabetes Knowledge Questionnaire

Items	Content Validity Ratio	Content Validity Index
1- Which one is the recommended fasting blood sugar? a) Less than 130; b) Less than 162; c) Less than 140; d) I do not know	0.88	0.88
2- Which of the following might cause hypoglycemai? a) Heavy exercise; b) Overeating; c) Lack of insulin injection; d) I do not know	1	0.84
3- How often is HbA1c measured? a) Every month; b) Every 2 months; c) Every 3 months; d) I do not know	0.84	0.92
4- What is the recommended level of HbA1c? a) Less than 5; b) Less than 7; c) Less than 8; d) I do not know	1	0.96
5- What is the definition of hypoglycemia? a) Blood sugar < 90; b) Blood sugar < 80; c) Blood sugar < 70; d) I do not know	0.92	0.84
6- Which one is the symptom of hypoglycemia? a) Numbness of hands and feet; b) Severe thirst; c) Tachycardia; d) I do not know	0.84	0.88
7- Which one of the following is recommended to be eaten during hypoglycemia? a) Five dates; b) Sweetened water with 4 sugar cubes; c) Bread; d) I do not know	0.84	0.92
8- In hypoglycemia, how long after eating something is recommended to check the blood sugar? a) Fifteen minutes later; b) One hour later; c) Two hours later; d) I do not know	1	0.88
9- What is the best way to take care of your feet? a) Looking at the feet and washing them daily; b) Massaging the feet daily with alcohol; c) Putting your feet in water for an hour every day; d) I do not know	0.92	0.96
10- Which complication of diabetes causes tingling in the hands and feet? a) Kidney disease; b) Nerve disease; c) Liver disease; d) I do not know	0.88	0.88
11- How often should you go for a foot examination? a) Once every 3 months; b) Once every 6 months; c) Once a year; d) I do not know	0.84	0.88
12- What is the recommended blood pressure for diabetics? a) Less than 150/90; b) Less than 120/80; c) Less than 140/90; d) I do not know	0.84	0.84
13- When is the best time to visit a doctor for a general examination? a) One year after the diagnosis of diabetes; b) Three years after the diagnosis of diabetes; c) As soon as diabetes is diagnosed; d) I do not know	0.84	0.88
14- What do you think is the first sign of kidney disease? a) Kidney pain; b) Burning urine; c) Proteinuria; d) I do not know	0.88	0.88
15- Which one has the highest level of sugar? a) Cooked chicken; b) Baked potato; c) Peanut butter; d) I do not know	1	0.92
16- Which one raises blood sugar the most? a) Watermelon; b) Lettuce; c) Cucumber; d) I do not know	0.92	0.96
17- Which form of the apple is the best form to eat? a) Apple juice; b) Whole apple; c) Grated apple; d) I do not know	0.88	0.92
18- Which one is the best choice during hypoglycemia? a) Honey; b) Low fat milk; c) Juice; d) I do not know	0.92	0.96
19- How many minutes of exercise are recommended for diabetics in a week? a) Sixty minutes; b) Thirty minutes; c) One hundred-fifty minutes; d) I do not know	0.92	0.96
20- Which type of physical activities is the most beneficial one for diabetics with bleeding eyes? A) Walking; b) Running; c) Swimming; d) I do not know	0.92	0.92
21- When is an exercise forbidden for a patient with diabetes? a) Blood sugar > 150; b) Blood sugar > 200; c) Blood sugar > 250; d) I do not know	1	0.92
22- How can one prevent hypoglycemia during exercise? A) Eat a sugary or carbohydrate food before exercise without measuring blood sugar; b) Eating sweet drinks during exercise without measuring blood sugar; c) Measure blood sugar before exercise and eat a sugary or carbohydrate food if needed; d) I do not know	0.92	0.92
23- How hard should a diabetic patient exercise? a) Low; b) Medium; c) Exercise is not suitable at all; d) I do not know	0.84	0.84
24- How many days should a patient with diabetes do exercise? a) One day; b) Two days; c) Three days; d) I do not know	0.88	0.92
25- What should you do if you find out that you have not injected insulin in the morning before lunch? a) Do not eat lunch to lower your blood sugar; b) You inject twice as much as you should have injected correctly; c) First you check your blood sugar and based on that you decide how much insulin to inject.; d) I do not know	0.84	0.92
26- If you inject insulin in the morning but do not eat breakfast, your blood sugar level may.... a) Increase; b) Decrease; c) Not change; d) I do not know	0.84	0.96
27- In order to perform a blood test, it is recommended that .... a) I take insulin even the night before; b) I do not take insulin the night before; c) I do not know	0.88	0.96

Table 2. Results of Kaiser-Meyer-Olkin and Bartlett Tests

Kaiser-Meyer-Olkin Test	Bartlett Test	df	P-Value
0.82	1398.74	351	0.001

Table 3. Results of Factor Analysis of Knowledge Questionnaire Expressions

Items	Factor Loading	Explained Variance (R^2)	Factor Loading	Explained Variance (R^2)	Factor Loading	Explained Variance (R^2)	Factor Loading	Explained Variance (R^2)	Factor Loading	Explained Variance (R^2)	Factor Loading	Explained Variance (R^2)	Correlation with Total Score
1	0.55	0.3035											0.61 [a]
2	0.48	0.1444											0.66 [a]
3	0.61	0.3721											0.58 [a]
5			0.62	0.3844									0.62 [a]
6			0.49	0.2401									0.71 [a]
7			0.55	0.3025									0.55 [a]
8			0.60	9.36									0.63 [a]
9					0.44	0.1936							0.69 [a]
10					0.52	0.2704							0.71 [a]
12					0.68	0.4624							0.57 [a]
13					0.59	0.3481							0.62 [a]
14					0.42	0.1764							0.68 [a]
15							0.44	0.1936					0.55 [a]
16							0.27	0.9729					0.59 [a]
17							0.49	0.2401					0.72 [a]
19									0.60	0.36			0.7 [a]
20									0.47	0.2209			0.69 [a]
21									0.52	0.2704			0.56 [a]
22									0.41	0.1681			0.72 [a]
23									0.55	0.3025			0.68 [a]
24									0.62	0.3844			0.61 [a]
25											0.58	0.33	0.66 [a]
26											0.65	0.42	0.61 [a]
27											0.7	0.49	0.73 [a]

[a] P-value < 0.001

Table 4. Fits of the 6-Factor Model of the Knowledge Questionnaire

Indices	NFI	NNFI	GFI	CFI	IFI	RFI	RMSEA	RMR	Chi-square/df
Amount	0.93	0.95	0.91	0.96	0.96	0.92	0.04	0.19	1.21
Acceptable			> 0.09				< 0.08	< 0.08	< 3

Table 5. Test Test-Retest Reliability of Knowledge Questionnaire Factors

Items	Internal Correlation Coefficient	Pearson	
		Correlation Coefficient	P-Value
General	0.89	0.95	< 0.001
Hypoglycemia	0.86	0.91	< 0.001
Complications	0.91	0.94	< 0.001
Nutrition	0.94	0.89	< 0.001
Physical activity	0.82	0.92	< 0.001
Insulin	0.92	0.91	< 0.001
Total	0.88	0.92	< 0.001

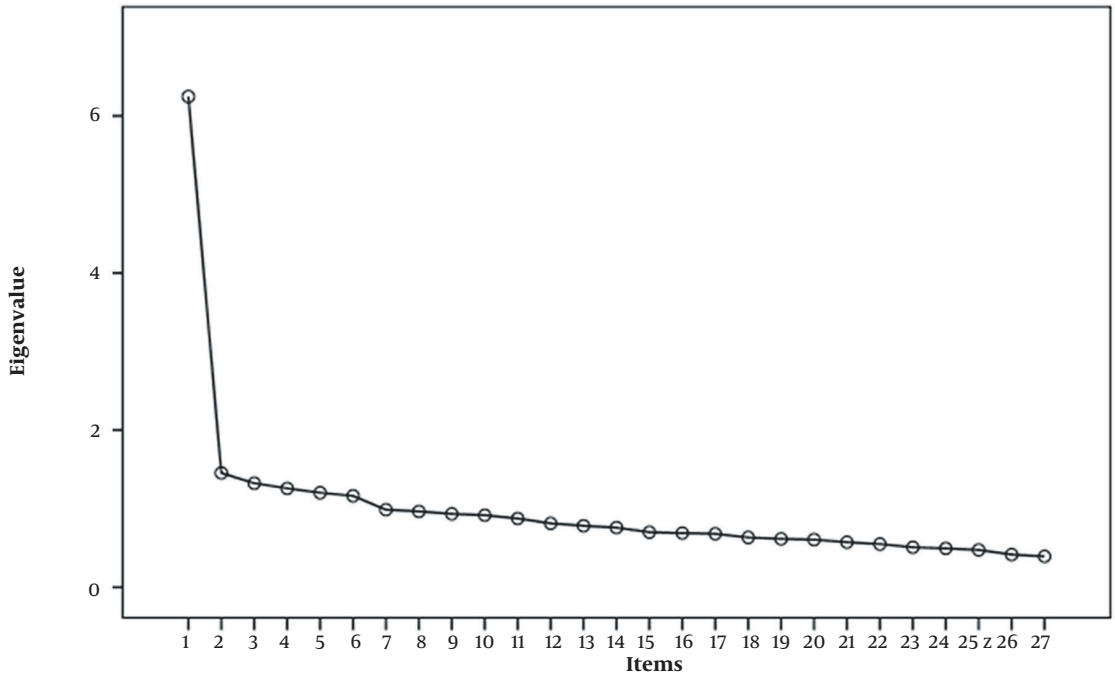

Figure 1. Scree plot diagram (pebble)

Table 6. Cronbach's Alpha Coefficient of Questionnaire Factors

Items	α
General	0.89
Hypoglycemia	0.91
Complications	0.92
Nutrition	0.85
Physical activity	0.92
Insulin	0.91
Total	0.9

the confirmation of the acceptable validity of the rest of questions.

According to results of the exploratory factor analysis test, 23 items were placed in 6 areas: General questions, Hypoglycemia, complications of the disease, nutrition, physical activity, and insulin. When designing this questionnaire, an attempt was made to address the factors that were effective in managing diabetes. The scale designed by Eigenmann et al. also examined the normal blood glucose levels, complications, diet, exercise, blood sugar monitoring, annual checkups, support services, and sick days (18).

Blood glucose control indicators were included in the general questions subscale since the knowledge of the optimal level of blood sugar can help patients to perform better in cases of high blood sugar; in other words, this knowledge empowers them to manage their diabetes. Items for monitoring glucose had also been included in previous questionnaires designed for diabetes knowledge (13, 14).

The definition, symptoms, and treatment of hypoglycemia were considered in hypoglycemic subscale. Although hypoglycemia is more common in patients with type 1 diabetes, those with type 2 diabetes who are on insulin therapy are also at high risk. In other words, hypoglycemia is a common side effect of diabetes treatments, especially insulin, and imposes a significant burden on individuals and health care systems (19).

According to ADA, awareness of the signs and symptoms, as well as appropriate measures during hypoglycemia, are key educational points (20). The test-retest correlation coefficient for this subscale was 0.86. In the hypoglycemia knowledge scale designed by Alotaibi for primary school teachers, the correlation coefficient was 0.95 (21). The reason for the higher reliability of the questionnaire in the given study may have been attributed to the higher education level of the samples compared to the samples of the present study.

In the complication subscale, the optimal time to examine the various complications of diabetes was examined. According to the experts, most patients become

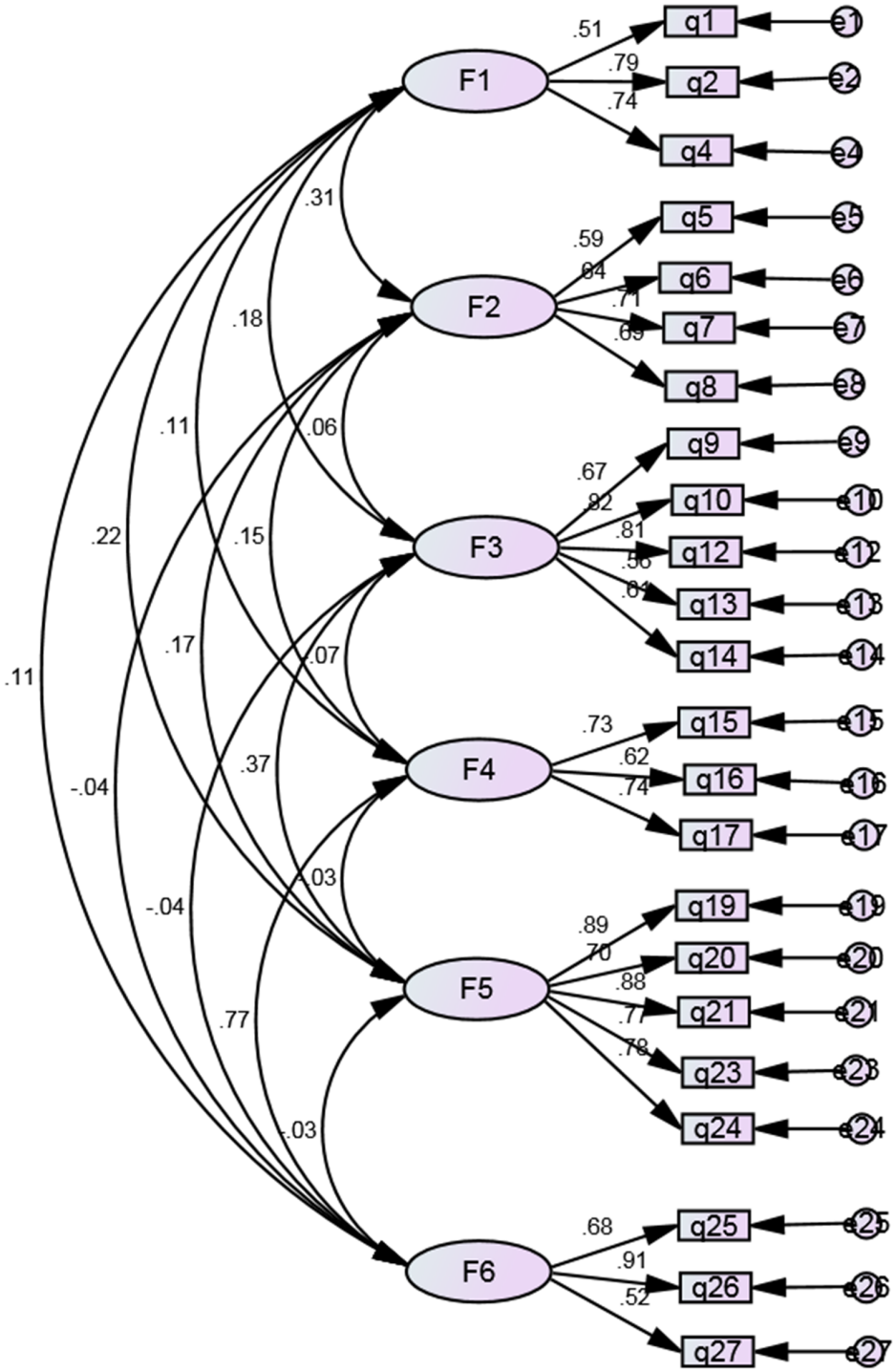

Figure 2. Factor Loads of Items in the Knowledge Questionnaire

aware of their diabetes only when a long time has passed since the onset of the disease, and they have already suffered from its side effects. Awareness of the complications helps patients not to loss valuable time to prevent or minimize the complications. Regarding the complications of diabetes, Alzahrani et al. has suggested that controlling modifiable risk factors through periodic eye examinations can delay the progression of retinopathy (22).

Another subscale in the present questionnaire was the one which examined the physical activities of diabetic patients. Although physical activity has not received enough attention in the previous questionnaires (11, 14), it is an important, recommended treatment for diabetes and according to studies, patients' knowledge about the method of performing physical activities can significantly contribute to blood sugar control (23). Therefore, knowledge of the conditions and the recommended level of physical activities was found necessary to control weight and blood sugar, as well as to prevent muscle atrophy in patients with diabetics.

Acceptable internal consistency for this tool was obtained using Cronbach's alpha test, which was higher than that for the tools previously designed by Fitzgerald et al. (24) and Eva Menino et al. (14). In general, the different results may have been due to the differences in the studied samples regarding age, educational level, training, quality of treatment, etc.

5.1. Limitations

Attempts were made to improve the quality of the present study; however, it faced some limitations. Since our study participants were only patients with type 2 diabetes and holding at least a primary school diploma, the validity of this questionnaire for patients with type 1 diabetes as well as for illiterate patients remained unknown.

5.2. Suggestions

It was suggested that further studies should be carried out to confirm the instrument developed in this study. It was also recommended that lower age groups, patients with lower and higher levels of education, and larger sample sizes should be selected in order to further investigate this tool.

According to our study findings, the questionnaire was a valid scale designed to assess the knowledge of patients with T2DM about various dimensions related to the disease.

Footnotes

Authors' Contribution: Mehrabbeik, A.: Introduction author/original researcher; Azizi, R.: Methodologist/assistant researcher; Rahmanian, M.: Methodologist; Namiranian, N.: Methodologist/discussion author; Shukohifar, M.: Data analyzer; Asi, M. J.: Assistant researcher.

Conflict of Interests: There is no conflict of interests.

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