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Araştırma Makalesi–Research Paper

BLOOD GLUCOSE MEASURING SKILLS OF ADOLESCENTS AGED BETWEEN 12 AND 18 YEARS WİTH TYPE 1 DIABETES MELLITUS: INSTRUMENT DEVELOPMENT AND PSYCHOMETRIC TESTING

TIP 1 DIABETES MELLİTUSLU 12- 18 YAŞ ARASI ADÖLESANLARDA KAN ŞEKERİ ÖLÇÜM BECERİLERİNİ DEĞERLENDİRME ÖLÇEĞİ: ÖLÇEK GELİŞTİRME ÇALIŞMASI

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Özet

Bu araştırma 12 ve 18 yaşları arasındaki tip 1 diabetes mellituslu adölesanlarda kan şekeri ölçüm becerileri değerlendirme ölçeğini geliştirebilmek için planlanmış bir ölçek geliştirme çalışmasıdır. Araştırma metodolojik tipte olup tip 1 diabetus mellitus tanılı 12-18 yaş arasında olan ve araştırmaya katılmak için gönüllü olan 309 adölesan ile yapılmıştır. Araştırmada veri toplama yönteminde, 'Tanıtıcı Bilgi Formu' ve geliştirilmiş olan 35 maddelik 'Kan Şekeri Ölçüm Becerileri Taslak Form' kullanılmıştır. Verilerin analizi SPSS 25.0 ve Amos paket programları kullanılarak değerlendirilmiştir. 'Kan Şekeri Ölçüm Becerileri Taslak Forumu'nun kapsam geçerliliği ise Davis Tekniği kullanılarak gerçekleştirilmiştir. Ölçeğin geçerlik ve güvenirliği için ise Cronbach Alpha katsayısı, madde toplam puan korelasyonları, açıklayıcı ve doğrulayıcı faktör analizleri uygulanmıştır. tip 1 diabetes mellituslu 12- 18 yaş arası adölesanlarda kan şekeri ölçüm becerileri değerlendirme ölçeği toplam varyansın %73,558'ini açıklayan 5 alt boyuttan ve 28 maddeden oluşmaktadır. Ölçeğin Kaiser-Meyer-Olkin (KMO) değeri ise 0.888, Bartlett's küresellik Testi ise X2=7207,466 olarak istatistiksel ileri düzeyde anlamlı bulunmuştur. Ölçek maddelerinin kapsam geçerlilik indeksi ise 0,85-1,00; faktör yükleri ise 0,61-0,96; madde toplam puan korelasyonları 0,427- 0,653 ve alt boyutların Cronbach Alpha Güvenirlik Katsayısı; 0,895- 0,946 olup yüksek güvenirliktedir. Araştırmamızda geliştirilmiş olan tip 1 diabetes mellituslu 12- 18 yaş arası adölesanlarda kan şekeri ölçüm becerilerini değerlendirme ölçeği beşli likert tipte bir ölçek olup 28 madde ve 5 alt boyuttan oluşan geçerli ve güvenilir ölçektir.

Anahtar Kelimeler: Tip 1 Diyabet, Geçerlik, Güvenirlik, Kan Glukoz Ölçümü, Ölçek Geliştirme, Adölesan

Abstract

The aim of this study is to develop a blood glucose measurement skills assessment scale in adolescents aged 12-18 years with type 1 diabetes mellitus. The study is of methodological type and was conducted with 309 adolescents aged 12 and 18 years who were diagnosed with type-1 diabetes mellitus and volunteered to participate in the study. The 'Descriptive Information Form' and the developed 'Blood Glucose Measurement Skills Draft Form' consisting of 35 items were used in the research. SPSS 25.0 and Amos package programs were used for data analysis. Content validity of the 'Blood Glucose Measurement Skills Draft Form' Davis Technique was used. Cronbach Alpha Coefficient, item-total score correlations, explanatory and confirmatory factor analyzes were used for the validity and reliability of the scale. Factor analysis results supported the 28-item as multidimensional with five domains. In adolescents with type 1 diabetes mellitus between the ages of 12 and 18, the Kaiser-Meyer-Olkin value of the blood glucose measurement skills assessment scale was 0.888, and the result of the Bartlett's Test was found to be statistically highly significant (X2 = 7207.466). The content validity index of the scale items was between 0.85 and 1.00, factor loadings were between 0.61 and 0.96, item-total score correlations were between 0.427 and 0.653 and the Cronbach's alpha reliability coefficient of the sub-dimensions was between 0.895 and 0.946 indicating high reliability. The 'Blood Glucose Measuring Skills of Adolescents Aged Between 12 and 18 years with Type 1 Diabetes Mellitus (BGMS-A)' developed in our study is a five-point Likert type, and it is a valid and reliable scale consisting of 28 items and 5 sub-dimensions.

Keywords: Type 1 Diabetes, Validity, Reliability, Blood Glucose Measurement, Scale Development, Adolescent.

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1. INTRODUCTION

Diabetes mellitus causes serious complications due to uncontrolled blood sugar effects. It is a long-term condition characterized by high blood sugar and its incidence is increasing (Doherty, 2015 pp. 407-416). Diabetes self-management education and support of patients is critical to prevent acute complications and reduce the risk of long-term complications. There is substantial evidence to support a range of interventions to improve diabetes outcomes (American Diabetes Association, 2021 pp. 1-2).

Type 1 diabetes mellitus is a common chronic condition in childhood. The age of onset for childhood Type 1 diabetes mellitus occurs at ages 4 to 6 years and early adolescence 10 to 14 years (Felner et al., 2005 pp. 213-220). Epidemiology, pathophysiology and response to treatment in pediatric-onset diabetes are different from those in adult-onset diabetes. The 10th edition of the diabetes atlas confirms that diabetes is one of the fastest growing global health emergencies of the 21st century (International Diabetes Federation, 2021). According to the International Diabetes Federation's 10th edition of diabetes atlas, it is estimated that 1,211,900 children and adolescents younger than 20 years of age have type 1 diabetes worldwide (Ogle et al., 2022 pp. 43). The cause of this increase, which also threatens global health, has been stated as the reflection of the modern lifestyle (Phillips et al., 2017 pp. 417- 421). Non-compliance with treatment has increased the current incidence, which leads to high costs for health budgets (Ortiz & Ortiz, 2005 pp. 307- 313).

In the treatment of type 1 diabetes, the main purpose is to keep the insulin level in the plasma within normal values. Complications start with the non-compliance with treatment. Therefore, the management of this complex process is of great importance (Lowes et al., 2015 pp. 54- 62). Treatment of diabetes mellitus includes medical nutrition therapy, exercise, education of the individual with diabetes and his / her family, and insulin therapy. In the treatment of children with type 1 diabetes and their families, a multidisciplinary expert team sensitive to the difficulties of the family should be included. One of the most difficult periods of chronic disease management in human life is the adolescence due to both physiological and psychological processes. Glycemic control also worsens during adolescence due to physiological insulin resistance caused by high levels of growth hormone (Boogerd et al., 2014 pp. 394- 402; Forsander et al., 2017 pp. 651- 659; Stahl-Pehe et al., 2017 pp. 808-816).

During this period, responsibility of diabetes self-management no longer belongs to the parents but to the adolescent (Agarwal et al., 2017 pp. 524- 531). Therefore, finding appropriate ways to improve self-management levels of patients with DM is very important (Shirivastava et al., 2013 p. 3). Adolescents need lifelong treatment, drugs regulating their blood glucose levels and lifestyle adjustments to control the progression of the disease. In addition, diabetes has long and repetitive characteristics that require patients and their families to have the ability to perform self-monitoring and management of the disease. Self-management is considered

among the most important features of modern health management (DiMeglio et al., 2018 pp. 105- 114).

Self-management is essential to reduce the complications of diabetes in the short and long term. Having a good self-control and proper diet planning, doing physical activities of daily living, using insulin, and monitoring the blood glucose level daily are integrated parts of diabetes care (Lowes et al., 2015 pp. 54- 62; Abubakari et al., 2016 p. 2).

In particular, an individual's self-monitoring of blood sugar, achieving and maintaining the goals of individualized glycemic control are among the cornerstones of diabetes care (Ercan and Kan, 2004 pp. 211- 216). While blood glucose monitoring for glycemic control should be performed at least 6-10 times a day according to the ISPAD (International Society for Pediatric and Adolescent Diabetes) and ADA [American Diabetes Association], it should be performed 4 times a day according to the IDF (International Diabetes Federation) (Westen & Rosenthal, 2003 pp. 608- 618). Therefore, it is extremely important to examine the blood glucose measurement skills of adolescents with Type 1 diabetes, to repeat the training they received from healthcare team members when necessary, and to determine their attitudes towards these skills in a reliable and valid manner. Our literature review demonstrates that no scale has been developed for this and similar purposes.

1.1. Purpose

In the present study, it was aimed to develop a measurement tool to determine the blood glucose measurement skills of adolescents aged 12-18 years with Type 1 Diabetes Mellitus in a reliable and valid manner.

This study includes two phases reporting scale item development (Phase A) and psychometric testing (Phase B) of Blood Glucose Measurement Skills for Adolescents aged 12 to 18 years with Type 1 Diabetes Mellitus (BGMS-A). The instrument development phase included the following:

Phase A: The instrument development phase includes; 1. Conceptual Definition Item Generation 2. Content Validity Assessment. 3. Face Validity Assessment

Phase B. The psychometric testing phase includes; 1. Evaluation of construct validity, 2. Evaluation of internal consistency.

2. METHODS

2.1.Phase A. Scale Item Development

A comprehensive review of the literature on the challenges faced by adolescents with diabetes and diabetes self-management skills was conducted to develop an item pool. In the

comprehensive literature review, it was concluded that adolescents did not comply with blood glucose monitoring and treatment regimens, and had difficulty in developing their self-management skills.

The adolescent information form and the scale for assessing the blood glucose measure trial form were used to collect the study data. In order to reveal the blood glucose measurement skills of adolescents, and to determine the items to be included in the trial form of the scale, the researcher reviewed the literature and analyzed the scales developed for similar purposes, and then created a 35-item trial form of the scale. Responses given to the items in the trial form are rated on a 5-point Likert type scale ranging from 1 to 5 (1 = “I strongly disagree", 2 = "I rarely agree", 3= "Sometimes I agree", 4 = "I mostly agree", 5 = "I always agree").

Content Validity Assessment

Validity is the degree to which the scale serves its intended use, and the degree to which the property is to be measured can be measured preventing it from being mistaken with any other property (Davis, 1992 pp. 194- 197). In the present study, the content validity of the scale aimed at assessing blood glucose measurement skills of adolescents with type 1 diabetes was studied. Content validity refers to the degree to which the items in the measuring tool measure the specified properties correctly, and the appropriateness of the relationships between the factors (Tavşancıl, 2018). At this stage, a 35-item trial form created to obtain expert opinion was presented to the views of 13 people working in the field of health [nurses providing training on diabetes, specialist nurses and physicians] and academic nurses (Şimşek, 2007). The experts were asked to rate each item of the scale as “not suitable”, "somewhat suitable", "quite suitable" and "very suitable" based on the Davis Technique. Based on the feedback from the experts, the trial form was rearranged and the 34-item scale assessment of blood glucose measuring skills in adolescents with type 1 diabetes was developed. Content Validity Index (CVI) values in the study varied between 0.85 and 1. The CVI value of the overall scale was 0.96.

Face Validity Assessment

The 34-item trial form was administered to 102 adolescents in the sample to study its construct validity and reliability. Based on the data obtained from the participating adolescents, the arithmetic mean, standard deviations, item discrimination t value, factor common variance, factor load value, factor load values after rotation, item total coefficients, Cronbach’s α reliability coefficient when the item was deleted, and Cronbach’s α reliability coefficient of the factors were calculated. Then, 4 items [items 6, 7, 12, 17] were removed from the 34-item trial form and the number of the items in the trial form was reduced to 30.

2.2.Phase B. Psychometric Testing

Working Design

At this stage of the study, the psychometric properties of BGMS-A were tested. A methodological design was used at this stage. Medical research ethics committee approval was obtained before the study was conducted. Approval of the medical research ethics committee of the Egean University was obtained (Institutional Review Board (IRB) number: 99166796-050.06.04). In addition, an institutional permit was obtained from the institution where the study was to be conducted. Written informed consent was obtained from the adolescents and parents participating in the study.

Participant

The data were collected by face-to-face interview method using a form containing sociodemographic and clinical characteristics and the blood glucose measurement skills assessment scale for adolescents developed by the researchers.

In the literature it is emphasized that in a scale development study, the size of the sampling should be five- or ten-fold the number of the items in the scale. Therefore, because in our study, a 35-item trial form was used, it was decided that the number of adolescents with type 1 diabetes to be included in the study should be between (5x35) 175 and (10x35) 350. The study was carried out with volunteering adolescents. The pilot implementation of the study was conducted with 102 adolescents. The sample of the study consisted of 309 adolescents. These adolescents were not included in the pilot study. The inclusion criteria for adolescents are as follows: Having been diagnosed with diabetes for at least 1 year, measuring blood sugar at least 4 times a day, being in the 12-18 age group, being literate, not having a physical or mental disability preventing the person from participating in the study.

The research was carried out between January 2020 and September 2020 in the Pediatric Endocrine Service and Pediatric Endocrine Polyclinic of a Ministry of Health Hospital in Izmir, a province in western Turkey. This hospital was preferred due to its high number of patient population in its region. Adolescents completed the data collection tool themselves. Data collection took 7-10 minutes on average

Statistical Analysis

The data were analyzed using the IBM SPSS Statistics 25-Amos package program. Means and percentages from descriptive statistics were used. Adolescents' sociodemographic and clinical characteristics were analyzed by number, percentage, mean and standard deviation.

The validity and reliability of the scale were tested. The CVI and construct validity analysis were used for validity. Explanatory Factor Analysis (EFA) and Confirmatory Factor

Analysis (CFA) were used to test the construct validity of the scale. In the reliability analysis of the scale, item analysis was tested using Cronbach's alpha reliability coefficient and reliability test (Spearman Brown Correlation Coefficient).

Construct validity

Factor analysis was performed for construct validity. Kaiser-Meyer-Olkin (KMO) and Bartlett Sphericity tests were used for the main sample size before the analysis. The EFA as performed to investigate the sub-dimension structure of the new scale whose sample size was determined. After the Exploratory Factor Analysis, the CFA was performed to measure conceptual integrity. After the CFA, two items requiring further improvement were removed from the 30-item scale. After the removal of these two items, the EFA was re-performed on the 28-item scale.

3. RESULTS

3.1. Characteristics of Participants

309 adolescents participated in the study. 54.4% of adolescents are female. Their age mean was 14.44 ± 1.93. Of the adolescents, 46.6% (n = 144) were in secondary school and 53.4% (n = 165) were in high school. 20.1% of the mothers (n=62) and 22% of the fathers (n=68) of the adolescents were primary school graduates. The rest of the adolescents' parents were high school and college graduates. The percentage of children with blood sugar health problems in their families was 31.1% (n=96). The rate of adolescents with a chronic disease in their family is 6.5% (n= 20).The percentages of adolescent who had family members or relatives cardiogenic disease, nephrological disease and endocrinological disease 15% (n = 3), 30% (n = 6), and 55% (n = 11), respectively. The mean number of the blood glucose measurements made by the adolescents during the day was 4.68% ± 2.06. The average of HbA1c values measured in the last 3 months was 9.89 ± 2.35 (min: 4.90%, max: 16.60%) (Table 1).

3.2. Construct Validity

The EFA and CFA were used for the construct validity of the scale. At this stage, the factor structure of the scale was analyzed using the EFA. The EFA was performed for the 30-item form of the scale. The results of Bartlett's test and KMO test were taken into consideration to determine whether the data were suitable for the factor analysis (Büyüköztürk et al., 2012). Results of EFA of BGMS- A are shown in Table 2. EFA found that the KMO coefficient was 0.888, and the Bartlett's test result was X2 = 7207,466, (degrees of freedom= 378) $p<0.001$. Five factors with eigenvalues greater than 1.00 were found. These five factors explain 73,558% of the total variance. The process sub-dimension explained 24.318% of the total variance, the device preparation sub-dimension explained 13.841% of the total variance, the process preparation sub-dimension explained 13.150% of the total variance, the hygiene sub-dimension

explained 11.460% of the total variance, and assessment sub-dimension explained 10.789% of the total variance. The result of these two tests demonstrated that the data set was suitable for the factor analysis.

Table 1. The sociodemographic of the Adolescents With Type-1 Diabetes (N=309)

Variables	**M±SD[3] (min-max)**
Age (years)	14.45±1.93 (12-18)
Diabetes diagnosis year	4.11±2.66 (1-13)
Gender	Number (Percentage)
Female	168 (54.4)
Male	141 (45.6)
Education	
Secondary school	144 (46.6)
High school	165 (53.4)
Living place	
Village	33 (10.7)
District	30 (9.7)
City	57 (18.4)
Big city	189 (61.2)
Mother's education	
Primary school	62 (20.1)
Secondary school	102 (33.0)
High school	99 (32.0)
University	35 (11.3)
Illiterate	11 (3.6)
Father's education	
Primary school	68 (22.0)
Secondary school	99 (32.0)
High school	96 (31.1)
University	36 (11.7)
Illiterate	10 (3.2)
Diagnosis in family	
Yes	213 (68.9)
No	96 (31.1)
Individuals diagnosed	
Parents, siblings	59 (61.5)
Other relatives	37 (38.5)
Chronic disease	
Yes	289 (93.5)
No	20 (6.5)
Chronic disease type	
Cardiological diseases	3 (15.0)
Nephrological diseases	6 (30.0)
Endocrinological diseases	11 (55.0)
Total	309 (100)

Table 2. Exploratory Factor Analysis (n = 309)

Item Number	Items	Factors	Factor loading values in principal component analysis	Rate of variances explained by factors
Item 14	**I place the test strip properly into the blood glucose meter**	Factor 1 Process	0.77	24.318%
Item 16	**After taking the test strip from its box, I quickly close the lid of the box.**		0.79	
Item 17	**I decide / determine the site from which I can take the blood sample**		0.80	
Item 19	**While I take a blood sample from my finger, I prick the tip of my finger.**		0.78	
Item 20	**I adjust the lancet according to the insertion site from which I will take the blood sample.**		0.77	
Item 21	**I wipe off the first drop of blood with a piece of dry cotton**		0.80	
Item 22	**For measurement, I milk my finger from bottom to top and take the drop of blood onto the test strip.**		0.77	
Item 23	**I bring my finger closer to the test strip inserted in the blood glucose meter, so that the**		0.84	

	strip absorbs the blood.			
Item 24	**I wait until the meter signals that there is enough blood on the test strip.**		0.81	
Item 25	**After I draw my blood sample, I press on the insertion site with a piece of dry cotton.**		0.80	
Item 8	**I store / keep my test strips in their box.**	Factor 2 Device Preparation	0.74	13.841%
Item 9	**I check the expiration date of my test strips**		0.83	
Item 10	**I check the test strips for deformation or discoloration.**		0.87	
Item 11	**I replace the lancet of the lancing device every day**		0.85	
Item 12	**I can use the lancing device.**		0.82	
Item 1	**Before I measure blood glucose level, I wash my hands with warm water and soap**	Factor 3 Process Preparation	0.72	13.150 %
Item 3	**I use the lancet insertion sites from which I draw blood for blood glucose measurement alternately.**		0.93	
Item 4	**I know alternative lancet insertion sites from which I can draw blood for blood glucose measurement**		0.87	

Item 5	**I pay attention to the texture / integrity of the lancet insertion site from which I draw blood for blood glucose measurement.**		0.79	
Item 30	**After I complete the blood glucose measurement, I wash my hands again with warm water and soap**	Factor 4 Hygiene	0.75	11.460 %
Item 31	**I put the materials I use to measure blood glucose into a wastebasket.**		0.89	
Item 32	**I put the lancets I use to measure blood glucose into another container.**		0.79	
Item 33	**I give the lancets I use while I measure blood glucose level to the nurse giving the diabetes training when I come to the hospital for control.**		0.76	
Item 34	**I check my materials I will use for my next blood glucose measurement**		0.81	
Item 26	**I immediately record the reading on the blood glucose meter.**	Factor 5 Assessment	0.61	10.789%
Item 27	**I can interpret the values of my blood glucose measurement**		0.81	

Item 28	**I know what to do when my blood glucose level is high.**			0.96	
Item 29	**I know what to do when my blood glucose level is low.**			0.90	
	Total Scale	-	-	-	73.558%

In the factor analysis, primarily in the principal component analysis, varimax axis rotation was performed, in order for the eigenvalue of the items in the scale to be 1. The EFA results showed that the process preparation, device preparation, process, assessment and hygiene sub-dimension factor loadings ranged from 0.72 to 0.93, 0.74 to 0.87, 0.77 to 0.84, 0.61 to 0.96, and 0.75 to.89.

The results of the exploratory factor analysis indicated that the scale had a five-factor structure varying between 0.723 and 0.898.

Of these factors, the first one included ten items (items14, 16, 17, 19, 20, 21, 22, 23, 24, 25). The first factor formed by the items whose load value was 24.604% was called "Process".

The second factor included five items (items 8, 9 ,10 ,11, 12). The second factor formed by the items whose load value was 24.604% was called "Device Preparation".

The third factor included five items (items 30, 31, 32, 33, 34). The third factor formed by the items whose load value was 24.604% was called “Hygiene".

The fourth factor included four items (items 26, 27, 28, 29). The fourth factor formed by the items whose load value was 12.269% was called "Assessment".

The fifth factor included four items (items 1, 3, 4, 5). The fifth factor formed by the items whose load value was 10.789% was called "Process Preparation".

Results of CFA of BGMS-A are shown in Figure 1.

CFA found that the process preparation, device preparation, process, assessment and hygiene sub-dimension factor loadings ranged from 0.73 to 0.93, 0.74 to 0.87, 0.77 to 0.82, 0.62 to 0.95 and 0.75 to 0.88, respectively. The fit indices calculated by CFA to evaluate the model fit of the 28-item trial form are as follows: RMSEA = 0.066; CFI = 0.938; GFI = 0.850; AGFI = 0.818; RMR = 0.042. In order to provide evidence for the construct validity determined with the exploratory factor analysis, the CFA was conducted on the data obtained from different individuals.

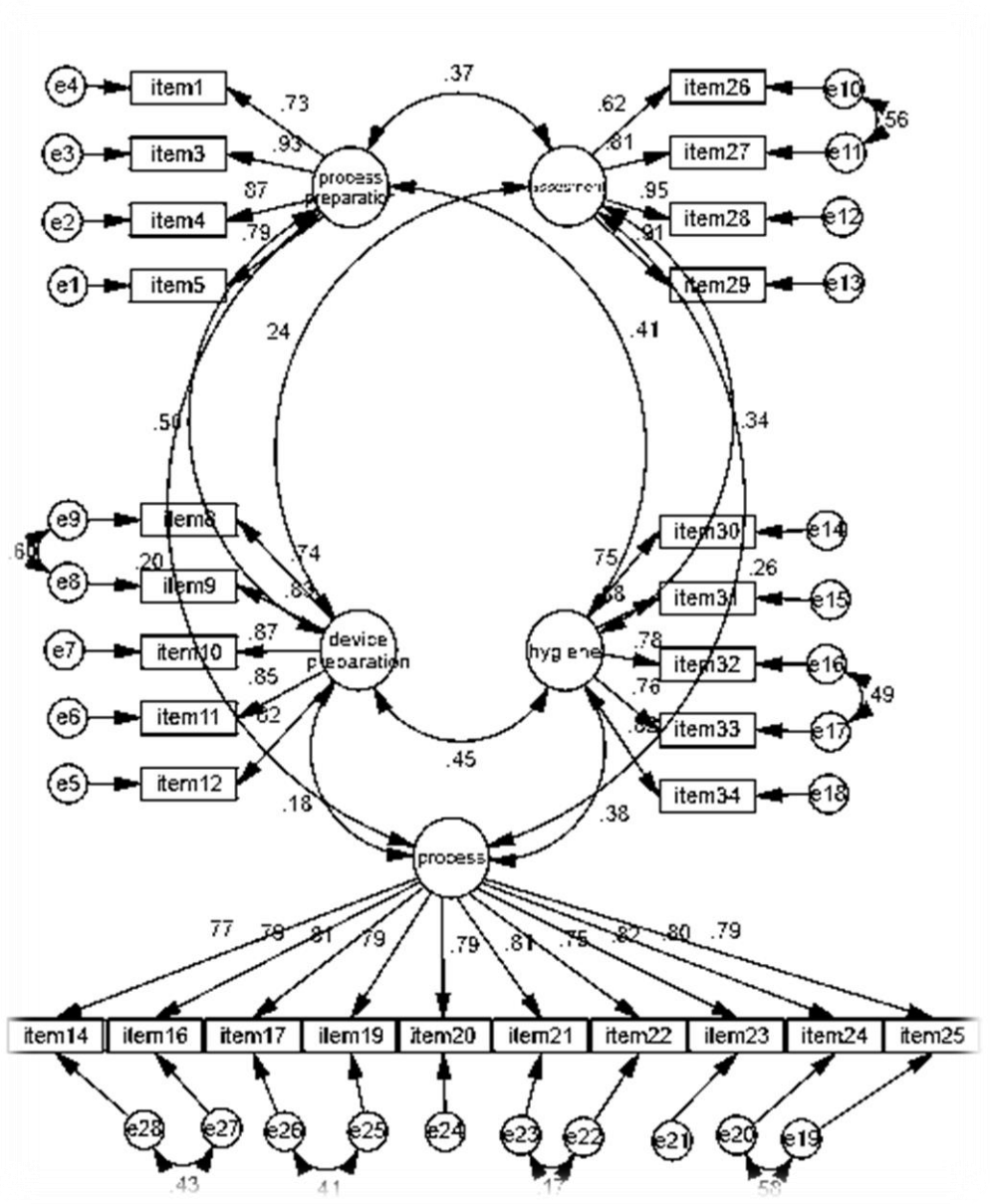

Figure 1: Confirmatory Factor Analysis Model

These values indicated that the scale fit was ensured. The statistics of X2 / s = 2.327 was also significant (p <0.01) which suggests that the scale's goodness of fit was acceptable. As is indicated in the literature, the chi-square / df ratio below 3 and 5 indicates excellent and moderate fit respectively, RMSEA and RMR values <0.05 indicate good fit, RMSEA and RMR values between 0.05 and 0.08 indicate adequate fit, and the CFI value greater than 0.95, the GFI value greater than 0.90 and the AGFI value greater than 0.85 indicate an acceptable fit.

After the confirmatory factor analysis, 2 items were removed from the 30-item scale, and the KMO value calculated for the suitability of the factor analysis of the data for the 28-item trial form was 0.888 and the chi-square statistics calculated with the Bartlett's test was significant (X2 = 7207.46, p <0.001). The results of these two tests demonstrated that the data set was suitable for factor analysis.

Factor loadings of the EFA of the blood glucose measurement skills assessment scale in adolescents with type 1 diabetes are given in detail in Table 2.

According to the EFA, the scale consists of 28 items and 5 factors. These factor loadings indicate that the scale explains the blood glucose measurement skills in adolescents with type 1 diabetes well.

3.3. Basic Item Analysis and Cronbach's Alpha Coefficients

The reliability coefficient of the BGMS-A (28 Items) was found to be α = 0.925 which suggests that the scale can explain the quality to be measured with it (Esin, 2015 pp. 193-234). The process preparation (4 Items), device preparation (5 Items), process (10 Items), assessment (4 Items), hyginee (5 Items) sub-dimension reliability coefficients were α = 0.895, α = 0.919, α = 0.946, α = 0.907, α = 0.902 respectively. In the reliability analysis, item-total score correlations of the 28-item scale were examined. It was observed that the correlation coefficients of the examined scale items with the whole scale ranged between 0.423 and 0.697 (p=0.00).Results of item-total score correlation, item-sub-dimension score correlations, and correlations of sub-dimensions of the BGMS- A are shown in Table 3.

This study found that the process preparation, device preparation, process, assessment and hygiene sub-dimension correlation coefficients ranged from 0.788 to 0.835, 0.809 to 0.852, 0.758 to 0.829, 0.724 to 0.870 and 0.721 to 0.845 respectively. They were all statistically significant (p=0.00).

3.4. Sub-dimension Correlation

The correlation between the sub-dimensions and the scale was examined. The correlations between the whole scale and sub-dimensions were highly positive and statistically significant (r = 0.823, p=0.00). The correlations of the process preparation sub-dimension, device preparation sub-dimension, assessment sub-dimension and hygiene sub-dimension with the entire scale were found to be positive at a moderate level and statistically significant (r = 0.575, r = 0.571, r = 0.594, r= 0.643 p= 0.00) (Table 3).

Table 3. Item-total score correlation, item-subscale score correlations, and correlations of subscales of the Blood Glucose Measurement Skills Assessment Scale For Adolescents (n = 309)

Item number	**Scale subscales**	**Item total Score correlations (n=309)**		**Item-subscale total score correlations (n=309)**		**Relationship between the scale score and subscale scores (n= 309)**		**Cronbach Alpha**
		r	***p***	***r***	***p***	***r***	***p***	
Item 1	**Process preparation**	0.478	0,00	0,797	0.00	0.575		0.895
Item 3		0.473	0,00	0.835	0.00	0.00		
Item 4		0.474	0,00	0.788	0.00			
Item 5		0.423	0,00	0.814	0.00			
Item 8	**Device preparation**	0.457	0.00	0.815	0.00	0.571		0.919
Item 9		0.492	0.00	0.852	0.00	0.00		
Item 10		0.443	0.00	0.852	0.00			
Item 11		0.445	0.00	0.820	0.00			
Item 12		0.427	0.00	0.809	0.00			
Item 14	**Process**	0.619	0.00	0.829	0.00	0.823	0.00	0.946
Item16		0.697	0.00	0.808	0.00			
Item17		0.676	0.00	0.812	0.00			
Item19		0.653	0.00	0.795	0.00			
Item20		0.619	0.00	0.776	0.00			
Item21		0.599	0.00	0.819	0.00			
Item22		0.607	0.00	0.758	0.00			
Item23		0.597	0.00	0.828	0.00			
Item24		0.618	0.00	0.827	0.00			
Item25		0.650	0.00	0.811	0.00			
Item26	**Assessment**	0.496	0.00	0.724	0.00	0.594	0.00	0.907
Item27		0.511	0.00	0.875	0.00			
Item28		0.456	0.00	0.897	0.00			
Item29		0.449	0.00	0.870	0.00			
Item30	**Hygiene**	0.519	0.00	0.721	0.00	0.643	0.00	0.902
Item 31		0.552	0.00	0.825	0.00			
Item32		0.486	0.00	0.845	0.00			
Item 33		0.477	0.00	0.839	0.00			
Item 34		0.558	0.00	0.758	0.00			

3.5. Test-retest Reliability

BGMS-A was filled by adolescents and 34 adolescents were selected for test-retest reliability analysis. It was reapplied 4 weeks later. As shown in Table 4, there was a statistically significant positive correlation between test-retest scores (entire scale: r = 0.93, p=0.00; process preparation: r = 0.86, p=0.00; device preparation: r = 0.92, p=0.00; Process: r = 0.94, p=0.00; assessment: r=0.95 p=0.00 hygiene: r=0.89 p=0.00; There was no difference between the averages obtained as a result of these two measurements made with an interval of four weeks. (p=0.00)

The scale for the assessment of blood glucose measuring skills of adolescents with type 1 diabetes mellitus is a 5-point Likert type scale and consists of 28 items. The minimum and maximum possible scores to be obtained from the scale are 28 and 140 respectively. There are no reverse scored items in the scale.

Table 4. Test-retest mean scores on the subscales of the Blood Glucose Measurement Skills Assessment Scale For Adolescents (n=34)

Scale and subscales	**Blood Glucose Measurement Skills Assessment Scale For Adolescents**		**Anaysis Result**	
	First practice X ± Sd	***Second practice X ± Sd***	***r***	***p***
Total Scale	124,41±13,84	121,82±13,66	0.93	0.00
Process preparation	18,44±1,99	18,38±1,99	0.86	0.00
Device preparation	22,06±3,54	22,47±3,67	0.92	0.00
Process	39,03±11,24	40,38±10,58	0.94	0.00
Assessment	17,12±3,81	17,15±3,47	0.95	0.00
Hygiene	23,56±2,03	23,24±2,05	0.89	0.00

4. DISCUSSION

Type 1 diabetes has various effects on life. Self-monitoring and follow-up is extremely important in order to minimize or prevent these effects. Self-monitoring is the assuming the responsibility of the diabetes care by the child with diabetes. The child can balance his or her glycemic control and reduce the frequency of hospitalizations and long-term complications of diabetes through frequent and accurate measurements. Glycemic control performed correctly by the child can provide a flexible lifestyle in the long term and minimize the diabetes-related expenses in the future. Skills used for the frequent and accurate blood glucose measurements are the only method in which both the process and optimal glycemic control can be achieved (Acemoğlu and Aktürk, 2012 pp. 316-319).

The results of the analysis demonstrated that the reliability of the questionnaire administered was approximately 92%. According to the result of EFA, the scale had a 5-factor structure. The result of KMO test for Sampling Adequacy was 0.888 and Bartlett's sphericity test result was X2 = 7207.466 (degrees of freedom = 378), which was considered significant p <0.001. The fact that the KMO was 0.89 and that the Bartlett test was significant indicated that the items that made up the questionnaire were consistent with the factor analysis.

The model created was then subjected to the CFA, and its fit was evaluated. The model had good fit values. After the analysis was performed, the number of the items in the 35-item trial scale was reduced to 28 items. With these items, a 5-factor structure was created: Process Preparation, Device Preparation, Process, Assessment and Hygiene. The reliability values of the factors varied between 89% and 94%.

The CFA was performed to verify the created model. The contribution of the 5-factor structure to the variance was 73.56%. According to this finding, the 5-factor structure accounted for more than half of the variance suggesting that the factor structure was strong.

In this analysis, the RMSEA, GFI and CFI values were calculated as 0.066, 0.85 and 0.938 respectively. RMSEA was at an acceptable level of fit and was statistically significant. On the other hand, other goodness of fit values (GFI and CFI) were also above 0.8, and according to the literature, the value close to 1 indicates a good fit. According to the results of the CFA, the factor loadings were greater than 0.7. The analysis of the content integrity of the created model indicated that the model had a consistent construct. In order to determine that the consistency did not change over time, invariance [test-retest] and internal consistency analyses were conducted to evaluate the reliability of the scale for the assessment of blood glucose measuring skills on adolescents with type 1 diabetes mellitus aged 12 to 18. In the present study, the scale administered to 34 participants was readministered to the same group after 2-4 weeks (Esin, 2015 pp. 193- 234; Acemoğlu and Aktürk 2012 pp. 316- 319). The Pearson Correlation Coefficient was calculated in order to evaluate the correlation with the total scores

obtained from the sub-dimensions in both administrations of the scale. In the present study, correlation coefficients of the five sub-dimensions of the scale varied between 0.86 and 0.95. The test-retest score correlation of the overall scale was calculated as 0.93. All the r-values determined in the study were higher than 0.70.

Glycemic control performed correctly by the child can provide a flexible lifestyle in the long term and minimize the diabetes-related expenses in the future. Skills used for the frequent and accurate blood glucose measurements are the only method in which both the process and optimal glycemic control can be achieved (Phelan et al., 2018 pp. 75-83). Within this context, we believe that the scale we developed to measure the adequacy of blood glucose measurement skills on adolescents aged 12-18 years with Type 1 Diabetes Mellitus was a valid and reliable tool.

5. CONCLUSIONS

Type 1 diabetes has various effects on life. Self-monitoring and follow-up is extremely important in order to minimize or prevent these effects. Self-monitoring is the assuming the responsibility of the diabetes care by the child with diabetes. The child can balance his or her glycemic control and reduce the frequency of hospitalizations and long-term complications of diabetes through frequent and accurate measurements. the adolescent blood glucose measurement skills assessment scale consisted of 28 items and five sub-dimensions, and the results were obtained as a result of examining the psycholinguistic and psychometric properties of the draft scale. When the scores that can be taken from the scale are calculated, the lowest score that can be obtained from the scale is 28, and the highest score is 140. High scores that can be obtained from the scale indicate that blood glucose measurement skills perform better.

As a result of the analysis, it was seen that the adolescent blood glucose measurement skills assessment scale is a valid and reliable measurement tool to evaluate the blood glucose measurement skills of adolescents in Turkish society. The scale could be used by healthcare professionals in standardizing the evaluation of blood glucose measurement skills of adolescents with Type-1 diabetes, in decision-making processes and in the follow-up of adolescents.

The BGMS-A scale developed in this study is valid. It has been concluded that this scale can reliably evaluate the behavior of adolescents aged 12-18 in Turkish society regarding their blood glucose measurement skills. The scale can be used in future studies in Turkish society and can easily be adapted for use in other societies because of its universal items regarding blood glucose measurement skills. In addition, the scale can be used in different languages and cultures, but it is recommended to perform a validity and reliability analysis for this.

Strengths and Limitations

The study was conducted during the pandemic period; therefore, we had trouble achieving the sample size. The main limitation of the present study, aimed at evaluating the blood glucose measurement skills of adolescents with type 1 diabetes, was that the study was conducted in only one hospital in Izmir and it included adolescents between the ages of 12 and 18. Another limitation was that it was difficult to reach adolescents due to the Covid-19 pandemic began during the research process.

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