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Effect of an intervention program on improving the knowledge and self-care practices for diabetic School-age children

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Abstract
Background: Diabetes mellitus (DM) is one of the most common endocrine and metabolic conditions in childhood.
The Aim of the Study: to testing the effect of an intervention program on improving the knowledge and self-care practices for diabetic school-age children.
Design: The study was conducted using pre/post research design.
Setting: study was conducted in six governmental primary and preparatory schools in Mansoura city, Dakahlia Governorate.
Sample: A purposive sample of 120 diabetic children and diagnosed as having type I diabetes mellitus (DM) for at least 6 months.
Tools: Four tools were used to collect the data for this study, namely a structured interview questionnaire, knowledge assessment and reported self-care practices, an observation checklist, and intervention program.
Results: there are clear deficiencies in diabetic schoolchildren's of their knowledge and the related self-care.
Conclusion: after the implementation of a training program there was remarkable improving in their knowledge and practices.
Recommendations: The training program should be implemented in settings providing care for diabetic children, with longer follow-up in order to assess its long-term effects.

Keywords: Diabetic school-age children, intervention program, knowledge, and self-care practices

Introduction

Diabetes is one of the most common challenges to health in the new Century (Bixo Ottosson *et al*.,) [8]. Type I diabetes is known to be one of the most prevalent chronic childhood illness (Grady *et al*., 2017) [13]. The incidence of this disease is continually rising all over the world (Cheon, 2018) [10], and it might be associated with the feeling of stigma, which complicates its management (Brazeau *et al*., 2018) [9]. The incidence of the disease is higher among adolescents, but the rates continue to be high in third decade adults, which necessitate self-care efforts to achieve good control (Lee *et al*., 2018) [19].

Self-care is a goal-oriented activity, which can be taught. The foundation of Orem self-care concept is that everyone needs a self-care strategy to be able to preserved health and ensure good quality of life (Orem *et al*., 2003). Diabetes self-care is not an easy task; it needs a lot of efforts to comply with the management plan, and this requires knowledge and skills (Stoianova *et al*., 2018) [25]. However, research consistently demonstrates deficiencies in diabetic patients' knowledge of the disease and related self-care practices (Heinemann *et al*., 2018) [14]. Thus, children with Type 1 diabetes need to learn self-care and related knowledge and skills in order to be able to manage this complicated disease (de Cássia Sparapani *et al*., 2017; Klein *et al*., 2018) [11, 18, 23]. This is of particular importance in the adolescent age when teenagers feel the need to be self-dependent in the management of their illness (Strand *et al*., 2018) [26]. Hence, the need for well-structured educational programs for diabetic schoolchildren (Mouslech *et al*., 2018) [21].

The advances in the technology of blood testing and medication administration for diabetic patients has contributed much to ease the procedures of self-care among them. Thus, blood glucose monitors using capillary blood samples have shown dramatic advances over the last years (Heinemann *et al*., 2018) [14]. Devices with color image indicators were developed to ease the process of monitoring and interpreting blood glucose levels for better self-care (Grady *et al*., 2017) [13].

Diabetes self-management education by a trained Certified Diabetes Educator (CDE) is the standard of care for patients with diabetes to increase their self-management skills and to encourage preventive care.

The pediatric and community health nurses have frequent and prolonged contacts with diabetic children, and are thus in the best position to intervene with the aim of improving their knowledge and self-care skills. In Egypt, the assessment of self-care practices among diabetic children has seldom been investigated. Hence, the present study is an

attempt to fill this gap through implementing and evaluating a self-management educational program for diabetic children.

Significance of the Study

Diabetes self-care education is a critical element of care for all people with diabetes and necessary to improve patient outcomes. The findings of the researchers who have examined the effect of diabetes education programs on diabetes self-care practice indicated that compliance with daily screening of blood, urine glucose, and medication has improved, Also some studies indicated that young patients got more improvement and more benefit from the practical part of the educational program, specifically in foot care and insulin injection Ali, (2011) [4], Abdel Megeid, &El-Sayed, (2012) [1] Ali, *et al*., (2014) [3]. The current study highlights the fact that self-care educational program for children with type1diabetes mellitus increases patient's self-care agency to meet therapeutic self-care demands including diet control, exercise, medication taking and personal hygiene and safety practices.

Aim of the Study

The study is aimed at testing the effect of an intervention program on improving the knowledge and self-care practices for diabetic school-age children.

The Research Hypothesis

The diabetic schoolchildren will have satisfactory level of knowledge and adequate self-care practices (insulin self-injection and blood glucose self-testing) after implementation of the intervention program.

Subjects and Method

Research Design

The study was conducted using pre/post research design.

Setting

It was carried out at the following six governmental primary and preparatory schools in Mansoura city, Dakahlia Governorate.

Subjects

A purposive sample of 120 diabetic children was selected from the above mentioned setting fulfilling the inclusion criteria of being a primary/ preparatory school child, and diagnosed as having type I diabetes mellitus (DM) for at least 6 months. The children with other chronic diseases or mental disorders were excluded.

Data Collection Tools

Four tools were used to collect the data for this study, namely a structured interview questionnaire, knowledge assessment and reported self-care practices, an observation checklist, and intervention program

Tool 1: Structured Interview Questionnaire

It was developed by the researcher to assess diabetic children's Socio-demographic data, medical history, and physical assessment. It consisted of the three parts.

- **Part I: Socio-demographic Data:** It included child age, gender, school grade, birth order, and number of siblings, in addition to parents' education, mother job, residence, and family income.
- **Part II: Medical History:** This covered the mode of onset and duration of diabetes, and number of related symptoms.
- **Part III: Physical Assessment:** This was for recording the findings of a quick physical assessment of child. In this part the researcher observe the child to detect any abnormal finding. The researcher measured the child weight and height and recorded it for calculation of the Body Mass Index (BMI). The laboratory tests results (blood glucose: fasting and postprandial, and the level of glycated hemoglobin (HbA1c) were also copied from the child's medical file.

Tool 2: Knowledge Assessment and Reported self-care Practices

It was developed by the researcher to assess knowledge and reported self-care practices, it includes two parts:

- **Part I: Knowledge Assessment:** This part was intended to assess child' knowledge of diabetes mellitus and related care. It covered the disease definition and nature, etiology, manifestations, treatment, and self-care, practices as diet, mediation, exercises, hygiene, and safety precautions.

Scoring System

For scoring of the knowledge items, a correct response was scored 1 and the incorrect zero. The scores were summed-up and the total divided by the number of the items, giving a mean score, which was converted into a percent score. Child's knowledge was considered satisfactory if the percent score was 50% or more and unsatisfactory if less than 50%. This part was used in pre-post testing.

- **Part IV: Reported self-care Practices:** This consisted of a series of questions asking child about the self-care practices related to medication intake, urine analysis, diet regimen, exercising, personal hygiene, follow-up, and personal habits.

Scoring System

The practices reported to be "done" were scored 1 and the "not done" zero. The scores of each part and for the total scale were summed-up and converted into percent scores. The child's reported self-care practice was considered adequate if the total percent score was 60% or higher.

Tool 3: Observation Checklist pre/post

It was developed by the researcher to assess the practice of self-care skills of diabetic children before and after the intervention. The observational self-care practices checklist was designed according to Orem self-care framework (Orem *et al*., 2003). To assess the self-care practices that are made of the diabetic child independently (educative-development) and was given score "4", or with his/her guardian assistance (partially compensatory) or done by the advocate (wholly compensatory).

Scoring System

The items observed to be done independently were scored "2," with assistance "1," and not done by child "0." For each of the two skills, the scores of the items were summed-

up and the total divided by the number of the items, giving a mean score, which was converted into a percent score. The practice of the skill was considered adequate if the percent score was 60% or more, and inadequate if less than 60%.

Tool 4: Intervention Program

The intervention program was developed in simple arabic language by the researcher based on patient's needs assessment, literature review, researcher experience, and opinion of the medical and nursing expertise to evaluate effect of intervention program on improving the knowledge and Self-Care Practices for Diabetic School-Age Children and consists of two parts:

- **Part I:** Procedure of insulin self-injection: It includes nine items related to insulin injection technique such as hand washing, prepare equipment's, invert or roll of the vial of insulin in the hands to mix well. Prepare dose of insulin, prepare site of insulin and Inject insulin.
- **Part II:** Procedure of blood glucose self-testing (Glucometer/strip): includes ten items related to blood glucose level such as hand washing, prepare equipment's, Set on glucometer, prepare lancet and site, puncture finger, apply drop of blood on strip, obtain reading, discard needle……..etc.

Methods of Data Collection

- Upon receiving administrative approval for conducting the study from the Ministry of education in Dakahlia governorate and schools administrators.
- The study tools and intervention program was designed by the researcher after an extensive review of the relevant literature.
- The tools were face and content-validated through experts' opinions. They were presented to a panel of three professors from the faculties of Nursing at Mansoura and Elfayoum Universities. They checked the items for relevance, clarity, comprehensiveness, and logical sequence. The reliability of the checklists was tested through calculating their Guttman split-half coefficients. They showed high reliability with coefficients 0.71 for the self-injection practice checklist, and 0.92 for the self-testing practice checklist.
- **Pilot Study:** A pilot study was carried out on a sample representing 10% of the main study sample. The necessary modifications were done and the tools were finalized accordingly. These children were not included in the main study sample.
- **Ethical Considerations**: The researcher carried out the study according to the Declaration of Helsinki (DoH). The parent/guardian of each participant schoolchild provided a verbal informed consent after obtaining clear information about the aim of the study and its benefits, as well as the right to refuse or withdraw at any time without giving any reasons. The researchers ensured confidentiality of any obtained information. No incentives or rewards were offered to participants.

Procedure

The fieldwork for this study was achieved through two phases: The pre-test phase and the post-test phase

- The pre-test phase: the researcher visited the study settings and started to recruit the required sample of schoolchildren. For this, the medical files of the children were reviewed, and the ones who fulfilled the criteria were included in study sample. After securing consents from parents, each recruited child was individually interviewed after explaining the purpose of the study. This was done using the data collection forms. Then, a physical assessment of the child was carried out, and he/she child was observed while practicing insulin injection on simulator, and blood testing by glucometer. The knowledge and practice parts constituted the child's baseline or pretest values. Each child took around 45 minutes to complete the interview and the observation. This phase lasted from the 1st of September to the 30th of December, 2017.
- **The post-test Phase:** Concerning the post-test phase, the same instrument was carried out to collect data after three month from conducting the intervention program and it lasted for 2 months. Upon completion of the training, its effectiveness was evaluated. The researcher reported the processes of interviewing each child and observing him / her while performing insulin self-injection and self- testing of blood glucose using the relevant tool.

Statistical Analysis

Data entry and statistical analysis were done using SPSS 20.0 statistical software package. Data were presented using descriptive statistics in the form of frequencies and percentages for qualitative variables, and means and standard deviations and medians for quantitative variables. Guttman split-half coefficient was calculated to assess the reliability of the practice checklists. Qualitative categorical variables were compared using chi-square test. Spearman rank correlation was used for assessment of the inter-relationships among quantitative variables and ranked ones. In order to identify the independent predictors of the knowledge and practice scores, multiple linear regression analysis was used and analysis of variance for the full regression models done. Statistical significance was considered at p-value <0.05.

Results

The study sample included 120 schoolchildren, mostly from primary grades (65.0%), whose age ranged between 8 and 14 years, median 10.5 years as shown in Table 1. There were slightly more males (53.3%), and only 4.2% had no siblings and 31.7% were firstborn. Their father and mother educational levels were mostly intermediate (54.2% and 75.8%), and almost all mothers were housewives (96.7%). Slightly more than a half of them were having urban residence (51.7%), and sufficient family income (52.5%).

As presented in Table 2, more than two-thirds of the children had a less than 5-year illness duration, and in slightly more than a half of them, the diabetic state was discovered by a coma (51.7%). Almost all of them were having symptoms (98.3%), with median 4.0 symptoms. Their physical examination revealed that 30.8% were having at least one abnormal finding. Less than one-fourth of them were overweight/obese (22.5%). Their median levels of fasting, postprandial blood glucose, and HbA1c were respectively 160.0, 220.0, and 10.0.

Table 3 demonstrates that only less than one-third (29.2%) of the children were having adequate total reported self-care. The highest areas of reported self-care were related to personal hygiene (80.0%), and medication intake (66.7%). Conversely, none of them reported adequate self-care related to urine analysis (0.0%), and only 5.8% in follow-up, and 18.3% in exercising.

Table 4 points to a statistically significant improvement in children's knowledge of diabetes ($p<0.001$), where only 10.8% had satisfactory knowledge before the intervention, which rose to 100.0% after the intervention. The table also demonstrates post-intervention statistically significant improvements in their practice of insulin self-injection and blood glucose self-testing skills ($p<0.001$).

As illustrated in Table 5, the post-pre improvement in children's scores of self-testing had moderate statistically significant positive correlations with the improvements in their knowledge and insulin injection improvements. Moreover, the improvements in knowledge scores had mild to moderate statistically significant positive correlations with child's number of siblings, number of symptoms, self-care score, and postprandial sugar, and negative correlations with parents' education and the duration of diabetes. The improvements in self-injection scores had mild to moderate statistically significant positive correlations with child's age, number of siblings, mother education, family income, duration of diabetes, and HbA1c level, and negative correlations with the fasting and postprandial bold glucose levels. As for the improvements in self-testing scores, they had mild to moderate statistically significant positive correlations with child's number of siblings, birth order, family income, number of symptoms, and self-care score, and negative correlations with father education.

The multivariate analysis (Table 6) revealed that the child age, mother work, and the number of symptoms were the statistically significant positive predictors of child's reported self-care score. Conversely, mother education and the duration of diabetes were negative predictors. The model explains 43% of the variation in the reported self-care score.

Concerning the change in knowledge score, Table 7 displays that the study intervention was the main statistically significant positive predictor, in addition to urban residence, On the other hand, mother education was a negative predictor. The model explains 94% of the variation in the knowledge score.

The same table illustrates that the knowledge score was the main statistically significant positive predictor of the insulin self-injection score, in addition to father education, while child age and mother education were negative predictors. The model explains 57% of the variation in this score. As for the self-testing score, knowledge score was its main statistically significant positive predictor in addition child school grade and father education. Meanwhile, child age and birth order were negative predictors. The model explains 53% of the variation in this score.

Concerning the HbA1c level, Table 8 demonstrates that father education was the only the statistically significant positive predictor. Conversely, mother work, urban residence, number of symptoms, and the self-injection score were its negative predictors. The model explains 40% of the variation in the HbA1c level.

Table 1: Socio-demographic characteristics of children in the study sample (n=120)

	Frequency	**Percent**
Grade:		
Primary	78	65.0
Preparatory	42	35.0
Age:		
<10	55	45.8
10+	65	54.2
Range	8.0-14.0	
Mean±SD	9.6±3.0	
Median	10.5	
Gender:		
Male	64	53.3
Female	56	46.7
Birth order:		
1	38	31.7
2+	82	68.3
Range	1-4	
Mean±SD	1.9±0.7	
Median	2.0	
Siblings:		
0	5	4.2
1+	115	95.8
Range	0-4	
Mean±SD	3.0±0.9	
Median	3.0	
Father education:		
Basic	43	35.8
Intermediate	65	54.2
University	12	10.0
Mother education:		

Basic	20	16.7
Intermediate	91	75.8
University	9	7.5
Mother job:		
Housewife	116	96.7
Working	4	3.3
Residence:		
Rural	58	48.3
Urban	62	51.7
Family income:		
Insufficient	57	47.5
Sufficient	63	52.5

Table 2: Medical history and laboratory results of children in the study sample (n=120)

	Frequency	**Percent**
Duration of illness (years):		
<5	84	70.0
5+	36	30.0
Range	<1.0-10.0	
Mean±SD	3.4±1.9	
Median	3.0	
Mode of discovery:		
By chance	23	19.2
Coma	62	51.7
Lab test	35	29.2
Have symptoms	118	98.3
No. of symptoms:		
Range	0-6	
Mean±SD	3.9±1.4	
Median	4.0	
Total physical examination:		
Normal	83	69.2
Abnormal findings	37	30.8
BMI:		
Normal	93	77.5
Overweight/obese	27	22.5
Fasting blood glucose (mg/dl):		
<126	20	16.7
126+	100	83.3
Range	110.0-220.0	
Mean±SD	156.1±27.2	
Median	160.0	
Postprandial glucose (mg/dl):		
<200	51	42.5
200+	69	57.5
Range	130.0-320.0	
Mean±SD	214.5±53.5	
Median	220.0	
HbA1c (%):		
<8	7	5.8
8+	113	94.2
Range	7.0-12.0	
Mean±SD	9.8±1.5	
Median	10.0	

Table 3: Reported self-care practices among children in the study sample (n=120)

	Frequency	**Percent**
Adequate (60%+) self-care in:		
Medication intake	80	66.7
Urine analysis	0	0.0
Diet regimen	62	51.7
Exercising	22	18.3
Personal hygiene	96	80.0
Follow-up	7	5.8
Personal habits	69	57.5
Total reported self-care:		
Adequate	35	29.2
Inadequate	85	70.8

Table 4: Pre-post-intervention children's knowledge and self-care skills

	Time				X^2 test	p-value
	Pre		Post			
	No.	%	No.	%		
Total knowledge:						
Satisfactory (50%+)	13	10.8	120	100.0		
Unsatisfactory	107	89.2	0	0.0	193.08	<0.001*
Insulin self-injection:						
Adequate	40	33.3	120	100.0		
Inadequate	80	66.7	0	0.0	120.00	<0.001*
Self-blood testing:						
Adequate	52	43.3	119	99.2		
Inadequate	68	56.7	1	0.8	91.31	<0.001*

*Statistically significant at p<0.05

Table 5: Correlation matrix of children pre-post-intervention paired changes in scores of knowledge and practices and their BMI and lab results and their personal and disease characteristics

	Spearman's rank correlation coefficient		
	Post-pre-intervention changes in scores		
	Knowledge	Self-Injection	Self-Testing
Post-pre-intervention changes in scores:			
Knowledge			
Self-injection	.073		
Self-testing	.427**	.693**	
Age	.151	.228*	.002
No. siblings	.305**	.338**	.431**
Birth order	.197*	.133	.349**
Father education	-.410**	-.158	-.443**
Mother education	-.241**	.264**	-.110
Family income	.162	.394**	.427**
No. of media	-.139	-.440**	-.385**
Duration of DM	-.183*	.311**	-.122
No. of symptoms	.418**	.082	.429**
Self-care score	.335**	-.056	.214*
BMI	.090	.160	-.073
FBS	.157	-.249**	-.020
PPS	.203*	-.472**	-.083
HbA1c	-.140	.236**	-.086

* Statistically significant at p<0.05
** Statistically significant at p<0.01

Table 6: Best fitting multiple linear regression model for the reported self-care score

	Unstandardized Coefficients		Standardized Coefficients	t-test	p-value	95% Confidence Interval for B	
	B	Std. Error				Lower	Upper
Constant	35.02	3.87		9.040	<0.001	27.35	42.70
Age	0.54	0.27	0.19	2.000	0.048	0.01	1.08
Mother education	-2.58	0.89	-0.25	-2.914	0.004	-4.33	-0.83
Mother working	10.83	3.62	0.23	2.995	0.003	3.67	18.00
Duration of DM	-1.03	0.39	-0.24	-2.611	0.010	-1.81	-0.25
No. of symptoms	2.73	0.47	0.46	5.804	<0.001	1.80	3.67

R-square = 0.43 Model ANOVA: F=18.63, p<0.001
Variables entered and excluded: gender, birth order, residence, grade, father education, family history, knowledge score

Table 7: Best fitting multiple linear regression model for the knowledge and self-care skills scores

	Unstandardized Coefficients		Standardized Coefficients	t-test	p-value	95% Confidence Interval for B	
	B	Std. Error				Lower	Upper
Knowledge score							
Constant	-1.91	2.72		-0.702	0.484	-7.27	3.45
Mother education	-1.95	0.49	-0.07	-3.964	<0.001	-2.91	-0.98
Urban residence	2.65	0.81	0.05	3.288	0.001	1.06	4.24
Intervention	47.33	0.79	0.96	60.228	<0.001	45.79	48.88
r-square=0.94 Model ANOVA: F=1220.50, p<0.001 Variables entered and excluded: age, gender, grade, birth order, residence, duration of illness, number of symptoms, father education, mother job, income, family history							

Insulin self-injection practice score							
Constant	31.18	8.87		3.517	0.001	13.71	48.65
Age	-1.17	0.58	-0.10	-2.020	0.045	-2.31	-0.03
Father education	9.29	1.98	0.28	4.682	<0.001	5.38	13.20
Mother education	-12.37	2.76	-0.29	-4.475	<0.001	-17.81	-6.92
Knowledge score	0.98	0.06	0.68	16.007	<0.001	0.86	1.10
r-square=0.57 Model ANOVA: F=81.23, p<0.001 Variables entered and excluded: gender, grade, birth order, residence, media at home, duration of illness, number of symptoms, mother job, family history							
Self-testing practice score							
Constant	20.46	9.95		2.056	0.041	0.86	40.05
Grade	17.40	4.82	0.24	3.608	<0.001	7.90	26.90
Age	-4.23	0.77	-0.36	-5.514	<0.001	-5.74	-2.72
Birth order	-5.58	2.22	-0.11	-2.516	0.013	-9.95	-1.21
Father education	4.86	1.49	0.15	3.271	0.001	1.93	7.78
Knowledge score	0.91	0.06	0.64	14.454	<0.001	0.78	1.03
r-square=0.53 Model ANOVA: F=55.77, p<0.001 Variables entered and excluded: gender, residence, duration of illness, number of symptoms, mother education and job, family history							

Table 8: Best fitting multiple linear regression model for the HbA1c level

	Unstandardized Coefficients		Standardized Coefficients	t-test	p-value	95% Confidence Interval for B	
	B	Std. Error				Lower	Upper
Constant	9.83	0.55		17.964	<0.001	8.75	10.91
Mother working	-3.16	0.44	-0.37	-7.118	<0.001	-4.03	-2.28
Urban residence	-0.50	0.16	-0.16	-3.054	0.003	-0.82	-0.18
No. of symptoms	-0.28	0.06	-0.27	-4.541	<0.001	-0.41	-0.16
Self-injection score	-0.01	0.00	-0.20	-2.803	0.005	-0.01	0.00

R-square=0.40 Model ANOVA: F=27.71, p<0.001
Variables entered and excluded: age, grade, birth order, residence, duration of illness, mother education, family history, knowledge score, self-testing score

Discussion

The study findings indicate that the diabetic schoolchildren in the study settings have deficient knowledge of diabetes and related self-care, as well as the practices of such care. The training program led to significant improvements in their knowledge and practice of self-care skills. Based on these findings, the research hypothesis set can be accepted.

The current study results revealed that only less than one-third of them had adequate total reported self-care. The reported self-care areas of highest deficiency were those related to urine analysis, and importance of exercising and follow-up. Moreover, approximately one-third of them had inadequate self-care practices related to intake of medications. Such deficiencies in self-care practices might be attributed to certain misconceptions related to the care of diabetic children, especially concerning the practice of physical exercise and related unfounded fears. In congruence with this, a study in the United States analyzed the fears of hypoglycemia that discourages physical exercise among diabetic patients and how to deal with such worries given the benefits of physical activity (Martyn-Nemeth *et al*., 2018) [20]. Moreover, a study in Brazil reported that physical exercise is beneficial for diabetic patients through enhancing antioxidant activities and lessening by reducing inflammation, and thus improves diabetic control (Farinha *et al*., 2017) [12].

A number of factors were shown to have significant influences on the reported self-care practices of the diabetic schoolchildren in the present study. The child age, mother work, and the number of symptoms seem to have positive effects on child's self-care score. The findings are plausible since an older age child is more able to be a self-dependent in managing the illness, and more he/she has symptoms, the more he/she is keen to care for self, which is in congruence with Jones and Foli (2018) [15] who discussed the maturation of diabetic children and its effect on their self-care abilities.

As for the effect of the working mother, it could be due to the less time she spends with her child so that he/she must care for self. In line with this, a study in Athens demonstrated that the time needed to perform self-care for diabetes is around four hours per day, which might not be afforded by a working mother (Shubrook *et al*., 2018) [23].

On the other hand, the current study results indicate that mother education is associated with less adequate reported self-care, which is expected given her lower health literacy. Lastly, the longer duration of diabetes had a negative effect on the reported self-care score, which might be explained by the weariness of the child and boredom from following the regimen.

According to the present study results, only around one-tenth of the schoolchildren had satisfactory knowledge of diabetes and its related self-care. This indicates a major deficiency in the patient education activities that should be provided to these children through school health and insurance programs. The lack of knowledge could explain their low adequacy of self-care as revealed in the study results. In congruence with this, a study in Dubai found a significant close relationship between the knowledge of diabetic children and their self-care practices (José Gagliardino *et al*., 2018) [16].

The implementation of the present study training program was associated with significant improvements in diabetic schoolchildren's knowledge of diabetes and related self-care practices. The finding is in agreement with those of Bernier *et al*. (2018) [7] whose study in the United States demonstrated significant improvements in the knowledge of

diabetic children following an educational intervention. The present study improvement in knowledge indicates that those children were eager to learn more about their illness and how to manage it. Thus, it fulfilled an unmet need among them. Moreover, the program content and process were very simple and commensurate with their level of understanding. In congruence with this, a study in Spain identified a number of unmet needs among diabetic schoolchildren, and recommended more training programs for the children as well as for their caregivers (Tomé Pérez *et al*., 2018) [27].

The independent positive effect of the training program on schoolchildren's knowledge was confirmed through multivariate analysis. Thus, the intervention program was identified as the main positive predictor of the knowledge score. Other factors influencing the knowledge score were the urban residence, which was a positive predictor, and mother education, which was a negative predictor. The positive effect of the urban residence might be related to their easier access to various sources of information and media. As for mother education, the findings indicate that those children whose mothers had low education benefited more from the training, which could be explained by their higher need and eagerness to information not provided by their mothers. In agreement with the finding concerning residence, a study in Germany demonstrated a wide discrepancy in the management of type I diabetes among areas with various socioeconomic levels (Auzanneau *et al*., 2018) [6].

The present study findings have also demonstrated that only around one-third of the schoolchildren could practice the self-care procedures of insulin self-injection and self-testing for blood sugar. Such deficiencies in these two important and basic skills for diabetic patients again reflects a lack of training from the side of their health care providers. This could be due to the misconception that these children are still too young to learn these procedures. In line with this, a study in Saudi Arabia demonstrated that the fears of self-injection and self-testing were among the factors limiting self-care among diabetic children (Al Hayek *et al*., 2017) [5].

After the implementation of the training program, significant improvements were revealed in schoolchildren's practices of the self-care skills of insulin self-injection and self-testing for blood sugar. The findings are in agreement with those of a study in Granada, which demonstrated the effectiveness of a similar nursing education program (Navarro Parado *et al*., 2014) [22]. However, the improvement revealed in the current study was not due to a direct of the intervention, but rather through improving the knowledge of these children as identified in the multivariate analysis. The finding underscores the importance of providing sound and simple information in order to improve self-care practices. Additionally, the group training with associated interactions among schoolchildren encouraging each other could have helped in the success of the training intervention. In agreement with this, a study in the United Kingdom demonstrated the importance of interaction among peers with diabetes in the self-care management of Type I diabetes (Kingod, 2018) [17].

The child's age was identified as a significant independent negative predictor of the scores of practice of the self-care skills of insulin self-injection and self-testing for blood sugar. Thus, the younger age children had more benefits from the training in these skills compared to the older ones. This might be due to that older age children might have had better pre-intervention scores so that the improvement is less obvious among them. Thus, age-appropriate support in diabetes education was recommended by Bixo Ottosson *et al*. (2017) [8] in Sweden.

As a consequence of the improved knowledge and self-care skills among the diabetic schoolchildren in the present study, their laboratory findings were examined. The main laboratory test that indicates control of diabetes is the level of glycated hemoglobin (HbA1c). According to the study results, the insulin self-injection score was identified as a significant independent negative predictor of the level of HbA1c. Thus, the higher the child scores in insulin self-injection, the lower is his/her HbA1c and the better is his/her diabetes control. The finding provides evidence of the importance of training diabetic children in this important self-care skill. Nonetheless, the levels of HbA1c were still high and indicate poor glycemic control, which is often reported in Type I diabetes research (Sonmez *et al*., 2018) [24].

Conclusion and recommendations

In conclusion, there are clear deficiencies in diabetic schoolchildren's of their illness and the related self-care. The implementation of a training program is effective in improving their knowledge and practice of the self-care skills of insulin self-injection and blood glucose self-testing. The findings highlight the importance of such training endeavors in such a chronic disease that needs lifelong care. The training program should be implemented in settings providing care for diabetic children, with longer follow-up in order to assess its long-term effects. School health nurses and teachers need to be trained in training-of-trainers (TOT) programs in order to be able to carry out their health educational roles towards diabetic children.

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