

THE RELATIONSHIP BETWEEN QUALITY OF SELF-MONITORING AND GLYCEMIC CONTROL IN ROMANIAN CHILDREN WITH TYPE 1 DIABETES MELLITUS

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Abstract

Objectives: Optimal glycemic control is mandatory in diabetic children and adolescents for the prevention of diabetes complications, but it is difficult to be obtained due to a series of factors, including the limited availability of blood glucose self-monitoring tests. The aim of our study was to investigate the relationship between the number of daily self-monitoring tests and quality of glycemic control. **Material and method:** We enrolled 783 individuals previously diagnosed with Type 1 Diabetes Mellitus and investigated the significance of differences in HbA1c values between groups with distinct number of blood glucose measurements at home for each age group. **Results:** We found significant improvements of glycemic control with the increase in the number of daily tests, with some particularities among the groups. **Conclusions:** Among other intrinsic and external factors, blood glucose self-monitoring has an important role in obtaining a good glycemic control.

key words: Type 1 Diabetes Mellitus; Self-monitoring blood glucose; Glycemic control.

Objectives

Regarding the treatment of Type 1 Diabetes Mellitus (DM) in children and adolescents it is well known that obtaining a good and sustained glycemic control is mandatory for preventing complications [1]. This is difficult to be reached mainly due to a series of age-related factors like the continuous morphological, physiological and

social changes, but also due to external causes represented by the lack of therapeutic patient education, limited access to quality insulin regimens and limited availability of blood glucose self-monitoring tests [2].

Current guidelines are recommending for diabetes monitoring in children the use of CGMS - continuous blood glucose sensor (the comprehensive level of care). When this is not available, the recommended level of care

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suggests the self-monitoring of blood glucose (SMBG) four up to six times daily, together with ketone testing during febrile illness, when blood glucose levels are above 250 mg/dL and in the case of persistent polyuria with elevated blood glucose. HbA1c should be assessed four to six times per year for young children and three times in an year for adolescents [3-6].

The aim of our study was to investigate the link between the number of daily blood glucose measurements at home and glycemic control as indicated by the HbA1c value.

Material and Method

We enrolled 783 individuals, 371 boys and 412 girls, all being previously diagnosed with Type 1 DM, admitted in the “Cristian

Șerban” Medical Center from Buziaș between 2008 and 2011. The main characteristics of these patients are shown in [Table 1](#). All children were at least once admitted before in the Medical Center and were on basal-bolus insulin therapy. Their blood tests (HbA1c, Triglycerides, Total, HDL and LDL cholesterol) were assessed in the second day of admission. HbA1c was measured using IFCC standardized immune-turbidimetric assay [7]. During the anamnesis, a special interest was given to the daily dose of insulin prior to admission, onset of disease and number of daily self-monitoring blood glucose tests. Only patients with relatively stable number of daily monitoring tests for at least three months prior to admission were selected for the study.

Table 1. Studied group characteristics.

Studied parameter	Entire group	0 tests	1 test	2 tests	3 tests	4 or more	P (ANOVA)
Number	783	27	35	117	187	417	-
Median age (range)	12 (1-17)	15 (8-17)	16 (4-17)	14 (5-17)	12 (3-17)	10 (1-17)	0.32
Diabetes Duration* (yrs)	4.49±3.25	5.89±3.87	4.34±2.46	5.63±3.03	4.33±3.35	4.10±3.21	0.07
Insulin dose prior admission* (IU/kg/day)	0.88±0.25	1.04±0.26	0.88±0.28	0.92±0.24	0.87±0.28	0.86±0.25	0.12
Total Cholesterol* (mg/dL)	164±34.8	183±51.1	176±31.5	175±49.9	162±27.0	160±29.8	0.03
HDLc* (mg/dL)	58.5±13.6	56.0±11.6	52±9.2	55.3±11.7	58.4±15.1	60.5±13.7	0.04
LDLc* (mg/dL)	87.6±27.4	103±42.3	94.4±28.7	96.7±37.9	84.8±22.9	84.0±22.5	0.08
Triglycerides* (mg/dL)	88.9±49.9	104±75.4	114±56.1	105±79.1	88.8±32.7	80.2±39.2	0.04

*- values are means ± standard deviation;

p value was assessed using analysis of variation test in the five studied groups

Parameters were analyzed for the entire group and also individually for each of the following age groups: one to seven years, eight to ten years, eleven to fourteen years and fifteen to seventeen years. Statistical analysis was used to calculate the significance of HbA1c means variance along with the variance of daily number of self-monitoring tests for the entire group (ANOVA test) and for each individual pair of groups (unpaired

t-test derived from Bonferroni post-hoc test). We accepted the standard significance thresholds for p-value as follows: p<0.05 – significant; p<0.01 – very significant and p<0.001 – extremely significant. Pearson’s correlation coefficient (r) was used to measure the strength of the association between two variables and its significance was assessed with t values distribution test.

Results

We found a significant improvement of HbA1c values along with the increase in the number of daily self-monitoring blood glucose tests. The mean HbA1c of patients with four

or more tests compared to those without monitoring was extremely significant lower, with 3.04 percentage points ($p < 0.001$). For the entire group, we found significant decreases of mean HbA1c for every increase in the number of self-monitoring tests, as shown in [Figure 1](#).

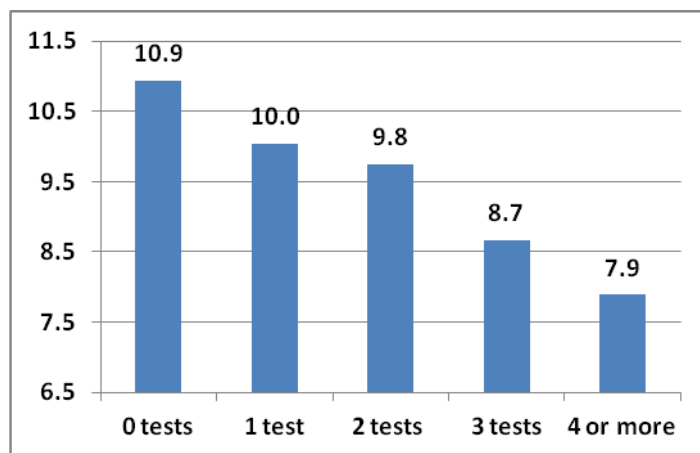


Figure 1. HbA1c mean values for the entire group.

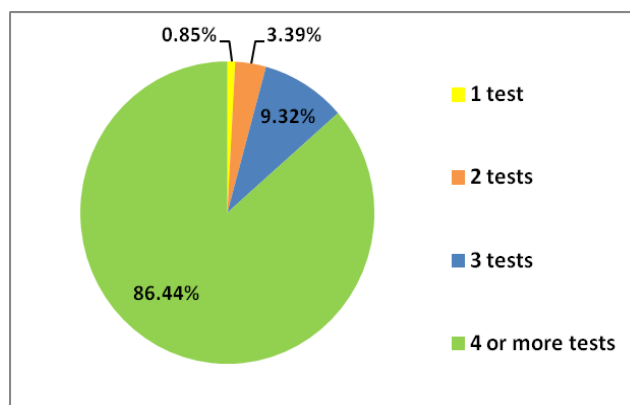


Figure 2. Daily self-monitoring in age group 1-7 years.

These differences were extremely significant between every studied pair of groups, except when increasing the number of monitoring tests from zero to one and one to two, where the differences were not significant and between zero and two daily tests where the mean differences were very significant ([Table 2](#)).

Table 2. Δ mean HbA1c; p was assessed using Bonferroni post-hoc test.

VS.	4	3	2	1
0	3.04	2.26	1.17	0.88
1	2.15	1.37	0.29	
2	1.86	1.09		
3	0.78			

Legend:

$p \geq 0.05$	$p < 0.05$	$p < 0.01$	$p < 0.001$
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In the 1 to 7 years age group, none of the 118 patients lacked home blood glucose monitoring, and only one patient had a single daily test before admission. More than 85% of them assessed blood glucose levels four times daily or more (Figure 2).

In these patients we only analyzed the improvement of glycemic control when increasing the number of blood tests beginning from two tests per day and we didn't find any significant variance in HbA1c values according to the number of daily glucose tests (p=0.10, ANOVA test)

The absence of significance is due to the low number of patients having two and three daily tests and it is present also when comparing individual pairs (Table 3).

Table 3. Δ mean HbA1c; p was assessed using Bonferroni post-hoc test.

VS.	4	3
2	0.74	0.12
3	0.62	

Legend:

p≥0.05	p<0.05	p<0.01	p<0.001
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From a total of 139 individuals aged between 8 and 10 years, more than 60% measured their blood glucose levels at home four times daily or more. We had only one

patient with one daily test and two performing zero tests (Figure 3).

In this group, the improvement of glycemic control with the increase in the number of daily blood glucose tests from two to four or more was extremely significant (p<0.001, ANOVA) (Table 4).

Table 4. Δ mean HbA1c; p was assessed using Bonferroni post-hoc test.

VS.	4	3
2	1.45	1.10
3	0.36	

Legend:

p≥0.05	p<0.05	p<0.01	p<0.001
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In individuals aged between 8 and 10 years, every increase in the number of daily blood tests used at home, starting from two or less lowers significantly the HbA1c values. Increasing test number from three tests daily decreased the HbA1c value, but not significantly (p=0.12, unpaired t test).

In the age group 11-14 years (279 patients), less than 50% performed more than three daily tests, and the ratio of those who didn't test their blood glucose or test it just once daily increased up to 3.58% and 4%, respectively (Figure 4).

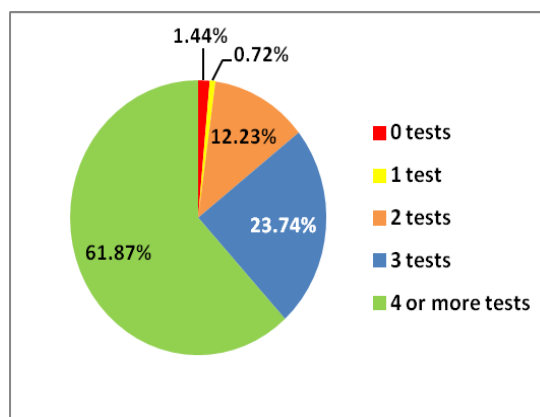


Figure 3. Daily self-monitoring tests in age group 8-10 years.

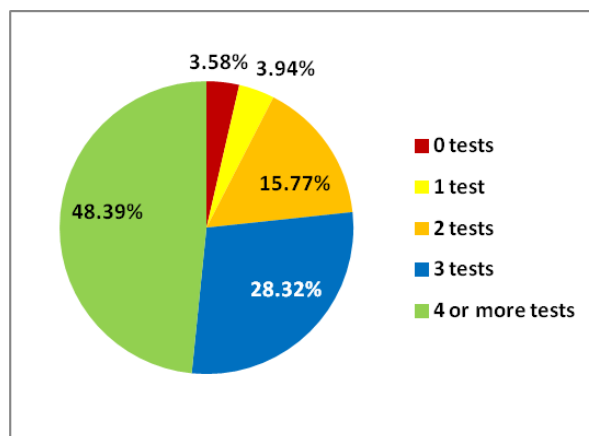


Figure 4. Daily self-monitoring tests in age group 11-14 years.

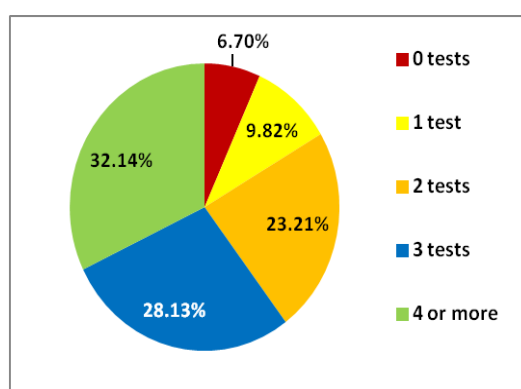


Figure 5. Daily self-monitoring tests in 15-17 years age group.

In this case we obtained the same significant improvements in glycemic control with the increase in the number of daily tests. The mean HbA1c decreased with 3.09 percentage points in those who performed four or more glucose tests compared to those who didn't test their blood glucose (Table 5).

Table 5. Δ mean HbA1c; p was assessed using Bonferroni post-hoc test.

VS.	4	3	2	1
0	3.09	1.97	1.44	1.18
1	1.91	0.79	0.26	
2	1.65	0.53		
3	1.12			

Legend:

$p \geq 0.05$	$p < 0.05$	$p < 0.01$	$p < 0.001$
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The age group 15-17 years comprised 224 individuals, with a proportion of 32.14% of patients assessing their blood glucose at least four times daily and a high proportion of those who didn't test their blood glucose or test it just once daily (Figure 5).

In this group, we found significant improvements with the increase in the number of daily tests (Figure 6). Of course, best improvement was observed after increasing the number of monitoring tests from 0 to 4 or more daily (2.67 percentage points, $p < 0.001$), but significant improvements were observed for most pairs studied, as shown in Table 6 and Figure 6.

The HbA1c values in the entire studied sample were significantly correlated with the number of daily self-monitoring blood glucose

tests performed at home, prior to admission. We found a Pearson correlation coefficient of -0.48 between these values (95% CI: -0.54 to -0.43; $r^2=0.23$), with an extremely significant p value (p for correlation <0.001) (Figure 7).

Table 6. Δ mean HbA1c; p was assessed using Bonferroni post-hoc test.

VS.	4	3	2	1
0	2.67	2.53	0.91	0.94
1	1.73	1.58	-0.04	
2	1.76	1.62		
3	0.14			

Legend:

$p \geq 0.05$	$p < 0.05$	$p < 0.01$	$p < 0.001$
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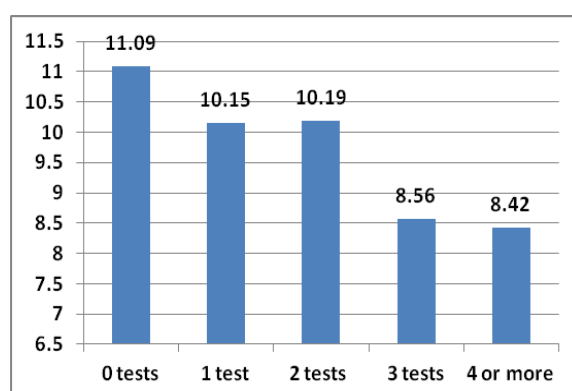


Figure 6. HbA1c values for age group 15 to 17 years.

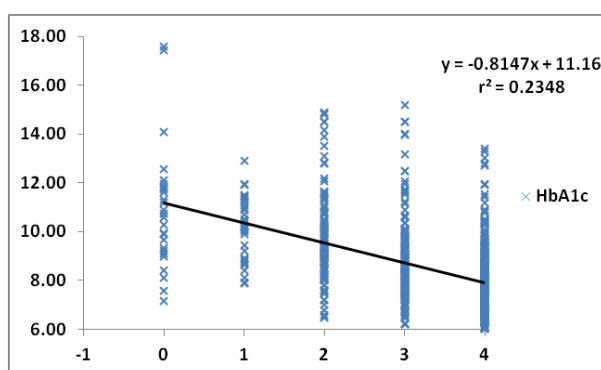


Figure 7. HbA1c values according to number of daily glucose tests.

Discussions

We found a strong relationship between the number of daily self-monitoring tests and the quality of glycemic control. As expected, the mean HbA1c decreases with the increase in the number of glucose tests.

For the entire group, the mean decrease of HbA1c value was 3.04 percentage points

which has both statistical and clinical significance. Nevertheless, the mean HbA1c value, even in the group with four or more daily tests (7.9%) was far from the target of 7%-7.5% recommended in guidelines [8,9], and this value was significantly higher in the groups with fewer daily glycemic tests. These facts are suggesting that for achieving at least a satisfactory glycemic control in children

treated with basal-bolus insulin therapy more than three daily glucose measurements are needed. Fortunately, the proportion of children

who are measuring their glycaemia accordingly increased significantly in time in Romania, as shown in [Figure 8](#) [10].

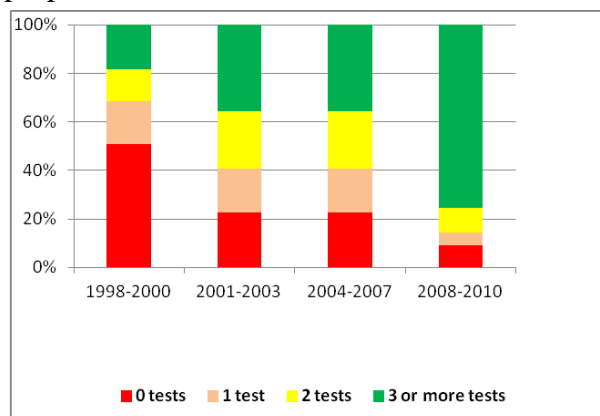


Figure 8. Proportion of daily blood glucose tests in Romanian children between 1998-2010.

We observed a trend, which was valid in most of our cases that for a decrease with approximately one percent of HbA1c there is a need to increase the number of daily tests with two, regardless the initial number of daily tests or patient's age. This improvement of glycemic control is important mostly because of the clinical evidence of the reduction in the incidence of chronic complications, the decrease with one percent in HbA1c leading to a decrease with 37% of microvascular complications and 14% of macrovascular complications [11-14].

Unfortunately, despite the fact that the same number of free strips for glucose self-monitoring is provided by the health insurance company for all the children (three strips per day), the proportion of those who are assessing their glucose four or more times daily decreases worryingly with age, from 86.44% in the age group 1-7 years to 32.14% in the age group 15-17 years, contributing to the decrease in the quality of glycemic control. Moreover, at the same number of glycemic assessments, the glycemic control is significantly declining with age, suggesting

the involvement of other factors in altering the quality of diabetes management such as hormonal, morphologic, physiologic and psychologic/social changes occurring over the age of ten years [14-16]. These differences were significant between all the pairs of studied groups, and were most important between the age groups 1-7 years versus 15-17 years, where we found an average increase in HbA1c of 0.6 percentage points for every additional self-monitoring tests (p=0.011).

Conclusions

Among other factors, home self-monitoring of blood glucose has an important role in achieving and maintaining an adequate glycemic control. Limited access to appropriate self-monitoring is leading to impairment of glycemic control, independent of other factors like therapeutic education or access to appropriate insulin treatment.

In children on basal-bolus insulin therapy, an acceptable glycemic control can be achieved only by assessing blood glucose levels more than three times daily, together with an optimal insulin dose adjustment. The

minimum number of tests still efficient for obtaining an improvement in blood glucose levels in children is two per day. The increase in the number of tests from zero to one exerts no significant effect over HbA1c values.

An optimal glycemic control in children can only be achieved with four or more daily blood glucose measurements together with suitable therapeutic education of the patient, psychological support and availability of quality insulin regimens.

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