ORIGINAL ARTICLE

UDC: 616-053.2:616.379-008.64
https://doi.org/10.2298/VSP170908106B

The effects of three months long continuous glucose monitoring in children with type 1 diabetes on multiple daily insulin injections

Efekti tromesečnog kontinuiranog praćenja glukoze kod dece sa dijabetesom tipa 1 koja primaju više dnevnih doza insulinskih injekcija

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Abstract

Background/Aim. The Professional System of Continuous Glucose Monitoring, the *i*Pro®2 CGM System (Medtronic) is designed to be worn together with a glucose sensor with an electrode inserted into the subcutaneous tissue, up to 7 days, without insight into the current level of glycemia. After reading data from the iPro®2 device, a realistic picture of the glycemia movement during the period of wearing the device is obtained. The aim of the study was to examine whether objective measurement information collected through the use of professional continuous glucose monitoring (CGM) contribute to improved metabolic control in children with type 1 diabetes mellitus who are on the multiple daily insulin injections (MDI). **Methods.** The study was conducted on 24 patients (14 girls) aged 5 to 18 years, with an average age 12 ± 3.3 years, in the period from June to December 2016 in the Clinic of Pediatrics, University Clinical Center of the Republic of Srpska in Banja Luka. Glycated hemoglobin (HbA1c) was measured in the laboratory at the start of the trial and 3 months afterwards in order to determine the effect of wearing professional *i*Pro®2 on metabolic control, and then three months later, to test for the long-lasting effects in the absence of iPro®2 monitoring. **Results.** The initial HbA1c was 7.78 ± 1.17% (min: 5.50%; max: 10.00%). After 3 months, HbA1c showed a statistically significant decrease to 7.34 ± 0.84% (min: 5.60%, max: 8.90%). At the six-month follow-up visit, without implementing professional CGM in the meantime, a significant increase in HbA1c was reached, with the average value of 7.68% ± 0.83% (min: 5.50%, max: 9.10%). **Conclusion.** This study shows that carrying a professional CGM for 7 days per month, 3 months continuously is associated with certain improvement of metabolic control in children with diabetes who are on MDI without increasing risks of hypoglicemia.

Key words:
diabetes mellitus, type 1; child; bosnia and herzegovina; drug monitoring; insulin; blood glucose self monitoring.

Apstrakt

Uvod/Cilj. Profesionalni sistem kontinuiranog monitoringa glikemije, *i*Pro®2 (Medtronic), je dizajniran za nošenje u kombinaciji sa glukoznim senzorom, čija elektroda je insertovana u potkožno tkivo, do sedam dana, bez uvida u trenutni nivo glikemije. Nakon očitavanja podataka sa *i*Pro®2 uređaja dobija se realna slika kretanja glikemije tokom perioda nošenja uređaja. Cilj ispitivanja bio je da se proveri da li informacije dobijene objektivnim merenjem putem profesionalnog kontinuiranog monitoringa glikemije doprinose poboljšanju metaboličke kontrole dece sa dijabetes melitusom tip 1 koji su na intenziviranom pen režimu insulinske terapije. **Metode.** Istraživanje je obuhvatilo 24 ispitanika (14 devojčica) uzrasta od 5 do 18 godina, prosečne starosti 12 ± 3.3 godina, u periodu jun-decembar 2016. godine na Klinici za dečije bolesti, Univerzitetski Klinički Centar, Banja Luka. Laboratorijski je izmeren glikozilirani hemoglobin (HbA1c) na početku ispitivanja, i nakon tri meseca kako bi se utvrdio efekat nošenja profesionalnog *i*Pro®2 na metaboličku kontrolu, te nakon još tri meseca kako bi se proverili dugoročni efekti u odsustvu *i*Pro®2 praćenja. **Rezultati.** Početni HbA1c bio je 7,78 ± 1,17% (min: 5,5%; max: 10%). Nakon tri meseca HbA1c pokazao je statistički značajno sniženje na 7,34% ± 0,84% (min: 5,60%; max: 8,90%). Na kontrolnom pregledu nakon šest meseci, bez upotrebe profesionalnog kontinuiranog monitoringa glikemije u međuvremenu, došlo je do značajnog porasta HbA1c na 7,68% ± 0,83% (min: 5,5%, max: 9,1%). **Zaključak.** Ova studija pokazuje da je nošenje profesionalnog kontinuiranog monitoringa glikemije sedam dana u mesecu, tri meseca u kontinuitetu, povezano sa određenim poboljšanjem metaboličke kontrole kod dece obolele od dijabetesa koja su na višednevnim insulinskim injekcijama, bez povećanja rizika od hipoglikemija.

Ključne reči:
dijabetes melitus, insulin-zavisni; deca; bosna i hercegovina; lekovi; monitoring; insulin; glukoza u krvi, samopraćenje.

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Introduction

Continuous glucose monitoring (CGM) is an important mean for determining the adequate insulin therapy and it is rapidly becoming the standard for the care of patients with diabetes [1]. Despite advances in insulin therapy (the introduction of short and long acting insulin analogs) and delivery systems (insulin pumps) only 30% children with type 1 diabetes meet the recommended international glycemic target of glycated hemoglobin (HbA1c) level of 7.5%. Postprandial hyperglycemia and glycemic variability are a trigger and the first step in the pathogenesis of micro and macrovascular complications in diabetes. Patients still most commonly adhere to the traditional glycemic control at least 4 to 6 times per day. Many studies have demonstrated the association of lower HbA1c to greater number of glycemic self-monitoring, but the exclusive focus on HbA1c may miss important fluctuations in glucose that are easily identified using continuous glucose monitoring [1–8]. Continuous glucose monitoring with iPro®2 is a holter monitor type that allows automatic glucose measurement in the subcutaneous interstitial tissue using a glucose sensor. The sensor measures the glucose level in the interstitium continuously every 10 seconds, and the mean measurement values are sent every 5 minutes to the iPro®2 device that keeps the data for the entire duration of the sensor life span. According to the manufacturer, the life span of the sensor is approximately 144 hours; after this time passes, the data are collected with CareLink iPro®2 applicational software which produces relevant statistical data including graphics for better understanding of glucose variability.

Such data can help both doctors and patients to determine adequate insulin therapy. There are studies that demonstrate the usefulness of the device for the CGM in real time by increasing the number of patients with target HbA1c, reducing glycemic variability, and reducing the risk of severe hypoglycemia. Patients who use multiple daily insulin injections (MDI) experience same benefit from CGM as well as patients using an insulin pump, and when they are compared in the studies, MDI regimen works the same or even better than insulin pump.

There are only a few studies exploring iPro®2-to monitor metabolic control in children with diabetes mellitus type 1 on MDI, although it is clear that it provides an excellent insight for all interested parties in the therapy context. An example of its successful use would be a recent study examining the effects of physical activity during the day on hypoglycemia during the night [9–14]. Thus, one of the aims of our study is to broaden research employment of this relatively novel tool for measuring glucose control.

Methods

The study was conducted in the period from June to December 2016 at the Clinic of Pediatrics, University Clinical Centre (UCC) of the Republic of Srpska in Banja Luka, Bosnia and Herzegovina. The study was approved by the Ethics Committee of Human Experimentation in Bosnia and Herzegovina. The study involved 24 children with diabetes mellitus type 1; 10 boys and 14 girls, aged 5 to 18 years (average age 12 ± 3.3 years and with average diabetes duration 2.5 years) (Table 1). All the patients were using ultra short-acting insulin before meal, and long-acting insulin once a day such as intensive insulin therapy. The criteria for inclusion in the study were: duration of type 1 diabetes mellitus more than one year; understanding and consent to follow prescribed protocols as well as regular visits to the doctor. Understanding and consent for monitoring protocol meant wearing iPro®2 device 7 days per 3 months, tracking and writing down the self-monitored blood glucose concentration for at least 4 times a day. Hypoglycemia was defined as a blood glucose concentration less than 3.9 mmol/L, while hyperglycemia was considered as a blood glucose concentration higher than 7.8 mmol/L. All participants, both parents and children, after they got to know the criteria, plan and protocol of this study committed to implement consistently the protocol during the self-monitoring at home and at regular medical visits. All the patients were followed up at the Clinic at baseline, during 3 and 6 months by the same investigator. Both demographic and clinical data were collected using a standardized data collection form.

Table 1

Demographic characteristics of the study participants

Characteristics	Baseline	Time spent on CGM (iPro®2)			After 3 months	After 6 months
		1st usage	2nd usage	3rd usage		
Mean age (years)	12.0 ± 3.3					
Duration of diabetes (years)	2.5 (min.:1; max.:14)					
Mean weight (kg)	153.83 ± 18.28					
Mean height (cm)	45.97 ± 14.88					
BMI (kg/m^2)	18.80 ± 2.90				19.00 ± 3.08	19.04 ± 3.18
Total insulin per kg (IU/kg)	0.65 ± 0.25	0.65 ± 0.25	0.63 ± 0.24	0.65 ± 0.28	0.65 ± 0.28	0.70 ± 0.25
HbA1c (%) – laboratory measure	7.78 ± 1.17				7.34 ± 0.84	7.68 ± 0.83
HbA1c (%) – estimated on *i*Pro®2		7.74 ± 1.30	7.39 ± 1.34	7.39 ± 1.06		

Note: Values are presented as arithmetic mean ± standard deviation, except for the duration of diabetes which presented as median with minimum and maximum values.
CGM – continuous glucose monitoring; BMI – body mass index; HbA1c – glycated hemoglobin.

The beginning of the study was marked as the first visit (Figure 1) when both laboratory measurements of HbA1c were conducted (performed at the UCC Banja Luka on Cobas E601, the Roche apparatus) and when iPro®2 device was activated in the patients for seven days. After receiving the data, they were discussed with the patients and therapy was changed, if deemed necessary. The second visit was done after one month with another reading of the 7-day iPro®2 device with the subsequent consultation regarding therapy. The third visit was done after the third iPro®2 device reading when HbA1c measurement was performed again. After 6 months from the beginning of the study, the third laboratory measurement of HbA1c was performed.

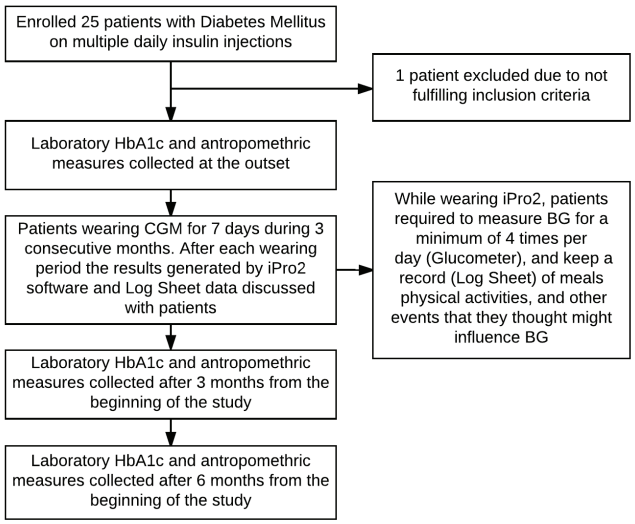

Fig. 1 – Flowchart of continuous glucose monitoring study completion. HbA1C – glycated hemoglobin; CGM – continuous glucose monitoring; BG – blood glucose.

Thus, within 3 months the participants wore a device for seven days per month. The iPro®2 device is a recorder that collects data from the sensor during the wearing period, and after taking off the device, the summarized data is generated through CareLink iPro®2 software in the form of relevant statistical results and graphics. It is important to note that the participants did not have an insight into the current glycemic values during the time that they carried the device, so they could see the results of the readings after 7 days. During the wearing of the device, the participants were obliged to measure the glycemic value using standard glucometers (Accu-Chek, Roche Diagnostic) for at least 4 times a day, and to keep records of the important events. The events reported by the participants required the report of: doses and times of insulin delivery, meals eaten (descriptive), the amount of carbohydrates per meal, and the type of physical activity and its duration. After each of the readings was collected, they were discussed with the investigators (the first two authors) when they attempted to determine the dependence on a particular event on the value of glycemia with the goal to educate the patients.

Based on the mean value of each measurement, CareLink iPro®2 software also estimates the HbA1c values that the respondent would have if she/he continues to behave according to the same patterns. Based on the analysis of the results after reading the data using a computer retrogradely, insulin therapy of patients was corrected.

Data analysis

When it comes to statistical analysis, categorical variables were analyzed by showing the distribution of the absolute and relative frequencies, while, for the numerical variables, the measures of central tendency and variability were used. Changes between the measurements were tested using the analysis of variance for repeated measures. To control for the inflated experiment-wise error rate, we used Bonferroni corrections when calculating *p*-values to test the differences between the measurement pairs. These differences were tested by both paired sample *t*-tests and its nonparametric alternative, Wilcoxon signed-rank tests. Wherever the tests gave the congruent results with regard to the statistical significance, we provided only the *t*-test results.

Results

The average initial measured value of HbA1c was 7.78% ± 1.17% (min: 5.5%, max: 10.0%). The results showed that after 3 months of using iPro2 devices value of HbA1c decreased to 7.34% ± 0.84% (max: 8.9%; min: 5.60%) ($\Delta M = 0.45$, $t = 2.67$; $P_{bonf} = 0.041$). At the final visit, after the three-month period without wearing the iPro®2 device, the HbA1c increased to 7.68% ± 0.83% (max: 9.1%; min: 5.5%) ($\Delta M = -0.35$; $t = -2.81$, $P_{bonf} = 0.3$). This final value is negligibly lower than the initial HbA1c value ($\Delta M = 0.1$, $t = 0.69$, $p_{bonf} = 1.00$).

In addition to the clinical measurements, the HbA1c values were estimated by iPro®2 devices once a month for three subsequent months after wearing the device for 7 days. The value for the last measurement 3 months after the start of the study was approximately equal to its time-related clinical measurements of HbA1c ($\Delta M = -0.05$, $t = -0.28$, $p = 0.779$), although the correlations between these measures were not exceptionally high ($r = 0.61$, $p < 0.001$) (Table 1).

A multiple daily insulin injections with short-acting analogue insulin before a meal and a basal analogue of long-acting were recorded for all subjects during the study. The average total insulin dose for all patients yielded 0.65 ± 0.25 IU / kg of body mass. After 3 months, there was no clinically significant increase neither in basal, nor in bolus insulin dose compared to the start of the study. The average dose of insulin after 3 months remained virtually identical to the initial insulin dose of 0.65 ± 0.28 IU/kg, while there was a significant improvement in metabolic control. For the last 3 months without the use of iPro®2, the total insulin dose somewhat increased to 0.70 ± 0.25 IU / kg of body weight, but metabolic control deteriorated (Table 2). None of the changes related to the insulin therapy reached the level of a statistical significance.

Table 2

Dosage (in IU/kg) of total, basal and bolus insulin during the study

Use of continous monitoring	Total insulin dose	Basal insulin dose	Bolus insulin dose
Baseline	0.65 ± 0.25	0.28 ± 0.13	0.38 ± 0.18
1st usage of iPro®2	0.65 ± 0.25	0.28 ± 0.13	0.38 ± 0.18
2nd usage of iPro®2	0.63 ± 0.24	0.27 ± 0.12	0.36 ± 0.16
3rd usage of iPro®2	0.65 ± 0.28	0.28 ± 0.12	0.38 ± 0.17
After 3 months from baseline	0.65 ± 0.28	0.28 ± 0.12	0.38 ± 0.17
After 6 months from baseline	0.70 ± 0.25	0.29 ± 0.11	0.41 ± 0.18

Note: values are presented as mean ± standard deviation.

Table 3

Results from iPro®2 7 days a month, during the three months period

Variables	Time on iPro2		
	1st usage	2nd usage	3rd usage
Number of sensor values	1,712.67 ± 259.65	1,841.83 ± 51.52	1,815.00 ± 122.30
Number of valid calibration	31.80 ± 8.66	35.54 ± 8.03	35.83 ± 7.38
% of time above target glycemia range (> 7.8 mmol/L)	60.21 ± 18.74	54.38 ± 19.54	56.88 ± 18.64
% of time in target glycemia range (3.9–7.8 mmol/L)	33.08 ± 17.47	38.71 ± 15.39	37.38 ± 17.40
% of time below glycemia range (< 3.9 mmol/L)	6.71 ± 7.09	6.92 ± 6.82	5.75 ± 5.57
Recording time (min)	8,563.33 ± 1298.27	9,209.17 ± 257.59	9,079.38 ± 611.48
Highest measured sensor glycemic value (mmol/L)	19.55 ± 3.12	19.38 ± 3.12	19.93 ± 2.89
Lowest measured sensor glycemic value (mmol/L)	2.83 ± 0.83	2.78 ± 0.61	2.73 ± 0.48
Average measured sensor glycemic value (mmol/L)	9.75 ± 2.04	9.18 ± 2.15	9.19 ± 1.69
Average time spent in one hyperglycemic episode (min)	375.50 ± 184.59	322.08 ± 209.69	322.70 ± 142.81
Average time spent in one hypoglycemic episode (min)	72.83 ± 50.38	63.13 ± 43.23	63.63 ± 41.28
AUC above limit	2.90 ± 1.67	2.43 ± 1.66	2.35 ± 1.31
AUC below limit	0.06 ± 0.09	0.04 ± 0.05	0.04 ± 0.06

Note: values are presented as mean ± standard deviation.
AUC – area under the curve.

Measurements using iPro®2 devices

According to the data retrieved from iPro®2 devices, the average number of readings from the sensor in the first measurement was 1712.67 ± 259.65. The number rose at the second and third measurement to 1,841.83 ± 51.52 and 1,815.00 ± 122.30, respectively. This was accompanied with the increase in the average number of calibrations (glycemic self-monitoring) at the second and third reading compared to the first carrying of the sensor (Table 3).

The results showed that the use of iPro®2 devices moderately reduced the average percentage of time spent in hyperglycemia in the second (54.38 ± 19.54%), and in the third measurement (56.88 ± 18.64%) compared to the initial reference value (60.21 ± 18.74%). In the second measurement, we observed, on average, 9.6% less hyperglycemia compared to the initial measurement ($t = 2.06$; $p_{bonf} = 0.153$), while in the third measurement this improvement was also present, but of somewhat smaller magnitude representing a decrease of 6% compared to the initial average value, ($t = 0.86$, $p_{bonf} = 1.00$). In addition, the readings showed a significant clinical shortening of the average time spent per one hyperglycemic episode, although the effect did not reach the limit of statistical significance presumably due to the small sample size. At the initial measurement the average time spent per one hyperglycemic episode was 375 minutes (6 hours and 15 minutes), whereas in the second measurements it was 322 minutes (5 hours and 22 minutes) (Table 3). In other words, this decrease of duration yielded on average 53.4 minutes (a decrease of 14.2%; $p_{bonf} = 0.351$). Similarly, in the third measurement, the average duration of a hyperglycemic episode was 322.7 minutes, which amounted to the reduction of 52.8 minutes compared to the baseline (decrease of 14.1%; $p = 0.624$) (Table 3).

Compared to the baseline (6.71 ± 7.09%), the percentage of time spent in hypoglycemia–slightly increased in the second measurement (6.92 ± 6.82%) but we observed a statistically significant reduction in the third reading (5.75 ± 5.57%). Consequently, the time spent in normoglycemia rose on average both in the second (38.71 ± 15.39%) and the third measurement (37.38 ± 17.40%) compared to the baseline (33.08 ± 17.47%).

Reducing the average duration of a hypoglycemic episode was similar to reducing the average durations of hyperglycemic episodes. The episodes of hypoglycemia were reduced, on average, by 9.7 minutes in the second measurement where the duration dropped from 72.8 minutes to 63.1 minutes (a reduction of 13.3%, $p_{bonf} = 1.00$). The almost identical situation was observed when comparing the initial and third measurement. The percentage change of time spent in hypoglycemia is negligibly higher in the second measurement (3.1% change compared to the initial measurement, $p_{bonf} = 1.00$), while in the third measurement it is slightly lower than in the initial measurement (by 14.3%; $p_{bonf} = 1.00$) (Table 3). Most importantly, no patient experienced severe hypoglycemia or ketoacidosis throughout the study.

With regard to the variability of glycemia measured in critical periods during the day, the conspicuous changes were related to periods of breakfast and lunch. In particular, after the first visit, there was a significant reduction in glycemia before lunch from 10.26 ± 3.59 mmol/L in the first measurement down to 7.79 ± 1.90 mmol/L after the third measurement. There was also a significant fall in glycemia after lunch from the initial 10.03 ± 3.00 mmol/L to 8.72 ± 1.91 mmol/L in the third measurement. Pre-breakfast glycemic values increased from 8.55 ± 2.51 mmol/L to 9.30 ± 2.69 mmol/L during the period of examination. It is also important to note that overnight glycemia was maintained at a satisfactory level, although the average values rose from 8.21 ± 2.19 mmol/L at the baseline to 8.90 ± 2.31 mmol/L in the third measurement (Table 4).

Table 4

Sensor glycemic values (mmol/L) in critical periods during the day

Period of a day	Usage of iPro®2		
	1st usage	2nd usage	3rd usage
Evening (23:00–03:00)	8.85 ± 1.96	8.61 ± 2.67	8.95 ± 2.16
Sleeping (03:00–06:00)	8.21 ± 2.19	8.13 ± 2.65	8.90 ± 2.31
Before breakfast	8.55 ± 2.51	8.67 ± 2.38	9.30 ± 2.69
After breakfast	12.87 ± 4.11	11.42 ± 3.68	11.13 ± 3.39
Before lunch	10.26 ± 3.59	9.32 ± 3.36	7.79 ± 1.90
After lunch	10.03 ± 3.00	9.81 ± 3.52	8.72 ± 1.91
Before dinner	8.70 ± 3.30	9.34 ± 3.15	8.32 ± 2.73
After dinner	9.76 ± 3.69	9.36 ± 3.12	9.26 ± 2.42

Note: values are presented as mean ± standard deviation.

Discussion

Our study with children with diabetes mellitus type 1 on a therapy of multiple daily insulin injections, showed that the use of the iPro®2 professional device for the CGM over period of 3 months was associated with several positive changes: a significant reduction in HbA1c, shortening the time spent in hyper and hypoglycemia, and clinically significant reduction of glycemic variability after 3 months, which was similar to other studies exploring the effects of wearing CGM devices [1]. This seems to be an important finding, having in mind that intensified insulin bolus-basal therapy regimen is rigid in comparison to insulin pump therapy, knowing that the success in lowering HbA1c is harder to achieve in patients with pen therapy [11, 13].

Nevertheless, some of the positive changes proved to be only short-term and the mechanism of change is not clear. For example, the reduction of HbA1c in the second measurement after 3 months might be a result of an increase in the average number of calibrations (glycemic self-monitoring) during the second and third wearing compared to the first wearing of the sensor [1]. On the other side, the deterioration of HbA1c after 3 months without the iPr®2o device indicates that 3 months of wearing the device may not be enough to gain a true insight into glycemic movements for a longer period of time. A longer use of this device could be a strategy in the treatment of children with diabetes.

One another extremely useful feature of iPro®2 devices for both the doctor and the patient is its ability to provide anticipated HbA1c after wearing the device for only 7 days. Such a measure indicates what can be expected if a patient continues with the same insulin therapy and habits related to glycemic control. It should be, however, noted that in our study correlations between the iPro®2 estimated and laboratory measures of HbA1c were not exceptionally high, hence although these HbA1c estimates obtained through iPro®2 are helpful - they should be used in a combination with clinical assessment. Future research should clarify the possible causes of the differences that result from such measures.

With the above in mind, iPro®2 estimated values of HbA1c also showed a significant improvement during the second and third wearing of the device compared to the first wearing. The second and third values of HBA1c were identical, which suggested that after getting the device the patients became more consistent with regard to the adherence to the guidelines and recommendations given, which was also observed in our clinical consultations. Indeed, the improvement of HbA1c values does not necessarily need to be a sign of a positive change, but in our study it was observed along with reduced duration of hypo- and hyperglycemia and reduced glycemic variability, which indicates the improvement.

Namely, the data collected showed that the percentage of time spent in hyperglycemia in both the second and third measurements were reduced relatively to the baseline. Simultaneously, the iPro®2 device showed that more time was spent in normoglycemia, and what is of particular importance, time spent in hypoglycemia was reduced on average for 9–10 minutes. Although these results were not statistically significant, this reduction in time spent in hypoglycemia might be of a clinical significance by reducing the likelihood of serious hypoglycemia. We learned in our sessions with the patients that the fear of a hypoglycemic event at school was a cause of elevated glycemia before and after lunch spotted during the first wearing. Our instructions targeted this behavior and we noticed a significant drop in glycemia before and after lunch during the third device wearing. Such results indicate that by using iPro®2 devices we can more precisely affect the changes of poor metabolic control by making the right decisions to change the insulin therapy or a lifestyle of a child with diabetes.

We also observed some reduction in glycemic variability during the later device wearing compared to the first wearing which is an additional benefit. The ability to monitor the dynamics of glycemic changes is on itself an important feature of such devices, and it is promising that effective diabetes monitoring could be achieved in a short time of using them.

Indeed, numerous studies have confirmed a significant influence of continuous glycemic monitoring on improvement of the metabolic control [1, 15–21]. However, Telo et al. [22] found that only 28% of children with diabetes mellitus type 1 that were offered a CGM accepted a possibility to use it.

Only motivated patients expressed that they would take more than one device (i.e. both the sensor and the insulin pump) on themselves for a few days. That said, we think that wearing iPro®2 system for 7 days, would be acceptable for most patients on MDI in terms of the length of time needed. This would be enough to bring a number of useful information to doctors, especially those information that the patient is unable to express, which subsequently could help in the more appropriate dosing of insulin therapy. The advantage of this device compared to the classical CGM devices with the real-time visibility of glycemia on the screen is that the doctor can see the usual pattern of glycemic events and hence can suggest an appropriate insulin treatment while eating and during the physical activity. By implementing numerous corrections of glycemic events during the day, based on explicitly monitored glycemic values, the practitioners lose the ability to get insight into the truer image of the pattern of behavior of the child with diabetes.

This study had several limitations. First of all, due to objective reasons, the number of patients was small, so we had a low statistical power for the tests conducted, and we were not able to include the control group in our design. Furthermore, the diverse age of the patients weakens the generalizability of the result. Such a small sample size also made it unrealistic to even consider to reliably model the effects of covariates on the outcomes. In addition, the duration of the study was limited to 3 months of the usage of the iPro®2 device or 6 months in terms of monitoring, due to the limited number of devices available to the investigators. Nevertheless, patients expressed the satisfaction with consultations they received during the study, because these consultations helped them to target bad eating habits during school and improve physical activities. As practitioners, we were also more confident in our advice since they were based on comprehensive information of individual glycemia variability.

Conclusion

This study showed that wearing a professional continuous monitoring of glycemic events for 7 days per 3 month led to some short-term and some long-term improvements in the metabolic control in children with diabetes mellitus type 1 who use multiple daily insulin injections. The results indicate that the iPro®2 system could be helpful in maintaining better metabolic control as the part of daily clinical practice, since glycemic self-monitoring has significant limitations and does not provide sufficient information for the doctor in order to give suggestion for adequate insulin therapy to improve the metabolic control in child with type 1 diabetes mellitus. A professional iPro®2 device for continuous monitoring of glycemia worn for 7 days per month, would provide the doctor with much richer insight into the habits and behaviors of a child with diabetes through retrogradely monitored glycemic variability during the day and night. In our clinical experience, we noticed that visual demonstrations of this variability are easily grasped by both patients and their parents, which in turn help them to draw better conclusions on the influence of important events, such as physical activity and carbohydrate intake. With this device, all interested parties have an insight into the real events throughout 7 days and nights, and in addition to the estimated HbA1c, this should be used to correct the therapy in advance and prevent the occurrence of high HbA1c. Because of all above said, future studies are necessary to confirm the long-term effectiveness of iPro®2 devices for metabolic control.

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Received on September 8, 2017.
Revised on April 10, 2018.
Accepted on June 8, 2018.
Online First June 2018.