Interfaculty Chair and Department of Public Health, Skubiszewski Medical University of Lublin
Clinic for Internal and Occupational Diseases, Institute of Agricultural Medicine in Lublin

## JUSTYNA JAWORSKA, PIOTR DZIEMIDOK, TERESA B. KULIK, EWA RUDNICKA-DROŻAK

# *Frequency of self-monitoring and its effect on metabolic control in patients with type 2 diabetes*

Diabetes is a disease in which the active participation of a patient in the treatment is an indispensable precondition for a rational therapy. Such active participation of patients in the treatment of diabetes requires their recognition of the essence of the disease and methods of self-monitoring, as well as change in life style, which enables to obtain the necessary state of metabolic control, therefore preventing remote complications and improving the quality of life (9).

Self-monitoring of blood glucose (SMBG), if it is a component of multi-directional procedure, effectively improves the treatment of diabetes, allows a patient to evaluate the response to the treatment applied and to determine whether the desired glycemia value has been obtained. The results of such glycemia control are useful in hyperglycemia prevention and help to adjust the doses of drugs and physical effort.

Self-monitoring of blood glucose is recommended to all patients with diabetes. According to the American Diabetes Association SMBG is especially important in patients treated with insulin, due to the possibility of occurrence of asymptomatic hypoglycemia. In patients with type 1 diabetes and pregnant women, it is recommended that self-monitoring of the level of glucose in blood is performed at least three times daily. In patients with type 2 diabetes the recommended optimum frequency of SMBG depends on the method of treatment. In insulin-treated patients glycemia measurements are recommended several times a day, while in those treated with oral agents – considerably less often – several times a week, especially when accompanied by the modification of diet, physical effort, in conditions of stress (2).

The aim of the study was to investigate the frequency of self-monitoring of blood glucose in patients with type 2 diabetes and to determine its effect on metabolic control measured as glycosylated hemoglobin level.

## MATERIAL AND METHODS

The study involved 218 patients with type 2 diabetes who reported to the Outpatient Department for diabetes at the Institute of Agricultural Medicine in Lublin, during the period from February 2002 to April 2003. All the patients who expressed consent to participate in the study completed a questionnaire form which contained questions concerning demographic data (sex, age, education, place of residence), duration of diabetes, method of treatment, and frequency of self-monitoring of blood glucose level. In the case of patients treated with insulin questions were asked about the ability to adjust insulin doses. In addition, the questionnaire contained questions concerning the life style (observation of diet, physical activity, habits, knowledge about the consequences of obesity and hypercholesterolemia). In order to evaluate fat deposition the body mass index was used BMI ($kg/m^2$). The values of the level of glycosylated hemoglobin ($HbA_{1C}$) were taken from medical records.

The population in the study was divided into four groups according to the frequency of SMBG. The first group were patients who tested their blood glucose levels at home at least once daily, the second group were patients who exercised self-control at least once a week; the third group covered patients who tested their blood glucose less often than once a week, and the fourth group – those who never practiced self-monitoring of blood glucose. In addition, the effect of self-monitoring on metabolic control was analysed according to the method of treatment. In the groups treated with insulin, as well as insulin and oral hypoglycemic agents, the ability to adjust insulin doses on glycemia control was studied. Kruskal–Wallis non-parametric test was applied in order to compare the analysed qualitative parameters between the groups examined, whereas the differences in the frequency of occurrence of specified parameters were evaluated by means of $c2$ test; $p < 0.05$ and considered as statistically significant. The results obtained were subject to statistical analysis with the use of Statistica 5.0 software for Windows 97.

## RESULTS

The study covered 218 patients with type 2 diabetes, aged from 30 to 84 (mean age 62.28±10.24) – 68.81% females and 31.19% males. Overall, 59.22% of patients stated that they tested their blood glucose levels at home at least once per day; 21.36% at least once a week, while 8.74% of patients monitored their blood glucose less than once per week. 10.68% of patients never practiced SMBG. Table 1 presents the characteristics of the population in the study according to the frequency of self-monitoring.

Table 1. Characteristics of patients by frequency of self-monitoring blood glucose

| | Frequency of blood glucose self-monitoring | | | | p |
| | ≥1/day | ≥1/week | <1/week | never | |
|---|---|---|---|---|---|
| % | 59.22 | 21.36 | 8.74 | 10.68 | |
| Sex | | | | | |
| females | 68.85 | 72.73 | 55.56 | 63.64 | NS |
| males | 31.15 | 27.27 | 44.44 | 36.36 | |
| Age (years) | 62.72±9.93 | 61.63±10.01 | 59.33±13.01 | 64.0±9.11 | NS |
| Place of residence | | | | | |
| urban | 72.13 | 54.55 | 44.44 | 36.36 | 0.04 |
| rural | 27.87 | 45.45 | 56.56 | 62.64 | |
| Education | | | | | |
| < 10 years | 39.34 | 36.36 | 55.56 | 72.73 | 0.01 |
| > 10 years | 60.66 | 63.64 | 44.44 | 27.27 | |
| Occupation | | | | | |
| agricultural | 19.67 | 18.18 | 22.22 | 45.45 | < 0.01 |
| manual worker | 27.87 | 40.91 | 33.33 | 18.19 | |
| office worker | 52.46 | 40.19 | 44.45 | 36.36 | |
| Duration of diabetes | | | | | |
| < 5 years | 9.84 | 55.55 | 44.45 | 27.28 | < 0.01 |
| 5-10 years | 21.31 | 9.09 | 22.22 | 45.46 | |
| > 10 years | 68.85 | 36.36 | 33.33 | 27.26 | |
| Treatment | | | | | |
| insulin | 39.34 | 40.91 | - | 9.09 | < 0.01 |
| insulin+oral agents | 32.76 | 13.64 | 11.11 | 18.18 | |
| oral agents | 28.87 | 45.45 | 88.89 | 72.73 · | |
| Ability to adjust insulin doses | 54 | 30 | 0 | 0 | NS |
| HbA$_{1C}$ | 8.06±1.14 | 7.38±1.48 | 7.68±1.58 | 8.13±1.48 | NS |
| BMI | 32.02±5.75 | 30.38±4.95 | 30.57±5.51 | 31.54±7.97 | NS· |

The Table presents quantitative date as mean values with standard deviation (±SD). Descriptive date are quoted in %. Kruskal–Wallis test was applied to compare quantitative parameters; differences in frequency of occurrence of specified parameters were evaluated by c2 test; p < 0.05 is considered as statistically significant.

The analysed groups of patients did not differ with respect to age and gender distribution. Statistically significant differences were observed with respect to the education level, place of residence (urban-rural), type of occupation performed (farmer, manual or office worker). The group with most frequent self-monitoring was dominated by patients with secondary school or university level of education (period of education over 10 years) – 60.66%, while in the group of patients who never practiced self-monitoring the majority of patients had only elementary or vocational education – 72.73% (p = 0.01). Moreover, urban inhabitants who performed office-type of work carried out self-monitoring statistically more often than the other patients, whereas such monitoring was the least popular among farmers.

The group of patients who most often independently monitored their glycemia was dominated by those with diabetes which had lasted for over 10 years (68.85%), whereas among patients who did not practice self-monitoring such people constituted only 27.26% (p < 0.01). It was noted that patients treated with insulin, and those treated with insulin and oral agents, dominated among patients who carried out self-monitoring most often (39.34% and 32.76% respectively), while in the group of those who never practiced self-monitoring the vast majority were patients treated with oral agents only (72.73%). The differences observed were statistically significant (p < 0.01).

The analysis of glycemia monitoring determined by means of the glycosylated hemoglobin level in the total population in the study did not confirm the effect of self-monitoring on metabolic control. Despite this fact, the highest levels of glycosylated hemoglobin were noted among people who never practiced SMBG. The effect of self-monitoring on glycemia control was analysed according to the method of diabetes treatment (Table 2). Among insulin-treated patients, as well as patients treated with insulin and oral agents, the analysis was also performed from the aspect of ability to adjust insulin doses in glycemia control (Table 3). The effect of intensification of self-monitoring on the improvement in glycemia control was not observed in any of the groups. Similarly, the ability to adjust insulin doses did not positively affect glycemia control.

Table 2. Level of HbA$_1$c (%) according to frequency of blood glucose self-monitoring and method of treatment

| Treatment | Frequency of blood glucose self-monitoring | | | | p |
|---|---|---|---|---|---|
| | ≥ 1/day | ≥ 1/week | <1/week | never | |
| Insulin | 7.74±1.21 | 7.14±1.41 | - | 7.81±1.31 | NS |
| Insulin + oral agents | 8.72±1.77 | 8.80±1.73 | 6.30±1.21 | 9.50±0.80 | NS |
| Oral agents | 7.69±0.96 | 7.30±1.40 | 7.86±1.59 | 8.08±1.57 | NS |

Table 3. Level of HbA$_1$c (%) according to ability to adjust insulin doses and method of treatment

| Treatment | Ability to adjust insulin doses | | p |
|---|---|---|---|
| | yes | no | |
| Insulin | 8.10±0.90 | 7.78±1.37 | NS |
| Insulin + oral agents | 9.90±1.91 | 8.48±1.66 | NS |

Table 4 presents health promoting behaviours according to frequency of self-monitoring. The analysis covered the observance of diet, physical activity, and other elements which could confirm full understanding of the goals of diabetes treatment, awareness of the problem of obesity or cigarette smoking. An increase in the percentage of those observing diet with the intensification of self-monitoring was not noted in the population in the study. No statistically significant differences were also observed in the percentage of smokers or non-smokers according to the frequency of self-monitoring. In the two groups of the most frequent self-monitoring the percentage of people exercising a planned physical

effort was the highest (60.78 and 71.43, vs. 28.57 and 54.55; p = 0.03), as well as the percentage of those who declared that they were aware of the consequences of overweight and obesity. However, the physical activity and awareness of the consequences of excessive fat deposition declared, did not exert any effect on objectively evaluated body mass. No statistically significant differences between groups were noted with respect to the value of the body mass index.

Table 4. Selected health promoting behaviours by frequency of blood glucose self-monitoring

|  | Frequency of blood glucose self-monitoring | | | | |
|---|---|---|---|---|---|
|  | ≥ 1/day | ≥1/week | <1/week | never | p |
| Observance of diet | 19.61 | 19.05 | 17.03 | 18.18 | NS |
| Physical activity | 60.78 | 71.43 | 28.57 | 54.55 | 0.03 |
| Awareness of obesity problem | 80.39 | 76.19 | 42.86 | 45.45 | < 0.01 |
| Cigarette smoking | | | | | |
| non-smokers | 62.75 | 66.67 | 42.96 | 45.45 | NS |
| ex-smokers | 31.37 | 19.05 | 42.86 | 36.36 | |
| active smokers | 5.88 | 14.29 | 14.29 | 18.18 | |

## DISCUSSION

Self-monitoring, understood as glycemia measurements independently performed by patients, has revolutionized the treatment of diabetes. According to the position statement of the American Diabetes Association, self-monitoring of blood glucose (SMBG) is considered an important component of diabetes care and is recommended for all insulin-treated patients (3). The aim of self-monitoring is the collection of information concerning a 24-hour glycemia profile, which allows the maintenance of its relatively constant level by the modification of insulin doses. Due to this method, patients gained a greater influence on the control of their glucose level. The American Diabetes Association (ADA) recommends the carrying out of self-monitoring to patients with type 1 diabetes at least three times daily. To patients with type 2 diabetes the optimal frequency of self-monitoring of blood glucose is dependent on the method of treatment. Insulin-treated patients are recommended that they perform glycemia measurements several times a day, while those treated with oral agents considerably less often – several times a week (especially with modification of diet, physical effort and in conditions of stress) (2).

Exercising self-monitoring is increasingly more popular; a number of reports, however, mention that SMBG is most widely spread among better educated and younger people (4, 6, 7). In addition, people with newly diagnosed diabetes and those with the disease lasting for 20 years are usually most keen on frequent self-monitoring (4). This was confirmed in the present study, where in the group performing measurements more often than once a day, patients with secondary school or university education level dominated, and where the duration of the disease had lasted for over 10 years, whereas among those who did not exercise control, the dominant were those with elementary or vocational education and diabetes lasting for 5–10 years.

For patients with type 2 diabetes the importance of self-monitoring still remains a matter for discussion. The ADA recommends self-monitoring of glycemia level to patients with type 2 diabetes, the frequency of control being according to the method of treatment, and simultaneously states that the determination of glycemia should be adequately more frequent in order to obtain the desired glycemia control (2). In the presented study, similar to previously quoted E v a n s  et àl., no advantageous effect of self-monitoring on glycemia control in patients with type 2 diabetes was observed, neither in the total population examined nor according to the method of diabetes treatment. Some reports indicate that self-monitoring in combination with modification of insulin doses improves the metabolic control

of type 2 diabetes treated with insulin (6). F r a n c i o s i  et al., who examined the effect of self-monitoring on metabolic control of diabetes in 3,567 patients with type 2 diabetes, confirmed a positive effect of diabetes control on metabolic control among insulin-treated patients who could modify their insulin doses, in other words, those for whom self-monitoring was an integral part of a widely-understood patient education designed to increase their engagement in the process of treatment (6). Our studies did not confirm this relationship. Skills of modification of insulin doses declared by patients treated with insulin and insulin in combination with oral agents did not improve glycemia control.

The effect of self-control on the level of glycolysated hemoglobin in patients with type 2 diabetes was the object of many randomized studies (1, 4, 5, 6, 7, 10, 11). W i n g  et al., who in a 62-week prospective study of patients with type 2 diabetes evaluated the effect of self-monitoring on glycolysated hemoglobin level, body mass and change in life style did not observe differences between patients who carried out self-monitoring and those who did not; the result of studies conducted by M i s o u r i among 61 patients with type 2 diabetes was similar (8). R u t t e n  et al., noted a beneficial effect of self-monitoring on type 2 diabetes control in groups treated with diet and oral agents (10). A tendency to improve type 2 diabetes control with an increase in the frequency of self-monitoring was observed by F o n t b o n n e  et al. in a 26-week study of patients treated with diet or oral agents (5). The results obtained by A l l e n  et al. (1), however, were not statistically significant. In the present analysis, no improvement of metabolic control was noted in patients with type 2 diabetes treated with oral hypoglycemic agents, nor in those treated with oral agents in combination with insulin.

The engagement of a patient in exercising self-monitoring should be associated with the change of life style, connected with the observance of the diet, increased physical activity, which as a result should lead to a better metabolic control. In the presented study the analysis of selected health promoting behaviours confirmed an insufficient observance of diet, poor popularity of physical activity with a simultaneous widely spread self-monitoring. H a r r i s  (7), E v a n s  et al. (4) observed positive changes in health promoting behaviours among patients exercising self-monitoring. However, in the present study the popularity of self-monitoring was not associated with a health promoting life style. The intensification of self-monitoring was not accompanied by the reduction of body mass, increased physical activity or more rigorous dietary regime. It appears that the observed lack of the improvement of glycemia control with increase in the frequency of self-monitoring is a consequence of insufficient understanding by patients of the essence of the disease and goal of self-monitoring carried out.

## CONCLUSIONS

1. Urban inhabitants with secondary school or university education who perform office work are more keen on frequent home glycemia monitoring.

2. In patients with type 2 diabetes the intensity of self-monitoring did not exert an influence on diabetes control evaluated by means of glycolysated hemoglobin level.

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## SUMMARY

The aim of the study was to investigate the frequency of self-monitoring of blood glucose in patients with type 2 diabetes and to determine its effect on metabolic control measured as glycosylated hemoglobin level. The study involved 218 patients with type 2 diabetes (68.8% of females and 31.19% of males) who reported to the Outpatient Department for Diabetes at the Institute of Agricultural Medicine in Lublin. All patients were asked to complete a questionnaire form containing questions concerning, among other things, demographic data, course of diabetes, method of treatment, ability to adjust insulin doses and frequency of self-monitoring of blood glucose level. The levels of glycosylated hemoglobin were obtained based on medical records. The analysis of the data showed that 59.22% of patients tested their blood glucose levels at home ≥1/day, 21.36% of them tested their blood glucose ≥1/week, whereas 8.74% of patients tested glucose <1/week. 10.68% of patients stated that they never practiced SMBG. Statistical differences were observed in the level of education. Among the group of patients who exercised self-monitoring the most dominant were those with secondary school or university level of education (60.66%), while among patients who did not maintain self-monitoring the greatest number had only elementary or vocational education (72.73) (p = 0.01). The greatest number of patients who most often maintained self-monitoring were office workers (52.46%), whereas among those who did not exercise self-monitoring, those employed in agriculture dominated (45.45%) (p < 0.01). Urban inhabitants exercised self-monitoring more frequently than urban inhabitants (p < 0.01). The frequency of self-monitoring did not affect glycemia control. Urban inhabitants with secondary school or university education level and those who perform office work are more keen on frequent home monitoring of glycemia. In patients with type 2 diabetes the intensity of self-monitoring does not exert any effect on diabetes control evaluated by means of glycosylated hemoglobin level.

Częstość samokontroli i jej wpływ na wyrównanie metaboliczne pacjentów chorych na cukrzycę typu 2

Celem pracy była ocena częstości prowadzenia samokontroli oraz wpływu samokontroli na wyrównanie metaboliczne cukrzycy, oceniane za pomocą poziomu hemoglobiny glikowanej, u pacjentów chorych na cukrzycę typu 2. Badaniem objęto grupę 218 chorych na cukrzycę typu 2 (68,8% kobiet, 31,19% mężczyzn), którzy zgłosili się do Poradni Diabetologicznej Instytutu Medycyny Wsi w Lublinie. Wszyscy pacjenci byli proszeni o wypełnienie ankiety zawierającej pytania, m.in. o

dane demograficzne, przebieg cukrzycy, sposób leczenia, umiejętności modyfikowania dawek insuliny oraz częstości samodzielnego oznaczania poziomu glikemii. Z dokumentacji medycznej uzyskano poziomy hemoglobiny glikowanej. Analiza danych wykazała, że 59,22% pacjentów samodzielnie kontrolowało poziom glikemii $\geq$1/dzień, 21,36% pacjentów kontrolowało glikemię $\geq$1 /tydzień, natomiast 8,74% pacjentów kontrolowało glikemię <1/tydzień, 10,68% pacjentów nie prowadziło samokontroli. Zaobserwowano statystycznie istotne różnice w poziomie wykształcenia. W grupie o najczęstszej samokontroli dominowali pacjenci z wykształceniem średnim lub wyższym (60,66%), natomiast w grupie nieprowadzącej samokontroli przeważali pacjenci z wykształceniem podstawowym lub zawodowym (72,73%) $p=0,01$. Wśród osób najczęściej prowadzących samokontrolę dominowały osoby pracujące umysłowo (52,46%), zaś wśród nieprowadzących samokontroli przeważały osoby zatrudnione w rolnictwie (45,45%) $p<0,01$. Osoby mieszkające w mieście częściej prowadziły samokontrolę niż mieszkające na wsi ($p<0,01$). Częstość samokontroli nie wpływała na wyrównanie glikemii. Należy wnioskować, że osoby mieszkające w mieście, o wykształceniu średnim lub wyższym, pracujące umysłowo, są bardziej skłonne do częstszego domowego monitorowania glikemii. U pacjentów chorych na cukrzycę typu 2 intensywność samokontroli nie wpływa na wyrównanie cukrzycy, oceniane za pomocą poziomu hemoglobiny glikowanej.