Brief Communications

A Randomized, Controlled Comparison of Instruction by a Diabetes Educator Versus Self-Instruction in Self-Monitoring of Blood Glucose

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It is not clear whether diabetic patients can learn accurate self-monitoring of blood glucose (SMBG) by use of written package instructions. In addition, it is unclear whether the improvement in accuracy of monitoring that results from professional training is due to the professional intervention or to a personal practice effect. For these reasons, improvement in accuracy of SMBG (using Chemstrip bG, Biodynamics Division, Boehringer-Mannheim, Indianapolis, Indiana) after a 30-min session of professional instruction in one group of diabetic patients was compared with improvement after 30 min of practice and study of package instructions in another group. After initial reading of package instructions in both groups, and after the practice session in the control group, mean percent error was 22–37%. In contrast, mean percent error declined to 9% after a professional training session. We conclude that learning SMBG solely by reading package instructions leads to unacceptable inaccuracy. However, by use of short, intensive instruction sessions, a diabetes educator can reduce such errors and teach highly accurate monitoring to most diabetic patients. DIABETES CARE 1985; 8:284–86.

Recent studies have demonstrated that trained medical personnel can perform self-monitoring of blood glucose (SMBG) by visual inspection of reagent strips with great accuracy.[1,2] In contrast, it has been reported that 30–40% of estimates by diabetic patients are in error by at least 20%.[2–4] Since such errors can lead to serious mistakes in insulin dose decisions and in diagnosis of hypoglycemia, effective patient education in SMBG is crucial. Although blood glucose monitoring strips and devices come with detailed instructions, it is not clear whether patients can learn accurate monitoring techniques by the use of such instructions without additional professional instruction. Thus, in this study, accuracy in SMBG was tested in two randomly assigned groups of diabetic patients without previous experience in blood glucose monitoring. The accuracy of one group was tested before and after a 30-min session during which a diabetes educator provided specific instructions in SMBG and the patients practiced such monitoring under guidance. The other group was tested before and after a 30-min session during which they received no help from an educator but studied the package instructions and practiced testing on their own. Comparison between these two groups allowed us to assess the effect of short-term, intensive SMBG education, independent of a personal practice effect.

METHODS

Subjects. Included in the study were the first 30 patients who gave consent and met the following criteria: (1) a history of diabetes mellitus (either type I or type II) originally diagnosed by a fasting plasma glucose >140 mg/dl, (2) an absence of prior experience in SMBG, and (3) the ability to read printed SMBG instructions (see below). Patients were randomly assigned to a self-education group (N = 14) or to a group instructed by a diabetes educator (N = 16). Thirteen of the patients in each group were taking insulin; the others were treated with oral hypoglycemic agents. All subjects were male. Subjects in the self-education group were similar to those in the professional instruction group in terms of age (54 ± 15 versus 56 ± 12 yr, mean ± SD), random plasma glucose level (204 ± 88 versus 237 ± 76 mg/dl), highest grade completed (11.4 ± 2.8 versus 13.3 ± 2.7), and duration of diabetes (13.3 ± 8.1 versus 10.4 ± 8.9 yr, no significant P-value).

Comparison of Accu-Chek with Autoanalyzer. The clinical study was designed so that visual estimations of blood glucose values by patients using Chemstrip bG (Biodynamics Division, Boehringer-Mannheim, Indianapolis, Indiana) would be compared with glucose values simultaneously determined by the educator using an Accu-Chek meter (Boehringer-Mann-

heim). Therefore, before use of the Accu-Chek, its precision was assessed by comparison with a highly precise and accurate glucose analyzer (Autoanalyzer, Technicon Instruments, Tarrytown, New York). Eleven whole blood glucose standards ranging from 47 to 382 mg/dl were obtained after insulin treatment of a normal human volunteer and by addition of small amounts of glucose to whole blood. Glucose values were then immediately measured by each author using Chemstrip bG with an Accu-Chek meter and by an Autoanalyzer. Using linear regression analysis, the following relationship was found: glucose level by Accu-chek = 33 + 0.81 × glucose level determined by Autoanalyzer; r = 0.997. Because of its precision, the Accu-Chek was deemed appropriate as a standard to which visual glucose estimations could be compared.

Study protocol. All patients in both groups were instructed to read the package instructions for visual determination of blood glucose by Chemstrip bG. Each patient then tested his blood glucose, and the patient's estimate was recorded by the educator. The educator also obtained a capillary blood sample from the patient at this time and privately determined the blood glucose level with an Accu-Chek meter. Subjects randomized to the self-education group then reread the instructions and practiced the technique for 30 min without the assistance of the educator. Then, blood glucose level was again visually estimated by the patient and measured by the educator using the Accu-Chek meter.

After initial measurement of blood glucose without assistance, patients randomized to diabetes education were given specific instructions by one of us (L.H.) for 30 min on the accurate use of Chemstrip bG. The following instructions were emphasized: (1) Before finger pricking, wash hands in warm water (to enhance superficial blood flow), then dry hands thoroughly. (2) After finger pricking, hold hand low (before level of heart, in order to impede venous return) while obtaining drop of blood. (3) Obtain a large, single, hanging drop of blood by squeezing lateral portion of the finger. (4) Do not smear blood while applying blood to reagent pad from above. (5) Wait exactly 60 s before wiping blood off reagent pad. (6) Compare color of reagent pad to the standard color in direct daylight, if possible. (7) Because the two reagent pads do not always provide the same estimates of blood glucose, use the lower pad when the upper pad shows no green and the upper pad when it does show green. (8) Unless color of reagent pad exactly matches that of the standard, estimate glucose value by interpolation.

Correct technique was first demonstrated to the patients by the educator monitoring her own blood glucose. The patient then performed the technique on himself with direct feedback from the educator and continued to practice with assistance for a total of 30 min. Finally, the patient again visually estimated his blood glucose level without assistance from the educator, and the educator obtained a separate capillary sample and measured the glucose level with the Accu-Chek meter. After patients who received assistance from the diabetes educator read the final blood glucose, they designated which one instruction given by the educator was the most helpful. Although not part of this study per se, patients who had been in the self-instruction group were given instruction by an educator later on the same day.

Calculations. Each visual estimation of blood glucose by the patients was compared with the glucose level as measured by the educator using the Accu-Chek meter (standard), and a percent error was calculated as ([patient estimate − standard value] ÷ standard value) × 100. For statistical comparisons, absolute value of percent errors were employed. To test for differences between groups, Student's unpaired, two-tailed *t*-test was used. To test for differences between the final and initial percent error within groups, Student's paired, two-tailed *t*-test was used.

Results are reported as mean ± standard deviation.

RESULTS

Both groups initially demonstrated large glucose estimation errors, approximately 20–40%, and such a degree of error persisted in the group who was self-educated (Figure 1). In the group who was professionally instructed, the education period led to a consistent decline in percent error from 22 ± 14% to 9 ± 8% ($P < 0.01$) (Figure 1). In addition, improvement in blood glucose estimates, as defined by the difference between the absolute values of final and initial percent errors, was much

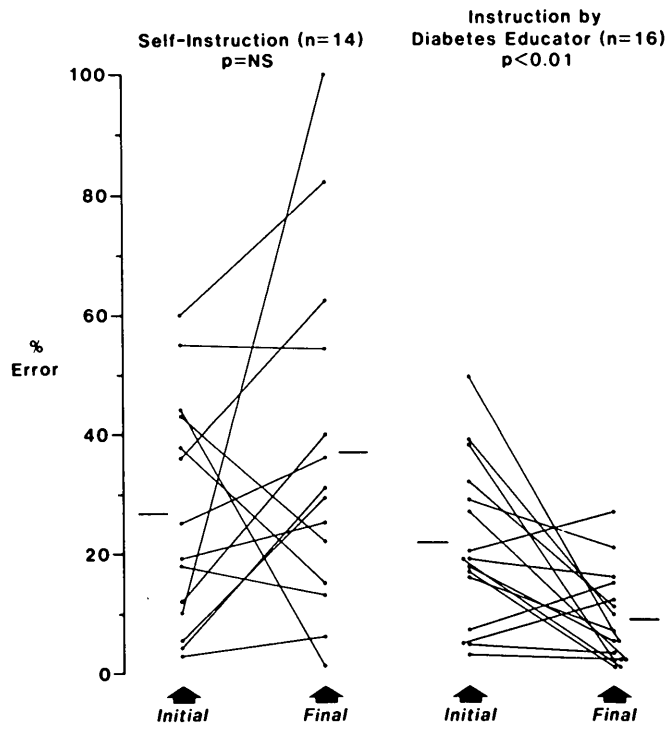

FIG. 1. (Left panel) A comparison of percent error in blood glucose monitoring in 14 diabetic patients before and after 30 min of practice and study of package instructions. Note lack of improvement. (Right panel) Percent error before and after a 30-min instructional session given by a diabetes educator to 16 diabetic patients. Note consistent improvement in accuracy.

greater in the professionally educated group than in the self-educated group (15 ± 17% versus −7 ± 30%, $P < 0.02$).

Using linear regression in the entire patient population, no significant correlation was found between initial percent error and age ($r = 0.116$), level of education ($r = 0.164$), or annual income ($r = 0.132$).

Of the instructions judged to be the most helpful to patients, the acquisition of a large drop of blood was given by six patients, holding the hand below heart level while obtaining blood was given by four patients, avoidance of smearing was given by three patients, and use of the upper reagent pad for glucose values >140 mg/dl was given by one patient. Three patients were unable to report a single instruction that was most helpful.

DISCUSSION

This study demonstrates that a 30-min period of instruction by a diabetes educator on performance of SMBG with Chemstrip bG improved accuracy to a greater extent than that achieved by simply reading the package instructions and practicing. We feel that inclusion of a control group who underwent practice and attempted self-education is important because, without it, the specific cause in improvement in patient performance after a period of professional education could not have been ascertained. In view of the lack of improvement after practice alone in our control group, we can conclude that instruction provided by a diabetes educator, not a personal practice effect, was responsible for the consistent improvement in accuracy of SMBG.

There are two plausible reasons why professional instruction in SMBG was superior to self-instruction. First, the diabetes educator in the present study provided several instructions that were not provided or unclear in the package insert. For example, Chemstrip bG package instructions do not specifically state that a hanging drop of blood should be lowered to the reagent pad from above, and many patients initially attempted to lower the test strip to the finger. In addition, the package instructions regarding estimation of glucose values by interpolation when neither reagent pad color matches the standard color on a vial are confusing to some patients. Therefore, it is likely that additions and revisions of the Chemstrip bG instructions would improve patient accuracy.

The second possible reason why instruction by a diabetes educator was superior to self-education is the ability of teachers to use techniques other than fixed, written instructions. For example, the diabetes educator provides direct feedback and immediate correction of mistakes. In addition, some persons appear to learn better from direct visual demonstration than from written instructions. It is likely that both the additional monitoring instructions and human teaching factors contributed to the superiority of diabetes education over self-education.

This study suggests that simple reading of package instructions for Chemstrip bG leads to unacceptable inaccuracy in SMBG by most diabetic male veterans. Although it is possible that greater accuracy of such self-instruction could be achieved by more highly educated or medically sophisticated patients, we found no evidence that level of education was correlated with performance. Indeed, we feel that accurate SMBG is sufficiently complex that all patients who perform such monitoring should be provided with specific training by a diabetes educator. Fortunately, a relatively short education period, 30 min, appears to be sufficient to achieve acceptable accuracy, i.e, a 9% average error.

Despite such success with short, intensive education sessions, newly achieved knowledge about control of diabetes may be lost relatively quickly, as shown by Korhonen et al.[5] For this reason, we feel that every patient instructed in SMBG should return for at least one refresher session after the initial instruction session.

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