Influence of Frequency, Time Interval From Initial Instruction, and Method of Instruction on Performance Competency for Blood Glucose Monitoring

Marcia A. Kucler, MSN, RN
Marlene Goormastic, MPH
Byron J. Hoogwerf, MD

In a sample of 178 nurses who had been instructed in the performance of fingerstick monitoring of blood glucose (MBG), we investigated variables that may predict their proficiency at subsequent MBG performance. All nurses were given initial instruction in a classroom-type setting or via a self-instructional packet, and initial proficiency was documented by initial testing. All nurses were retested 1–8 mo later. To address whether actual frequency of performing MBG at work affected proficiency, the nurses were categorized based on the frequency of performing MBG groups: >1 test/day (n = 53), >1 test/wk (n = 51), >1 test/mo (n = 52), and <1 test/mo (n = 22). No differences in test and retest scores were detected. To address whether the time interval from the original instruction and test to the retest affected proficiency, the nurses were divided into groups who had initial test <6 mo (n = 108) and >6 mo (n = 70) before the retest. Mean change in test scores was less in the >6-mo group than in the <6-mo group ($P < 0.01$), and they had a lower retest fail rate (3 vs. 12%, $P = 0.03$). To explain this unexpected finding, test scores were analyzed by groups based on the type of original instruction. Nurses who attended class (n = 79) were compared with those who had self-instruction (n = 99). The classroom-trained group had less change in test-to-retest score (P = 0.0002) and a lower retest failure rate (3 vs. 12%, $P <$ 0.05). *Diabetes Care* 13:488–91, 1990

Nonlaboratory blood glucose monitoring performed at bedside or by patients (monitoring of blood glucose [MBG]) has become an accepted practice in hospitals, clinics, and doctors' offices. Because of its increasing role as a replacement for laboratory-based serum and plasma glucose determinations, methods to ensure accurate and efficient utilization of the technology need to be developed and evaluated on an ongoing basis. National organizations such as the 1986 American Diabetes Association Consensus Panel (1), the American Diabetes Association (2), and the Joint Commission on Accreditation of Hospitals (3) now recommend training and ongoing monitoring of hospital personnel who perform MBG. In fact, training and testing programs are reported (4,5). Such studies support the need for high-quality training and follow-up to ensure that bedside MBG values are in a range considered acceptable for clinical use.

The Cleveland Clinic Foundation (CCF) is a large multispecialty hospital and clinic with 950 active beds. An MBG quality assurance program was implemented in 1987. It involved the training and evaluation of over 900 registered and licensed practical nurses from 36 inpatient units and 7 ambulatory clinics. The initial cost of training and evaluation to implement the program was conservatively estimated at $24,000.

The substantial cost in material and personnel resources for an annual program of this magnitude raised two relevant questions. *1*) Should personnel who perform MBG infrequently be trained and tested for competency in MBG? 2) Do personnel who perform MBG maintain minimum proficiency between annual testing periods? Both questions have clinical and economic implications. Clinically, infrequent performance of MBG or a decline in proficiency over time could increase the frequency of user error. Inaccurate MBG could result in

From the Departments of Nursing, Biostatistics, and Endocrinology, The Cleveland Clinic Foundation, Cleveland, Ohio.
Address correspondence and reprint requests to Dr. Byron Hoogwerf, Department of Endocrinology, The Cleveland Clinic Foundation, One Clinic Center, Cleveland, OH 44195.
Received for publication 10 July 1989 and accepted in revised form 15 November 1989.

inappropriate treatment or additional discomfort for the patient. Economically, duplication of MBG procedures and prolonged hospitalization due to inappropriate patient management could increase costs. Furthermore, personnel costs for evaluation and training are directly related to the frequency of proficiency testing.

The purpose of our study was to investigate several factors believed to influence MBG proficiency in nursing personnel. Two initial specific questions were addressed: Is user proficiency influenced by the frequency of performance of MBG? Is user proficiency influenced by the time interval between initial instruction and testing and the retest? After the initial data analyses, a third question was addressed: Is user proficiency influenced by the method of initial instruction?

RESEARCH DESIGN AND METHODS

Of the 940 nursing personnel originally trained and tested, 658 nurses met the following criteria for participation in the study: *1*) received certification in MBG through the CCF program, *2*) had the original test score and month of completion on record, *3*) was still employed by CCF, and *4*) responded to a survey on individual frequency of performing MBG. All nursing personnel who met the criteria were placed in four groups according to their reported frequency of performing MBG. Participants were then randomly selected with a random numbers table from each group. Some nurses changed frequency of performing MBG between initial instruction and follow-up testing. The reported frequency of testing at follow-up was used in the analyses. Table 1 shows the final breakdown by groups. The study of time interval between test and retest was divided into two periods: <6 mo and ≥6 mo.

Two methods of initial instruction were determined from records that had been kept when the CCF quality assurance program for MBG had been introduced. The first method of instruction involved a 1-h classroom presentation that included an instructor who led discussion on the rationale for MBG, a film on MBG procedure, a self-instructional packet with knowledge posttest, and supervised practice with MBG equipment. The second method involved individual study limited to the self-instructional packet and posttest. On successful completion of either instructional method, the nurse would return to her unit, where she would be tested at her convenience for skill proficiency in MBG. Only the test and retest scores for skill proficiency were used for this study.

Clinical instructors and designated preceptors served as data collectors. They attended a training session in which they tested each other in the presence of a nursing instructor (M.A.K.) with the skills list and the same equipment used on the units. Most had performed the original proficiency tests on their units, which reduced the possibility of rater variability between original and retest scores. On the day of data collection, nurses were approached and asked to complete a questionnaire estimating their average frequency of MBG performance at work. They were told that they would be retested for MBG proficiency during their shift. We informed participants at the beginning of their shifts to allow them preparation time. This was meant to simulate real-life situations in which a nurse assigned to a patient requiring MBG would have the opportunity to review the procedure if needed before proceeding. Only 11% of the nurses (based on questionnaire response) chose to prepare before being tested; they were equally distributed among the four MBG frequency groups. Meter calibration was the area most frequently reviewed.

The testing tool was a skill checklist used to evaluate proficiency of MBG. The checklist used a weighted scoring method, and key steps in the procedure were given higher relative values. For example, nonsmear blood application (covering the entire strip) and proper wiping are examples of the steps worth 7 points (vs. 2 points for the others). Therefore, any subject missing three major steps would fail. A score of 80 of 100 points was the minimum to ensure accurate blood glucose values. (The instrument is the property of CCF; specific details of the testing instrument may be obtained by correspondence with the authors.)

Statistical methods. Paired *t* tests were used to test for differences in scores within groups. Mean changes in scores between groups were tested with analysis of variance (ANOVA). Comparisons of failure rates (scores <80%) were performed with a χ^2-test. $P \leq 0.05$ was considered statistically significant. All analyses were performed with SAS statistical software (6).

TABLE 1
Nurses who qualified for study and randomly selected nurses in groups defined by frequency of monitoring of blood glucose (MBG)

Frequency of MBG	Qualified	Selected
>1/day	202	53
>1/wk	223	51
>1/mo	203	52
<1/mo	30	22*

*Due to small number of <1/mo participants, 100% were included in sample (8 nurses in qualified group changed frequency of performance of MBG or were not available for retest).

RESULTS

All nurses had to score ≥80% to be considered competent to perform MBG. Therefore, the original test scores ranged from 84 to 100%, with a mean score of 98%. The retest scores were consistently lower, with a range of 66–100% and a mean score of 92%.

To determine whether the frequency of MBG had an effect on retest scores, we analyzed each of the four groups based on this frequency. There were no differences in mean values for original test scores (99, 97, 98, and 97%), the retest scores (92, 90, 92, and 90%), or the range of values for the original test or retest between groups (Table 2).

To determine whether there was a difference in mean test scores as a function of time from the original test, we compared scores for nurses with an interval of <6 mo between instruction and retest (n = 108) with nurses who had been instructed ≥6 mo earlier (n = 70). Surprisingly, when we compared test scores for nurses with >6 mo between original test and retest and those who had a <6-mo interval, the mean ± SD decrement was 4.7 ± 6.1 (confidence interval [C.I.] 3.3, 6.4) for the former and 7.5 ± 7.5 (C.I. 6.1, 8.9) for the latter (Table 3). These values were significantly different (P = 0.01). Similarly, when we compared the failure rate on retest (Table 3), only 3% (2 of 70) in the >6-mo group failed, whereas 12% (13 of 108) in the <6-mo group failed (P = 0.03). The finding that retest scores and failure rates improved with longer intervals between testing than with shorter intervals was not consistent with our original expectations. Therefore, we analyzed a third variable, the method of instructional preparation of participants, as a possible influence on retest scores. We compared all nurses who received classroom instruction (n = 79) with those who had the self-instructional method (n = 99). A three-way ANOVA was used to test for mean score differences among groups, time and nature of original instruction (i.e., attended class vs. self-instruction), and various combinations of interactions. There was no significant three-way interaction. However, there was a significant interaction between time from original instruction and whether nurses attended the class (Table 4). Mean original test scores were not different between these two groups (classroom 97.6 ± 3.9%, self-instructional 98.2 ± 3.1%). At retest, the mean change (decrease) in score for nurses who attended class was 4.1 ± 5.6 compared with 8.2 ± 7.6% for nurses who used the self-instructional method (Table 4). This difference was statistically significant (P < 0.0002). Furthermore, when these two groups were compared to determine the number of nurses with scores <80 at the time of retest (Table 4), only 4% (3 of 79) of those who attended class had failing scores, whereas 12% (12 of 99) of those who used the self-instructional method failed (P < 0.05).

When we evaluated the possible relationship of classroom testing versus self-instruction in light of subsequent frequency of MBG, less frequent MBG appeared to accentuate the differences between groups with classroom instruction and self-instruction. There was no difference between mean decrement in test scores for classroom instruction and self-instruction in the group who frequently (>1 test/day) performed bedside monitoring (5.9 vs. 7.0, P = 0.43), whereas in groups who performed MBG >1 test/wk (3.8 vs. 9.3, P < 0.01) and >1 test/mo (2.7 vs. 8.9, P < 0.01) differences did exist; in the group that performed MBG <1 test/mo the numbers of nurses was small, but values still approached statistical significance (1.9 vs. 7.4, P = 0.07).

Further analysis of failure rates showed that nurses who had not taken the class, and hence had lower retest scores described above, were also in the group who were tested <6 mo from the original test. To see if there was any trend toward failing scores on the retest, we looked at the change in score between test and retest monthly for both the whole group and the group who had not taken the class (because this group had the lower retest scores). Neither of these analyses showed any significant differences among the scores or trends over time.

TABLE 2
Comparison of test and retest scores for each frequency of monitoring of blood glucose (MBG) group

Frequency of MBG	n	Score	Range
>1/day			
Original score	53	99.1 ± 2.4	(90–100)
Retest score	53	92.1 ± 6.0	(72–100)
Difference between scores	53	7.0 ± 5.7	(−4–19)
>1/wk			
Original score	51	97.4 ± 3.6	(85–100)
Retest score	51	90.3 ± 8.4	(66–100)
Difference between scores	51	7.1 ± 8.4	(−9–34)
>1/mo			
Original score	52	97.5 ± 3.5	(85–100)
Retest score	52	92.5 ± 6.4	(76–100)
Difference between scores	52	5.0 ± 5.9	(−5–17)
<1/mo			
Original score	22	97.3 ± 4.4	(84–100)
Retest score	22	90.6 ± 9.8	(71–100)
Difference between scores	22	6.7 ± 9.1	(−8–29)

Values are means ± SD.

TABLE 3
Differences in mean ± SD test scores and failure rates in nurses who had instruction <6 mo before retest compared with those who had instruction >6 mo before retest

	Differences in test scores*			Differences in failure rates†‡			
				Passed		Failed	
Time interval	Mean original score	Difference	Confidence interval	n	%	n	%
<6 mo	98.3	7.49 ± 7.46	6.08, 8.90	95	88	13	12
>6 mo	97.7	4.71 ± 6.14	3.28, 6.44	68	97	2	3

*P < 0.01; †P = 0.03; ‡χ^2 = 4.638.

DISCUSSION

Most MBG in the hospitalized patient is performed by nurses. This is generally true to ensure that results are accurate, precise, and obtained in a timely fashion. Although accuracy and precision could be obtained by laboratory technicians, most bedside tests are obtained in the premeal state (with immediate judgments made about in-

TABLE 4
Differences in mean ± SD test scores and failure rates in nurses who attended class instruction compared with those who had self-instruction in monitoring of blood glucose

Group	Differences in test scores		Differences in failure rates*†			
	Mean original score	Difference	Passed *n*	Passed %	Failed *n*	Failed %
Attended class	97.6 ± 3.9	4.1 ± 5.6	76	96	3	4
Self-instruction	98.2 ± 3.1	8.2 ± 7.6‡	87	88	12	12

*χ^2 = 3.949; †P = 0.047; ‡P = 0.0002.

sulin dose), and thus timeliness of testing is essential. Therefore, nurses will probably continue to be responsible for MBG. Furthermore, there is evidence that not all nurses are performing such tests accurately and that proper training and/or certification may improve the accuracy of performing MBG in the clinical setting (7).

Our data have several implications for such MBG. The data suggest that the nature of initial instruction is an important variable to predict subsequent performance of MBG. The nurses who had classroom instruction had better scores than those who used a self-instruction method. Whether this is a result of clearer instruction, better learning in a group situation, greater commitment to the procedure, or some other variable cannot be ascertained. Second, frequency of performing subsequent MBG at work is not associated with significant change in ability to perform on retests. This conclusion must be modified by the observation that nurses who had self-instruction but performed MBG on a daily basis were not different from the corresponding classroom-taught group, whereas the self-instructed nurses who monitored less frequently consistently scored lower than the corresponding nurses with classroom instruction. Third, there was no significant loss of capability to perform the test over the 8 mo of our study. We do not have information to indicate whether longer intervals between initial instruction and any of the variables studied would predict poorer performance of MBG. We predict that it is highly unlikely that well-trained nurses who perform the test frequently exhibit any deterioration in performance.

Other variables may influence proficiency of MBG performed by nurses. For example, the importance that nurses attach to MBG as part of their patient-care management may be important. Although it is not amenable to statistical analyses, a perception that MBG is important for patients may influence the accuracy of bedside testing.

In our data, we noticed that nurses with better retest scores practiced on units where integration of MGB into patient management was recognized and rewarded. Floors or nursing stations where patients, physicians, and nurses take a particular interest in MBG results may influence nursing performance. Further study is required to determine if commitment to this procedure influences proficiency.

These findings have implications for both quality of performance of MBG and, in turn, quality patient care and cost of education and reeducation for nurses performing MBG. In properly instructed nurses, proficiency probably does not need to be reassessed in the first 8 mo after instruction. The interval between reevaluation and instruction has very practical implications because of the costs of personnel time. Our initial costs for 1000 nurses were conservatively estimated at $24,000. If we assume $20/nurse per retest and 1.8 nurses per active hospital bed, annual retesting would cost approximately $0.10/hospital bed per day. These costs would, of course, be reduced if a longer interval without decreased proficiency can be confirmed. Ongoing assessments of nursing proficiency are under way at CCF to address these questions.

In summary, there are numerous variables that may have an impact on the proficiency of nurses to perform MBG. Of common variables that can be measured, our data demonstrate that the nature of initial instruction may be more important than the frequency of actually performing MBG at work. Furthermore, there is no significant deterioration in performance over periods >6 mo. Further studies are necessary to determine whether significant changes in proficiency occur over longer periods.

ACKNOWLEDGMENTS

We thank The Cleveland Clinic Foundation nursing staff (especially the clinical instructors for help with data collection), Theresa Babiak for assistance with data analysis, Mary Lou Monahan and Sarah Warm of MetroHealth Medical Center for comments on the manuscript, and Sylvia Dodich for help in preparing the manuscript.

REFERENCES

1. American Diabetes Association: Consensus statement: self-monitoring of blood glucose. *Diabetes Care* 10:95–99, 1987
2. American Diabetes Association: Policy statement: self-monitoring of blood glucose. *Diabetes Care* 8:515, 1985
3. Joint Commission Perspectives: *Standards on Decentralized Lab Testing and Approval.* Chicago, IL, Joint Commission on Accreditation of Hospitals, March/April 1989, p. 7–8
4. Belsey R, Morrison JL, Whitlow KJ, Baer DM, Nelson S, Hardwick DF: Managing bedside glucose testing in the hospital. *JAMA* 258:1634–38, 1987
5. Goodine JE, Hurxthal K, Nathan DM: Bedside capillary glucose measurement by staff nurses in a general hospital. *Am J Med* 80:803–806, 1986
6. SAS Institute: *SAS User's Guide: Statistics, Version 5 Edition.* Cary, NC, SAS Inst., 1985
7. Lawrence PA, Dowe MC, Perry EK, Strong S, Samsa GP: Accuracy of nurses in performing capillary blood glucose monitoring. *Diabetes Care* 12:298–301, 1989