

Blood Glucose Awareness Training Delivered Over the Internet

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Objective: Blood Glucose Awareness Training (BGAT), a psycho-educational intervention, trains individuals with type 1 diabetes to: 1) detect/interpret internal cues to better detect extreme BG, e.g. neurogenic and neuroglycopenic symptoms; and 2) interpret external cues to detect current and anticipate future extreme BG, e.g. insulin timing/dose, recent SMBG results. Although outcome studies utilizing BGAT are significant, limitations include requirement of eight weekly meetings, and limited professionals trained to deliver BGAT.

Research Design and Methods: Therefore, BGAT was operationalized for web-based delivery. The Internet allows BGAT delivery to be dynamic, engaging, convenient, and personalized. Using a 2 (BGAThome, N=20 vs. Control, N=20) X 2 (pre-post) design, efficacy was evaluated.

Results: BGAThome was judged as useful and easy to use, completed by 94% of the participants, and resulted in significant clinical improvements ($p < .05$).

Conclusions: The Internet may be an efficient and effective means of delivering diabetes interventions like BGAT.

Thirteen U.S. and European studies have documented the benefits of BGAT (1). These include improvements in detecting and reducing the occurrences of extreme BGs and their sequelae, e.g., reducing occurrence of ketoacidosis, severe hypoglycemia, hypoglycemia-related driving mishaps, and fear of hypoglycemia. We hypothesized that an Internet version of BGAT would be perceived as useful, completed efficiently, and produce greater clinical benefits as compared to a Wait List Control group (WLC).

RESEARCH DESIGN AND METHODS

A notice in *Diabetes Forecast* inviting participants to evaluate BGAThome.com resulted in 210 individuals completing an online screening in 10 days. Participants were the first 40 individuals who, by telephone interviews, met inclusion criteria: type 1 diabetes, routinely measuring BG >2/day, and willing to devote 1-2 hours a week for 8-10 weeks to complete BGAThome. Of 108 responders telephoned, 38 were unreachable, 14 were ineligible, and 10 declined participation (see Table 1).

After signing an IRB-approved informed consent, participants were mailed a hand held computer (HHC) and a LifeScan One-Touch meter and supplies for one month's use. Participants were instructed to: 1) activate the HHC prior to performing routine self monitoring of blood glucose (SMBG), 2) enter an estimate of their current BG, 3) based on this estimate indicate whether at that point they should eat fast acting carbohydrates, engage in vigorous exercise, or drive, and 4) perform SMBG and enter their actual BG. After returning the HHC, participants completed online a demographic questionnaire, the Diabetes Knowledge Scale, and the Hypoglycemia Fear Survey (2). This HHC and

questionnaire data was collected again 12 weeks later, along with Likert-scale items assessing BGAThome's benefits and usability.

Users were given 12 weeks to complete BGAThome's eight units, detailed elsewhere (1). Central to BGAT is completing daily BG Diaries, where participants: 1) record relevant BG information and symptoms, 2) estimate their current BG, 3) receive feedback on their estimate accuracy by performing and recording SMBG, 4) interpret the clinical significance of their accuracy with the Error Grid (2), and 5) anticipate their BG level an hour later. To encourage use of BG Diaries, participants were only given access to the next unit seven days following completion of the previous unit.

With Internet delivery to a heterogeneous sample, different individuals would be expected to pursue BGAT for various reasons. Thus, the primary outcome variable needed to incorporate a variety of possible desired outcomes. Consequently, our Improved Functioning Score (IFS) was a composite score where Assessment-1 dependent variables were converted to Z scores. Assessment 2 performance was converted to Z scores based on Assessment 1's mean and SD. Z scores for each outcome variable were summed, where 0 reflects average baseline functioning for all variables and +1 reflects performance across all variables 1 standard deviation above the sample's baseline mean (3). It incorporated the following variables:

Questionnaires

- Diabetes Knowledge Scale (% correct)
- Hypoglycemic Fear Survey (sum of Worry subscale)

Computer

- % SMBG readings within target range (3.9 -10mmol/L)
- Number of non-detected BG readings <3.9mmol/L

- Overall BG estimation accuracy (Accuracy Index) (4)
- When BG <3.9mmol/L number of Risky Decisions to:
 - Drive
 - Not eat fast-acting carbohydrates
 - Exercise

RESULTS

Two WLC and one BGAThome participants dropped out during the treatment period. Two BGAThome participants dropped out during Assessment-1.

ANOVA demonstrated that BGAThome resulted in greater improvement in IFS, interaction $F(1,33) = 4.20$, $p = .048$ (see Table 1).

On a 1= “Not at all” to 5= “Very” scale, treatment participants rated BGAThome as beneficial, easy to use and enjoyable, respective means \pm standard deviations of 3.8 ± 1.17 , $3.9 \pm .73$ and 3.8 ± 1.04 .

On average, participants completed BGAThome in 11 weeks, logged onto BGAThome.com 30.4 ± 16.51 times, and spent 26.4 ± 16.3 minutes on each unit. These measures of utilization indicate trends toward a relationship between more website use and increased benefits: More time spent on units was associated with greater IFS improvement ($r = -.36$, $p = .10$). More frequent log-ons were associated with greater improvement in knowledge ($r = .49$, $p = .03$) and fewer BGs < 50 mg/dl ($r = -.54$, $p = .02$). Age was not correlated with IFS improvement; however, education trended to be associated with improved IFS ($r = .45$, $p = .07$).

CONCLUSIONS

BGAThome was found to be beneficial, easy to use and enjoyable. This is the first time BGAT was made available to individuals with different goals, needs, diabetes regimens, and resources. Despite this heterogeneity, BGAThome improved performance summed

across all eight dependent variables an average of 2.37 standard deviations.

Greater BGAThome use appeared to yield improved benefits. Engagement might be further enhanced by: 1) incorporating a chat room where users share experiences and support, 2) employing a group context, led by a diabetes educator (5), 3) undergoing an initial motivational interview (6), 4) fiscally investing in training, and 5) having a pressing personal goal, such as achieving tight metabolic control because of pregnancy without increasing risk of severe hypoglycemia (7) or following a costly hypoglycemia-related driving mishap.

While our final participant sample came from 35 different US cities and 21 different states, allowing greater external validity, the sample size and its demographic composition (white, middle aged, educated individuals) was a limitation of this study. A larger, more representative sample would also allow investigation into the role of socioeconomic status, race and education.

Nevertheless, this study indicates the possible benefits of disseminating BGAThome over the Internet, in a personalized and self-directed format, serving a large number of individuals in a cost-effective manner.

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Table 1. Demographics of participants in the Waiting List Control and the BGAThome groups

Variables	Waiting List Control Group	BGAThome.com Group	Comparison p level
Demographics			
Sample size	18	17	
Age, Mean \pm SD years	52.7 \pm 13.96	43.7 \pm 14.06	$F(1,33) = 3.79, p < .07$
Sex, % female	56%	59%	$\chi^2 = .04, p < .85$
Race (% White)	100%	100%	
Years of Ed.	15.3 \pm 1.71	16.1 \pm 1.93	$F(1,33) = 1.86, p < .19$
Married	78%	71%	$\chi^2 = 1.13, p < .57$
Age at diagnosis	26.3 \pm 16.24	18.9 \pm 8.86	$F(1,33) = 2.79, p < .11$
Height (in)	66.6 \pm 13.73	67.6 \pm 4.15	$F(1,33) = .54, p < .47$
Weight (lbs)	163.2 \pm 30.99	178.3 \pm 47.32	$F(1,33) = 1.26, p < .28$
Dependent variables pre to post treatment			
% Decisions to eat fast acting carbohydrates when BG is \geq 3.9 mmol/L.	35 (25.4) to 25 (30.7)	36 (25.0) to 45 (30.9)	$F(1,24)= 3.73, p < .07$
% Decisions not to Drive when BG is $<$ 3.9 mmol/L.	57 (28.2) to 52 (36.5)	45 (32.6) to 59 (34.1)	$F(1,24)= 2.46, p = .13$
IFS	.46 (3.8) to .60 (4.0)	-.49 (4.0) to 1.87 (4.1)	$F(1,33) = 4.20, p < .05$