Hormones (2020) 19:215–222
https://doi.org/10.1007/s42000-020-00187-w

ORIGINAL ARTICLE

Relaxation training significantly reduced blood glucose levels in patients with type 1 diabetes mellitus

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Received: 30 May 2019 / Accepted: 10 March 2020 / Published online: 1 April 2020

Abstract

Purpose/Objective The present study was designed to test whether adding a relaxation training technique to the medical treatment of patients with type 1 diabetes mellitus could, adjusting for the non-specific factors of therapy, lead to an improvement in the patients' condition.

Method Forty-six participants were randomly allocated either to an experimental (intervention) group, receiving weekly sessions of relaxation training, or to a control group (placebo) receiving weekly blood circulation training exercises. Measures included the State and Trait Anxiety Inventory, blood glucose levels, high-density lipoprotein levels, cholesterol levels, body weight, HbA1c levels, the Mood Adjective Checklist (MACL), a diary checklist, and urine glucose levels. Assessment of psychological and physiological parameters was conducted before and upon completion of the intervention (8 weeks).

Results Trait anxiety and the main metabolic measurement of blood glucose levels and HbA1C revealed significant differences over time, predominantly among patients in the intervention group.

Conclusions Relaxation techniques as an adjunct to medical treatment are a useful tool for patients with type 1 diabetes mellitus.

Keywords Type 1 diabetes mellitus · Stress management · Relaxation training · Intervention group · Placebo group

Introduction

The 2016 global report by the World Health Organization (WHO) [1] stressed the need for cost-effective methods for controlling all types of diabetes. Self-management techniques have been used for many years in medical and mental health settings as additional tools for managing diabetes [2]. Both systematic reviews [2–5] and independent studies by Koloverou, Tentolouris, Bakoula, Darviri, and Chrousos [6] show that time-limited interventions, such as cognitive behavioral therapy (CBT), counseling techniques, and relaxation and meditation techniques, have been widely employed as cost-effective strategies for improving glycemic control and adherence in patients with type 1 and type 2 diabetes mellitus.

For the past five decades, evidence has been accumulating of the link between stress and blood glucose regulation among individuals with both types of diabetes [7]. Therefore, behavioral intervention techniques that help in managing stress may contribute significantly to diabetes regulation.

From a physiological perspective, regulation of autonomic nervous system activity via relaxation techniques can potentially contribute to medical management of diabetes, a mechanism suggested by Surwit and Feinglos as early as in 1984 [8]. Converging evidence has demonstrated decreases in blood glucose levels of patients with diabetes as a result of hypnotically induced suggestions coupled with relaxation exercises. Specifically, an early study, which has been attributed to Bauch (1935–1936), comprised perhaps the first experimental use of relaxation techniques for the control of diabetes symptoms. The clinical trial results were later summarized by

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Daniels [9], followed by further elaboration included in the studies of Vandenbergh et al. [10], Luthe and Schultz [11], Seeburg and DeBoer [12], and Koehler [13].

The idea that relaxation training may contribute to the medical management of both types of diabetes has been supported by various studies [8, 14–18]. It merits noting that the latter authors have suggested that stress is a potential contributor to chronic hyperglycemia, albeit its exact role is still unclear. A seminal study by Cerpa [19] in patients with type 2 diabetes employed three different groups: (i) patients using relaxation, (ii) patients in a diabetes education program, and (iii) a control group. The results showed that the relaxation group patients exhibited significant reductions in their blood glucose levels; however, participants' State and Trait Anxiety scores remained relatively constant for all three groups. Furthermore, systematic reviews and a meta-analysis of 29 randomized control trials (RCTs) on the effectiveness of psychological interventions in children, adolescents, and adults with type 1 diabetes mellitus indicated that those who had received psychological intervention (most studies examined variants of CBT) had significant reductions in their glycated hemoglobin levels as well as in their distress levels as compared to the control groups [2, 20]. Other systematic reviews have further confirmed the beneficial effect of psychological interventions, especially in terms of improvement in depression scores and self-management techniques on quality of life [2, 5].

The majority of studies investigating the effectiveness of stress management techniques among patients with type 1 diabetes mellitus have primarily employed an intervention and a control group. On the other hand, control groups were usually waiting list control groups and, therefore, non-specific factors of therapy may have emphasized the superiority of stress management techniques over control conditions. Non-specific factors refer to aspects of psychosocial intervention that elicit change but are not contingent on a particular theoretical framework, including the therapeutic alliance and patients' expectations of treatment [21]. According to this reasoning, earlier studies may not have adequately controlled for the influence of non-specific factors.

Building upon our previous work [22], which has corroborated the effectiveness of a relaxation training intervention over a waiting list control condition, the present study aimed to examine the added benefit of a relaxation training intervention over a placebo condition that would control for the non-specific factors of therapy with respect to anxiety levels and glycemic control.

Considering the above, we expected that patients in the intervention group would exhibit lower levels of anxiety and improvement in their glycemic control as measured by the State and Trait Anxiety Inventory, HbA1c, and blood glucose levels across time as compared to the placebo group. To this end, in order to overcome the limitations of the existing methodologies pertaining to the control condition, participants of the placebo group in our study received the same amount of attention from the researcher and shared similar expectations of treatment as compared to participants of the intervention group.

Method

Participants

The study took place at the outpatient diabetic clinic of the General Hospital of Athens, Evangelismos-Polikliniki, in Athens, Greece. Permission for this research was granted by the scientific board of the hospital.

To be included in the study, participants had to be between 18 and 60 years old, fluent in Greek, and diagnosed with type 1 diabetes mellitus at least 1 year prior to the study. Participants with pre-existing medical conditions and/or illiteracy were excluded. In particular, exclusion criteria included the presence of renal, cardiac, and retinal problems, or pregnancy. Congruent with this, four patients were excluded and two patients dropped out at the beginning of the study (between the 1st and 2nd week of individual meetings). It is noteworthy that during the 8-week intervention, none of the subjects dropped out.

The 48 final participants were randomly allocated to two groups. A simple randomization procedure was used, i.e., patients entering the office in an odd sequence were assigned to the intervention group and those in an even sequence to the placebo group.

Twenty-four type 1 insulin-dependent patients took part in the intervention group and 22 in the placebo group. The average duration of illness was 5 years. Twenty-one female and 25 male patients aged from 20 to 60 years ($x = 35.5$, $sd = 9.7$) were participants in this research.

The clinic was held daily and patients who had appointments for that day would be given a cover letter, with background information on diabetes and information about the study, by their physician. If patients expressed interest in learning more about the study, a nurse took them into a separate room where the researcher elaborated on the study. Those patients who agreed to participate were given appointments for their first session.

Details about participants' recruitment, treatment, allocation, and drop-out are depicted in the flow diagram in Fig. 1.

Training techniques

Intervention group Relaxation muscle training and deep breathing exercises based on Jacobson's progressive muscle relaxation technique [23] were taught by the researcher to the participants of the intervention group. Eight 20-min (approx.)

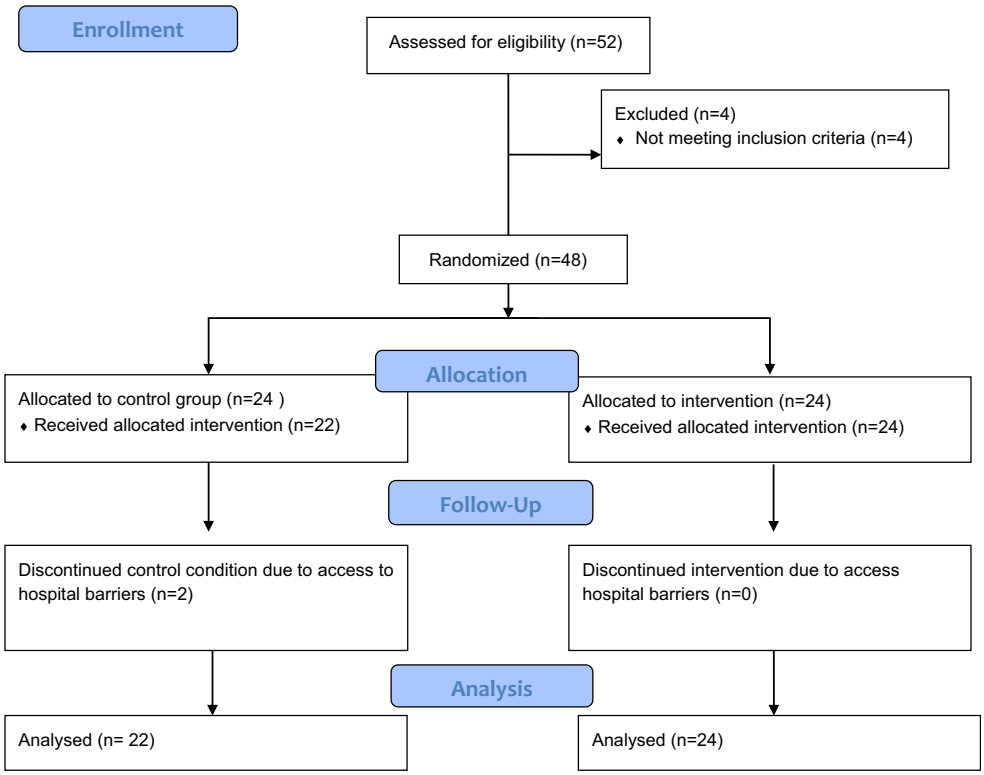

Fig. 1 Flow chart of participants' recruitment, treatment, and allocation

individual sessions, including 3–4-min diaphragmatic breathing followed by progressive muscle tension and relaxation exercises, were administered. The sessions were held weekly for 8 consecutive weeks and were conducted in the hospital while patients were lying on a bed in a separate room. The aim of the described training was to teach patients to use it as part of their daily routine, at home, at work, or whenever required. Patients were strongly encouraged to practice relaxation exercises daily at home throughout the 8-week period.

Placebo group Blood circulation exercises (BCE) were taught by the researcher to the participants of the placebo group. These are standardized ~~e~~xercises administered to most European diabetic clinics by pharmaceutical companies in the form of leaflets or posters in order to help increase the blood flow in the hands, arms, and legs. BCE included 12 different exercises for lower leg and heels (for example: "Get up on your toes and heels ten times"–counting 1 to 10) and four different exercises for hands and arms (for example: "Grab a soft ball with your hands, try to work the ball first in your right hand and then in your left–counting 1 to 10 for each hand"). Individual training sessions included 3–4-min diaphragmatic breathing followed by 15 min of BCE. They also took place in a separate room and were conducted individually. Sessions were held weekly for 8 consecutive weeks. The aim of the above training was to help patients to use BCE as part of their daily routine care of the lower limbs. They were strongly encouraged to practice BCE daily at home, throughout the 8-week period.

Both relaxation training exercises and blood circulation exercises were taped for each patient individually so as to help them practice daily at home. Daily practice was routinely recorded on the "Daily Diary Check List".

All sessions, corresponding to the two conditions (experimental and control/placebo), were delivered by the same therapist so that any treatment effect could be attributed to the relaxation intervention solely and not to the therapeutic capabilities of different researchers/psychologists.

Outcome measures of the trial

The following measurements were administered to both the intervention and the placebo groups pre- and post-treatment:

a. Psychological: The State and Trait Anxiety Inventory (STAI) [24, 25] is a psychological inventory based on a 4-point Likert scale and consists of 40 questions on a self-report basis. STAI measures two types of anxiety, state anxiety or anxiety about an event, and trait anxiety or anxiety level as a personal characteristic, and its main purpose is to assess different types of anxiety. STAI consists of two separate self-report scales for measuring state and trait anxiety. Higher scores are positively correlated

with higher levels of anxiety. Both scales consist of 20 test items.

b. Metabolic: Blood glucose levels (fasting plasma glucose), high-density lipoprotein, cholesterol levels, body weight, and glycosylated hemoglobin (HbA1c), which reflects glycemic exposure in the previous 8–12 weeks.

Treatment adherence

To ensure that participants, in both the intervention and the BCE groups, adhered to the treatment protocol (content of the intervention and control condition), the following instruments were used to monitor their degree of adherence:

Daily/weekly measurements

a. The Mood Adjective Check List (MACL) was developed and validated by Nowlis and Green [26]. Factor analysis of the scale revealed 12 hypothetical dimensions of mood. Mood scores and changes in mood score were studied in relation to environmental and psychological features, such as stressful motion picture films and communications, examinations, other films, social isolation, amount and quality of sleep, temperament traits, and sex differences. In the present study, it consisted of 33 adjectives describing mood feelings in the form of a checklist. Participants had to rate the particular list three times per week at home.
b. Daily Diary Check List. This checklist was answered daily by all participants at home. The list was created by the researcher and it consisted of eight self-rating scales. These are designed in order for the patient to check his/her daily goals and assess factors like personal feelings, diet compliance, practice of the training exercises with the use of a tape, (i.e., relaxation training for the intervention group and blood glucose exercises for the placebo group), and sleeping habits. This is also a valuable tool for the researcher to get feedback on the above checklist weekly, and to be able to assess the adherence of each patient to his daily and weekly goals (during the 8-week period).

Procedure

All patients received information about the purpose of the study and signed a written consent form individually. Upon discharge from the program, for ethical reasons, participants in the placebo group were given the opportunity to enter a new relaxation training program and patients in the intervention group to attend the blood circulation exercises sessions; however, these data were not taken into consideration in the present report. Relaxation exercises were delivered individually to all participants by the researcher in the intervention group, while blood circulation exercises were also delivered individually to all participants in the placebo group. To help patients of both groups apply the exercises at home, taped exercises were given to each participant for daily application. The researcher spent 1 h with each individual per week over a period of 8 weeks. The MACL was filled in weekly and the Daily Diary Check List was filled in daily at home by each patient. Participants in both groups continued their regular medical treatment during the study period.

Statistical analysis

A probability value of 5% was considered as statistically significant. The SPSS v. 20.0 Statistical Package was used for the analysis of the present data (SPSS Inc., Chicago, Il, USA).

A 2 × 2 mixed analysis of variance (ANOVA) was performed in order to investigate differences between the two groups with regard to physiological and psychological variables over time.

The multivariate analysis of variance investigated the significance of interaction and main effects for group (intervention vs. placebo) and time factor (pre- vs. post-treatment). The baseline differences for each of the dependent variables were assessed before the analysis to test for any group differences prior to treatment. To this end, the *t* test for independent samples was employed.

Results

Participants of both groups did not display any statistically significant differences in their baseline measures, as shown in Table 1, confirming the efficacy of the randomization procedure for the evaluation of the treatment.

Table 2 presents the descriptive statistics (means and standard deviations) as concerns the four main outcomes of the study: State Anxiety, Trait Anxiety, HbA1C, and blood glucose levels. The statistical significance of these findings derived from the ANOVAs is presented in Table 3 for reasons of clarity (they include the main effects of group allocation and timing as well as an interaction term).

As shown in Table 3, State anxiety levels were substantially reduced in both groups throughout the study period, revealing a statistically significant effect of time: $p < 0.001$. By contrast, the interaction term was not found to reach statistical significance, indicating that the intervention group did not confer an additional benefit to the control group: $p > 0.05$.

Regarding, Trait Anxiety levels, a 2 × 2 mixed ANOVA showed non-significant main effects for group (control vs. placebo) nor for time (pre-intervention vs. post-intervention); however, it showed a significant interaction term, taking the form of a cross-over interaction. In particular, there was an increase in trait anxiety levels at post-measurement for the

Table 1 Baseline differences between the intervention and placebo groups

	Experimental group Mean (s.d.)	Placebo group Mean (s.d.)	*p* value[†]
Body weight	67.5 (11.4)	71.9 (9.62)	0.913
HDL (%)	1.32 (0.36)	1.29 (0.38)	0.788
Cholesterol (mmol/l)	5.2 (1)	5 (0.9)	0.104
Blood glucose levels (mmol/l)	12.6 (6.1)	11.5 (5.5)	0.494
HbA1C (%)	10.4 (1.8)	9.3 (1.5)	0.323
State Anxiety	41.2 (9.6)	39.5 (6)	0.451
Trait Anxiety	42.4 (10)	40 (7.2)	0.112

[†] *t* test for independent samples was performed

control group and a concomitant decrease in trait anxiety for the intervention group. Hence, the statistically significant interaction term may be ascribed both to the improvement in the intervention group as well as to the exacerbation in the control condition.

A similar pattern of results was observed for HbA1c. There was no group or time main effect. The statistically significant interaction term, $p < 0.01$, suggests that there was no overall effect of either intervention or time, but there was a crossover interaction. The effect of time on the dependent variable is opposite, depending on the type of treatment. Thus, the statistically significant interaction term corresponds to both improvement in the experimental condition and exacerbation in the control condition. Post-hoc analysis revealed that the improvement in the intervention group was marginally statistically significant (mean diff = − 1.3, $p = 0.058$).

Concerning blood glucose levels, 2 × 2 mixed ANOVA revealed a statistically non-significant result with respect to the main effects of group allocation and time. Nonetheless, the statistically significant interaction term, $p < 0.01$, indicates that the rate of improvement of blood glucose levels was different between the two groups at the two time points.

ANOVAs/ANOVA revealed non-significant results for high-density lipoprotein, cholesterol levels, and body weight.

Table 2 Descriptive statistics results of the mixed ANOVA for the outcomes of the study: State and Trait Anxiety subscales, HbA1C (%), and blood glucose levels (mg %) for the intervention/placebo groups over time

	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Within group change scores (post-pre) Mean diff. (95% C.I.)
State Anxiety			
Intervention group	41.2 (9.6)	34.4 (8)	–
Control group	39.5 (6)	35.5 (8.9)	–
Between group change of scores (control-intervention) (Mean diff. (95% C.I.)	–	–	
Trait Anxiety			
Intervention group	42.4 (10)	38.8 (9.2)	− 3.6 (− 10.29, 3.09)
Control group	40 (7.2)	41 (8.6)	1.00 (− 5.98, 7.99)
	− 2.4 (− 9.24, 4.44)	2.2 (− 4.64, 9.04)	
HbA1C			
Intervention group	10.4 (1.8)	9.1 (1.61)	− 1.3 (− 2.63, 0.03)[1]
Control group	9.3 (1.5)	10.4 (2.1)	1.1 (− 0.29, 2.49)
Between group change of scores (control-intervention) (mean diff. (95% C.I.)	− 1.1 (− 2.46, 0.26)	1.3 (− 0.06, 2.66)	
Blood glucose levels			
Intervention group	12.6 (6.1)	10 (5)	− 2.6 (− 6.58, 1,38)
Control group	11.5 (5.5)	11.4 (4.2)	− 0.1 (− 4.25, 4.05)
Between group change of scores (control-intervention) (mean diff. (95% C.I.)	− 1.1 (− 5.17, 2.97)	1.4 (− 2.67, 5.47)	

Post hoc comparisons were not computed if the interaction was not statistically significant, [1] marginally statistically significant at $p < 0.1$

Table 3 Statistically significance testing results of the mixed ANOVA analysis for the main outcomes of the study: State Anxiety, Trait Anxiety, Hb1A1C (5) and blood glucose levels (mg%)

	F	*p* value
State Anxiety		
Group[1] (between-subjects factor)	0.12	0.731
Time[2] (within-subjects factor)	14.5	$p < 0.001$
Group[1] × time[2] interaction effect	2.8	0.101
Trait Anxiety		
Group[1] (between-subjects factor)	.21	0.649
Time[2] (within-subjects factor)	3.33	0.075
Group[1] × time[2] interaction effect	13.76	$p < 0.001$
HbA1C		
Group[1] (between-subjects factor)	0.73	0.398
Time[2] (within-subjects factor)	0.19	0.665
Group[1] × time[2] interaction effect	11.94	$p < 0.001$
Blood glucose levels		
Group[1] (between-subjects factor)	0.09	0.766
Time[2] (within-subjects factor)	2.48	0.122
Group[1] × time[2] interaction effect	4.24	0.045

[1] Reference category = control group, [2] Reference category = post intervention

Discussion

The experience of a chronic physical disorder such as diabetes may produce daily stress for the patient who has to cope with self-monitoring tasks (such as obtaining good glucose levels), diet regulation, and exercise in order to reduce the risk of any future complications. The present study was designed to examine one method of alleviating this continuous level of heightened anxiety and also to help patients improve their psychological well-being via a self-management technique, namely, relaxation training. The findings of this study strongly suggest that relaxation training can improve the emotional and metabolic control of patients with type 1 diabetes mellitus as compared to a placebo group, and are in agreement with findings from other studies [2, 5, 6, 8, 14–18, 22]. The present study encompassed a relaxation training intervention aiming to help patients with diabetes mellitus (1) to identify everyday life stresses, which seem to account for raised blood glucose levels, and (2) to help them use relaxation training as an additional tool in their daily routine and as part of a based setting intervention (i.e., for use at home and work) in order to improve their overall psychological control, and (3) to help them learn by using the above information to cope more effectively with diabetes regulation. Thus, this study describes the effectiveness of an intervention that controls for the non-specific factors of therapy (i.e., patient expectations and time spent with the therapist), as opposed to a placebo intervention.

One of the main hypotheses of this study was that both State and Trait Anxiety scores would decrease over time for the intervention group participants. The present findings, in relation to the State Anxiety scale, showed that participants in both groups significantly lowered their State Anxiety scores over time. This suggests that the equal amount of time spent with all participants weekly by the researcher and the feedback received during individual sessions could have contributed to this result. It may also be the case that participants in the BCE group, by practicing daily blood circulation exercises and monitoring progress via the Daily Diary Check List for a 2-month period, felt more at ease and in better control of their daily diabetic self-management tasks and thus less anxious. The latter finding substantiates the claim that non-specific factors in previous trials incorporating waiting list controls may have explained the improvements discerned in the intervention groups rather than the intervention per se [i.e., 14–18, 22].

On the other hand, the results of the Trait Anxiety scale suggest that, over time, there was a significant difference in both groups; however, the mean values suggest that participants in the intervention group had lower scores than those of the placebo group. The changes over time in trait scores could be attributed to the intervention itself, since it is expected that relaxation training would have an impact, while blood circulation exercises are non-specific to anxiety reduction. According to this reasoning, relaxation training interventions are capable of reducing the more chronic and enduring types of anxiety.

Our second hypothesis was that our metabolic parameters would have a positive change over time for the participants in the intervention group while remaining stable or increasing for the placebo group. As far as HbA1c is concerned, the results seem to show a significant interaction effect between group and time. Participants in the intervention had lower HbA1c levels in their post-treatment values as compared with those of the placebo group, which seems to concur with the findings of Cerpa [19]. It merits noting that in the placebo group there was a slight increase in HbA1c levels. This is understandable, as one may expect slight variations in HbA1C measurements over time. This difference was not found to reach statistically significant levels, as implied by the non-statistically significant finding of the time effect in mixed ANOVA (see Table 3). Therefore, the difference discerned in the placebo group may be attributed to chance.

In addition, post-treatment results for blood glucose levels showed a significant interaction between group and time for the intervention group only, and this seems to be in agreement with previous results [2].

The present findings indicate that the interaction of groups over time led to some significant changes in relation to the above parameters. It seems that relaxation exercises may help decrease trait anxiety levels over time and significantly

improve some metabolic parameters, such as HbA1c and blood glucose levels. Moreover, it is important to mention that the non-specific factors, including "attention" provided by the researcher to participants of both groups and treatment expectations, may have played an important role with regard to State Anxiety scores in both groups. Taken together, the results pertaining to State and Trait Anxiety scores, as well as the metabolic parameters, indicate that both conditions could make participants feel less anxious temporarily (state anxiety), but only the relaxation techniques enabled them to handle chronic anxiety (trait anxiety). Thus, it may be argued that better glycemic control may be induced primarily by reducing chronic anxiety.

Furthermore, relaxation training served as a self-management technique and an additional resource that had a lasting and enduring effect for most of the participants in the intervention group. This point was further substantiated by anecdotal reports during the weeks following the study, in which patients managed to effectively apply the relaxation response (learned during their 8-week program) to other stressful situations in their daily life, and especially to diabetes-related self-management tasks, such as monitoring glucose frequently and following medication and meal plans. This is also supported by other authors [5], who argue that self-management techniques, and relaxation training exercises in particular [27], delivered to patients with diabetes mellitus have a substantial effect on the management of diabetes and thus improve quality of life.

An important limitation, however, related to the present study is that emphasis was given to group changes rather than individual differentiations. Therefore, important information on individual variability was not available. Another limitation pertains to the technique of randomization, which may have introduced investigator bias, as treatment allocation was based on the random sequence of patients' entrance into the research room. The absence of statistically significant differences between the two groups at baseline lends support to the success of randomization; however, computer-generated random numbers should have been employed instead. Also, longitudinal studies with follow-ups at 12 and 18 months were not performed: these are necessary in order to explore medium- and long-term benefits of relaxation training and to develop an effective assessment tool for monitoring stress levels in routine clinical practice. Furthermore, larger sample sizes could have provided additional strength to the current findings. In addition, current studies are insufficient, and more studies are required to clarify which psychological interventions and treatment components improve the psychological health of patients with diabetes. Additionally, a further study recruiting larger sample sizes may have shed light on the clinical, socioeconomic, and psychological profile of patients with type 1 diabetes mellitus who respond better or worse to the relaxation training intervention. To this end, more information on the socioeconomic and psychological background of participants would be needed.

The findings of this study could serve as an additional tool to encourage medical professionals and health care providers to study and utilize relaxation techniques as adjuncts to the medical treatment of diabetes or as part of psychoeducation or self-management education programs designed to help patients with type 1 diabetes mellitus. Furthermore, by integrating an adequate control group and by exploring the effectiveness of interventions in routine clinical practice rather than in laboratory conditions, the present study adds to the existing evidence further substantiating that cost-effective interventions such as relaxation training administered to patients with type 1 diabetes could help them gain better control over their illness.

Acknowledgments STAI-AD copyrighted 1968, 1977 Charles D. Spielberger. All Rights Reserved. Permission for use of Greek translation received from the Publisher Mind Garden, Inc., www.mindgarden.com.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in the study involving human participants were in accordance with the ethical standards (Reference no. 239) of the research and scientific committee of Polikliniki, General Hospital in Athens, Greece and in accordance with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all patients included in the study.

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