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Effect of device-guided breathing exercises on blood pressure in hypertensive patients with type 2 diabetes mellitus: a randomized controlled trial

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Objective In patients with type 2 diabetes mellitus (DM2), it is hard to reach treatment objectives for blood pressure (BP) with classical treatment options. Recently, reducing breathing frequency has been advocated as a method to reduce BP. We examined if an electronic device such as Resperate, by reducing breathing frequency, would lead to BP reduction in a population of patients with DM2 and hypertension. Our secondary objective was to study the effect of this device on quality of life (QOL).

Methods A randomized, single-blind, controlled trial was conducted over a period of 8 weeks to evaluate the effect of this therapy on BP and QOL. The control group listened to music and used no other therapeutic device. BP and QOL changes were studied in 30 patients with DM2 and hypertension.

Results There was no significant difference in change in BP between groups; −7.5 [95% confidence interval (CI) −12.7, −2.3]/−1.0 (95% CI −5.5, 3.6) mmHg in the intervention group and −12.2 (95% CI −17.4, −7.0)/−5.5 (95% CI −9.7, −1.4) mmHg in the control group. Whether or not the target breathing frequency of 10 breaths/min was reached did not affect BP. There were no significant changes in QOL.

Conclusions The effects of Resperate on BP and QOL were not significantly different from those found in the control group. Furthermore, 40% of patients did not reach the target breathing frequency, making this device less suitable for clinical practice in patients with DM2. *J Hypertens* 25:241–246 © 2007 Lippincott Williams & Wilkins.

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Introduction

Diabetes mellitus type 2 (DM2) and hypertension commonly occur together, with a higher prevalence of hypertension in patients with DM2 than in the general population [1]. Prevalence of hypertension in diabetes patients was 39% in the Hypertension in Diabetes Study (HDS) [1]. In The Netherlands a prevalence of hypertension in the general population (20–70 years) of 27% for men and 22% for women was found (this percentage includes persons taking antihypertensive drugs) [2].

The United Kingdom Prospective Diabetes Study (UKPDS) showed that tight blood pressure (BP) control in patients with hypertension and DM2 results in a clinically important reduction of morbidity and mortality [3]. Both DM2 and hypertension have a negative impact on quality of life (QOL) [4].

Standard treatments of hypertension consist of a combination of pharmacological and non-pharmacological regimens. The UKPDS showed that in patients with DM2 two or more antihypertensive drugs are often required to attain BP goals [3]. Recently, a new non-pharmacological treatment has been proposed, consisting of breathing exercises guided by an electronic device; the Resperate (InterCure Ltd, Lod, Israel) [5]. The exercises are said to be successful if breathing frequency is less than 10 breaths/min at the end of the exercise. Exercises should be done daily for 10–15 min [5–9]. The rationale behind this therapy is that slow and regular breathing increases the baroreflex sensitivity, which can reduce autonomic imbalance. Autonomic imbalance is thought to be an important factor in the development of hypertension [10].

Studies with this device done so far report a significant reduction in BP after 8 weeks in hypertensive patients with or without the addition of antihypertensive drugs [5–9,11]. These studies had either no active control group or a control group that listened to music through a Walkman. Diabetes mellitus was an exclusion criterion in three studies [5,7,8].

The objective of the present study was to evaluate the efficacy of this non-pharmacological therapy by comparing its effects to the effects of listening to music with a Discman on BP and QOL in a population of patients with DM2 and moderate controlled BP.

Methods
Participants
Patients were recruited from the outpatient clinic of the Isala Clinics in Zwolle, The Netherlands. Eligibility criteria were: age over 18 years, diagnosis of DM2 more than 2 years ago, use of at least one antihypertensive drug without changes in the past 3 months, a systolic BP between 130 and 170 mmHg over the previous 6 months, and a systolic BP between 140 and 160 mmHg at the first study visit. Exclusion criteria were hospitalization in the past 3 months, deafness, blindness and cognitive abilities deemed insufficient for operation of a study device.

A letter containing information about the study and an invitation to participate was sent to 83 patients. Based on this information, 31 patients refused participation and 52 patients agreed to a first study visit. At this visit, 20 patients did not meet the BP inclusion criteria, one patient was excluded because of not taking any antihypertensive drugs at the time of the study visit, and another patient refused participation at the first visit. Thirty patients met all the criteria and entered the study. All patients gave informed consent. The study was approved by the Medical Ethics Committee of the Isala Clinics. Recruitment took place in the first half of 2005, with the starting point of the study being the date of recruitment.

Outcome measures, randomization and study design
The primary outcome measures were change in office and home BP. The secondary outcome measure was change in QOL.

Randomization was done using sealed non-transparent envelopes, which contained an 'I' or 'C', indicating the intervention and control group, respectively. Randomization took place prior to the first visit.

There were two study groups. The intervention group used the breathing device and the control group used a Discman with various kinds of random music. All patients were informed that the objective of the study was to compare different types of music therapy. In addition, patients in the intervention group were informed about the possible effect of slow breathing guided by music. None of the patients were informed about the treatment in the other study group. All data were entered in a database in duplicate by an independent third party, to minimize typing errors.

Patients visited the clinic twice. During the first visit patients were seen by the investigator for baseline measurements including BP, heart rate, height and weight (without coat and shoes), smoking status and QOL. The trial was explained to them, and all instructions were given both verbally and in writing. The patients were instructed in the use of the BP device and the breathing device or the Discman. Patients were asked to do the exercise every day for 56 days at approximately the same time and to measure their BP four times daily; twice within 5 min prior to and twice within 5 min following the exercise. The second visit to the clinic was 8 weeks after the initial visit. Patients were seen by the same investigator. Clinical measurements were again taken and the QOL questionnaire was filled out. Furthermore, questions about knowledge of other study participants or the other study group were asked, to test blinding. Data of the daily home BP and heart rate measurements, which had been written down by each patient in a study diary, were collected from the patients. Compliance with interventions was checked using the ratio between the actual number of treatment sessions performed and the requested number of sessions.

Blood pressure measurement
BP was measured both in the clinic and at home according to the Guidelines of the Dutch Institute for Healthcare Improvement (CBO) using an Omron M5-I (HEM-757; CEMEX Medical Technics, Nieuwegein, The Netherlands) automatic BP device [12,13]. Use of an automatic device prevents observer bias. Before BP measurement during the first study visit, the circumference of the upper arm was measured. When the circumference was 22–32 cm, the standard cuff (12 × 21.5 cm) was used. The large cuff (15 × 29.5 cm) was used when the circumference was between 32 and 42 cm. The measurements were done with the patient in a sitting position, after he or she had been sitting for a minimum of 5 min, with the cuff at heart level and the volar side of the lower arm resting on the desk. The cuff was applied to the bare arm 1–2 cm above the elbow fold. Any tight clothing was removed from the upper arm. The patient was asked to sit still, not to move the arm, and not to speak during measurement. The time between successive measurements was at least 15 s. Initially, the BP was measured twice on each arm. The mean of the two readings for the left arm was compared with the mean of the two readings for the right arm. When there was a difference of >10 mmHg of the systolic and/or diastolic BP between the two arms, future measurements were done on the arm with the higher BP. When the difference was less, an arbitrary arm was taken for all next measurements. For all analyses the mean of the two consecutive measurements was used.

Quality of life measurement
Patients filled out a QOL questionnaire containing the Dutch versions of the 12-item Short Form Health Survey (SF-12), the Problem Areas in Diabetes Scale (PAID) and

the WHO five-item Wellbeing Index (WHO-5) [14–18]. The SF-12 is a generic measure of health-related QOL. It is a reliable and validated short version of the SF-36 [14,15]. A physical component score (PCS) and a mental component score (MCS) can be calculated, with higher values representing better QOL (norm-based scores are standardized to a mean of 50 and standard deviation of 10). The PAID is a diabetes-specific 20-item questionnaire to score diabetes-related emotional distress. It is scored on a scale of 0 to 100, with higher scores indicating greater emotional distress. Reliability and validity are good for both the US and Dutch situations [16,17]. The WHO-5 measures psychological well-being in the general population. It has a score ranging from 0 to 100, with 0 representing worst possible and 100 representing best possible quality of life [18].

Statistical analysis

Statistical analyses were carried out using SPSS version 12.0.1 (SPSS Inc., Chicago, Illinois, USA). A significance level of 5% was used. As appropriate, parametric (Student's *t*) and non-parametric (Mann–Whitney U) tests were used to compare outcome measures between groups. The chi-squared test was applied for categorical variables. Baseline values and end-of-treatment values for home measurements of BP and heart rate were calculated by averaging the pre-exercise data of the first week (baseline) and the last week (end of treatment). Furthermore, change of home BP measurements over time was estimated by the linear regression coefficient for each patient and differences in mean regression coefficients between groups were tested using Student's *t* tests.

Analyses were by intention-to-treat principle. An additional intra-group analysis of the data was carried out to compare office BP of the patients who succeeded in achieving the target breathing rate (< 10 breaths/min) with those who did not.

The sample size required to detect an absolute reduction of 10 mmHg in systolic BP during the 8-week study with a power of 95%, and alpha 5% (two-tailed), was 28 (14 in the intervention group and 14 in the control group). This calculation was based on the mean systolic BP of patients with a systolic BP between 140 and 160 mmHg in our clinic being 148.3 ± 6.9 mmHg.

The report was written based on the 'Consolidation of the standards of reporting trials' (CONSORT) [19].

Results

Figure 1 shows the number of participants involved throughout the trial. Baseline characteristics of the patient population (*n* = 30) are listed in Table 1. These characteristics are comparable between the groups; there were more men in the control group (10 versus three in the intervention group).

Fig. 1
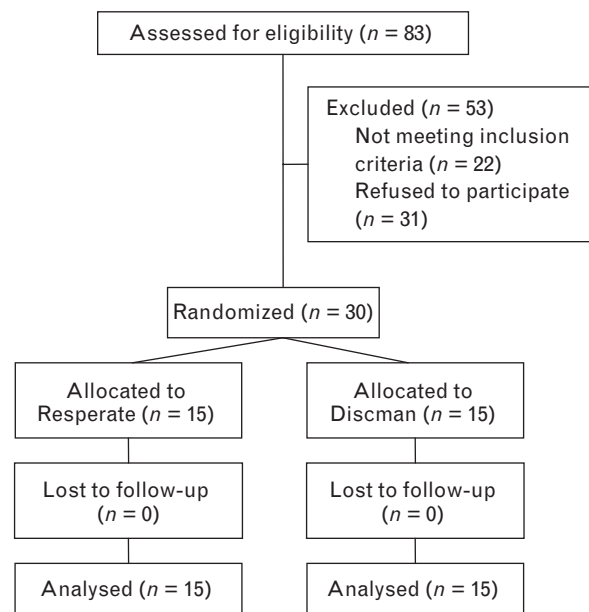
CONSORT flow diagram, reproduced from [19]. Number of participants in stages of the trial.

Blood pressure

Office systolic BP was significantly reduced at the end of the study in both the intervention and the control group [intervention, from 153.5 to 146.0 mmHg (*P* = 0.008); control, from 150.4 to 138.2 mmHg (*P* < 0.001)]. The office diastolic BP was significantly lower only in the control group [intervention, from 83.0 to 82.1 mmHg (*P* = 0.657); control, from 87.0 to 81.5 mmHg (*P* = 0.012)].

Table 1   Characteristics at baseline by treatment group

Variable	Treatment group	
	Intervention	Control
N	15	15
Age (years)	62.7 ± 6.0	61.0 ± 7.5
Male (%)	3 (20)	10 (67)
BMI (kg/m^2)	31.5 ± 4.7	32.5 ± 5.4
Systolic BP (mmHg)	153.5 ± 7.5	150.4 ± 8.2
Diastolic BP (mmHg)	83.0 ± 6.7	87.0 ± 8.3
Heart rate (bpm)	73.7 ± 9.5	78.5 ± 10.7
Number of antihypertensive drugs	2.3 ± 1.2	2.3 ± 1.4
QOL score		
PAID	8.8 (2.5;17.5)[a]	13.8 (6.9;32.2)[a] (*n* = 14)[b]
SF-12		
PCS	41.7 ± 9.8	39.7 ± 6.6
MCS	51.4 ± 7.6	46.7 ± 12.5
WHO-5	65.8 ± 19.5	56.3 ± 24.5

Values are mean ± SD or number (%). SD, standard deviation; BMI, body mass index; bpm, beats per minute; BP, blood pressure; QOL, Quality of Life; PAID, Problem Areas In Diabetes; SF-12, 12-item Short Form Health Survey; PCS, physical component score; MCS, mental component score; WHO-5, World Health Organization Wellbeing Scale. [a] Median (p25;p75) is given for a variable with non-normal distribution. [b] One PAID score could not be calculated because one patient left one question unanswered.

Table 2   Change in office measurements of blood pressure (BP) and heart rate after 8 weeks

| | Treatment group | | | |
	Intervention	Control	P^a	Difference between groups
Change in				
Systolic BP (mmHg)	−7.5 (−12.7, −2.3)	−12.2 (−17.4, −7.0)	0.86	4.7 (−11.7, 2.3)
Diastolic BP (mmHg)	−1.0 (−5.5, 3.6)	−5.5 (−9.7, −1.4)	0.94	4.6 (−10.4, 1.3)
Heart rate (bpm)	−1.7 (−6.3, 2.9)	−1.9 (−9.2, 5.4)	0.97	0.2 (−8.5, 8.1)

Values are mean (95% confidence interval). ^{a} P value of comparison between groups after 8 weeks.

There were no significant differences in change of office BP between the two groups (Table 2).

There were no significant differences in change of home BP measurements between the two groups (Table 3). Mean regression coefficients of the home BP measurements over time were small for both groups (ranging from −0.05 to −0.12 in the intervention group and −0.09 to −0.19 in the control group), indicating a minimal reduction of BP over time in the home setting. There were no significant differences between the intervention and control groups (data not shown).

Mean breathing frequency at the end of the daily exercise in the intervention group was 10.8 ± 6.7 breaths/min. A post-hoc analysis in the intervention group was carried out to test the difference in office BP between the nine patients who reached the target breathing frequency of 10 breaths/min and the six who did not. The mean breathing frequency was 6.2 ± 1.9 breaths/min in the first group and 17.7 ± 5.0 breaths/min in the latter. BP change was not significantly different between both groups; BP change was −5.5 [95% confidence interval (CI) −12.9, 1.9]/0.5 (95% CI −6.5, 7.5) mmHg in the group that did reach the breathing frequency target and −10.5 (95% CI −19.6, −1.3)/−3.2 (95% CI −10.4, 4.1) mmHg in the group that did not (P = 0.33 for systolic BP change and P = 0.42 for diastolic BP change).

Heart rate
Office heart rate did not change in either group [intervention, from 73.7 to 72.0 beats/min (bpm) (P = 0.44); control, from 78.5 to 76.7 bpm (P = 0.59)]. There were no significant differences in change of office heart rate between the two groups (Table 2). There was no significant difference in change of home measurements of heart rate between the intervention and control group (Table 3).

Quality of life
Table 4 shows that QOL did not change significantly over time, nor did it differ between the intervention and control groups.

Blinding and compliance
The questionnaire at 8 weeks showed that blinding was successful. No adverse events or side effects were reported. Compliance with therapy was high, with more than 90% of recommended daily sessions done by all patients in both groups (94% in intervention and control group).

Table 3   Change in home measurements of blood pressure (BP) and heart rate

| | Treatment group | | | |
	Intervention	Control	P^a	Difference between groups
Change in				
Systolic BP (mmHg)	−7.8 (−12.6, −3.0)	−8.8 (−14.1, −3.5)	0.77	−1.0 (−7.8, 5.8)
Diastolic BP (mmHg)	−3.3 (−6.7, 0.0)	−4.7 (−8.0, −1.3)	0.55	−1.3 (−5.8, 3.2)
Heart rate (bpm)	0.2 (−3.0, 3.4)	1.9 (−0.5, 4.3)	0.37	1.7 (−2.1, 5.5)

Values are mean (95% confidence interval). ^{a} P value of comparison between groups after 8 weeks.

Table 4   Change in quality of life (QOL) after 8 weeks

| | Treatment group | | | |
	Intervention	Control	P^a	Difference between groups
Change in QOL				
SF-12 PCS	−0.2 (−2.5, 2.2)	3.3 (−1.4, 8.0)	0.17	3.5 (−1.6, 8.5)
SF-12 MCS	1.2 (−2.7, 5.1)	1.4 (−3.8, 6.7)	0.94	0.2 (−6.0, 6.5)
PAID	−2.4 (−5.3, 0.5)	2.2 (−4.8, 9.3)	0.19	4.6 (−2.7, 12.1)
WHO-5	4.5 (−5.3, 14.4)	−4.0 (−19.6, 11.6)	0.33	8.5 (−26.2, 9.1)

Values are mean (95% confidence interval). SF-12, 12-item Short Form Health Survey; PCS, physical component score; MCS, mental component score; PAID, Problem Areas In Diabetes; WHO-5, World Health Organization Wellbeing Scale. ^{a} P value of comparison between groups after 8 weeks.

Discussion

This study shows that breathing exercises guided by an electronic device do not reduce BP in patients with DM2, as measured both in the clinic and at home, to a greater extent than listening to music on a Discman. We chose listening to music with a Discman as our control group to keep the interventions in both groups as similar as possible with the exception of the active lowering of breathing frequency in the intervention group.

Several clinical trials have shown that listening to music can lower BP. This is mostly investigated in a perioperative setting or in patients undergoing endoscopic procedures [20–23]. Because of this effect, choosing music as our control group enabled us to differentiate between the effect of listening to music (the Resperate produces musical tones as well) and the effect of reducing breathing frequency on BP.

Our study shows that we cannot attribute the effect on BP seen in the intervention group to the reduction of breathing frequency achieved with the device. However, only a small number of subjects were able to reduce their breathing frequency. Therefore, the question remains unanswered whether the failure to observe any effect on BP is due to lack of efficacy of the device, or due to the inability of our subjects to reach sufficiently low breathing frequencies. Our results do not support findings reported previously. To our knowledge, this is the first study of its kind done in patients with DM2. Grossman *et al.* [5] and Schein *et al.* [7] studied the effect in hypertensive patients, either with or without antihypertensive drug therapy, and used listening to music through a Walkman as their control group. Both reported significant BP reductions in the intervention group as compared to the control group: $-7.5/-4.0$ versus $-2.9/-1.5$ mmHg ($P = 0.001$, $P = 0.12$) and $-15.2/-10.0$ versus $-11.3/-5.6$ mmHg ($P = 0.14$, $P = 0.008$), respectively. Meles *et al.* [9] and Elliot *et al.* [11] used no device in their control groups and both reported significant decreases in systolic or diastolic BP in their intervention groups [Meles *et al.*: $-5.5/-3.6$ versus $-0.2/+0.9$ mmHg (NS, $P < 0.05$); Elliot *et al.*: systolic BP -15.0 versus -9.2 mmHg ($P = 0.012$)]. Rosenthal *et al.* [6] and Viskoper *et al.* [8] did not have control groups, but reported significant decreases in BP at 8 weeks: $-7.2/-3.4$ mmHg ($P < 0.01$, NS) and $-12.9/-6.9$ mmHg ($P < 0.001$ for both), respectively. In our opinion, using an active control in our study contributed to a more reliable outcome.

Hypertension is a multifactorial condition and in patients with DM2, as compared to non-diabetic subjects, other factors might be involved in eliciting hypertension. Moreover, consequences of the longstanding presence of DM2 and hypertension might play a role both in the severity of hypertension and its sequelae, and the possibilities to correct raised BP. For example, reduced baroreflex sensitivity (BRS) is an indicator of increased risk for mortality and morbidity and is associated independently with both diabetes mellitus and hypertension [24,25]. However, no measurements of BRS were done in the present or previous studies, and therefore we cannot conclude that having DM2 *per se* was the reason for our negative results. Having performed these measurements would possibly have given us important information.

In our study, nine of the 15 patients in the intervention group succeeded in lowering their breathing rates to the target of less than 10 breaths/min. This was despite the verbal and written instructions, repeated as necessary, with which the patient was provided. This makes Resperate therapy less attractive for use in clinical practice in patients with DM2. Not only are there questions about the efficacy of this device, only 60% of patients will achieve the breathing rates reported to maximize the effects of this treatment.

More research is needed to study the effects of both music and breathing techniques on BP. To eliminate bias, an independent double-blind study should be carried out in which the intervention and the control groups use the same device, with the only difference being that in the intervention group, but not in the control group, the breathing frequency can be altered (< 10 breaths/min). Furthermore, breathing frequency of the control group should be monitored. Baroreceptor reflex sensitivity and carotid intima–media thickness should be important parameters in every follow-up study.

We could not measure an effect on QOL with either intervention. The duration of the study may have been of insufficient length and scope to detect measurable changes in QOL. Moreover, hypertension, a condition often lacking symptoms, may have less of an effect on QOL than, for example, diabetes itself.

In conclusion, the effects of reducing breathing frequency with the Resperate on BP and QOL were not different from those found in the control group, and a large proportion (40%) of patients with DM2 did not reach the target breathing frequency, making this device less suitable for clinical practice in patients with DM2.

Acknowledgements

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