Original Article

How Does Deep Breathing Affect Office Blood Pressure and Pulse Rate?

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Little is known about the relation between deep breathing (DB) and blood pressure (BP). We studied the relationship between DB and BP in a large Japanese population. The subjects were recruited from randomly selected clinics and hospitals that were members of a medical association, and divided into two groups. In one group, BP was measured before and after taking 6 DB over a period of 30 s, and in the other group BP was measured before and after a 30-s rest in a sitting position without DB. Before these measurements, all patients rested 10 min or more in the waiting room and another 2 min or more in the doctor's office. Analyses were performed on data collected from 21,563 subjects. In both groups, systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate (PR) were significantly reduced after DB or a 30-s rest compared with the baseline measurements ($p<0.001$). SBP reductions were greater in the DB group than in the 30-s rest group (normotensives: −6.4±8.3 *vs.* −3.0±7.4 mmHg, $p<0.001$; untreated hypertensives: −9.6±10.2 *vs.* −5.9±9.1 mmHg, $p<0.001$; treated hypertensives: −8.3±9.6 *vs.* −4.4±8.3 mmHg, $p<0.001$). Greater BP reductions were found in patients with a higher baseline BP in both the DB and 30-s rest groups. In conclusion, the present study showed a baseline BP-dependent BP reduction by DB, suggesting that BP measurement should be done without DB in the office because DB lowers BP. (*Hypertens Res* 2005; 28: 499–504)

***Key Words*: office blood pressure, deep breathing, 30-s rest**

Introduction

Deep breathing (DB) is believed to lower blood pressure (BP), but no large population study has been conducted to clarify the relationship between DB and office BP and pulse rate (PR). Although the sixth report of the Joint National Committee (JNC 6) (*1*) recommended that as a BP measurement method, "two or more readings separated by 2 minutes should be averaged," and the seventh report of the Joint National Committee (JNC 7) (*2*) recommendation was that at least two measurements should be made and the average recorded, there have been few reports of BP differences between the first and second readings, which are generally separated by a few min of rest in a sitting position in the office. The aim of the present study was to clarify the effect of DB and a 30-s rest in a sitting position on the office BP and PR in both hypertensive and normotensive patients.

Methods

Collection of Data

We asked 19,055 clinics or hospitals in Japan that were members of Japanese Medical and Dental Practitioners for the Improvement of Medical Care (JMDPIMC) to participate in the study. The clinics and hospitals were randomly selected from locations throughout Japan to minimize the regional differences in prevalence, treatment and control of hypertension between rural and urban area (*3*) and comprised about 30% of

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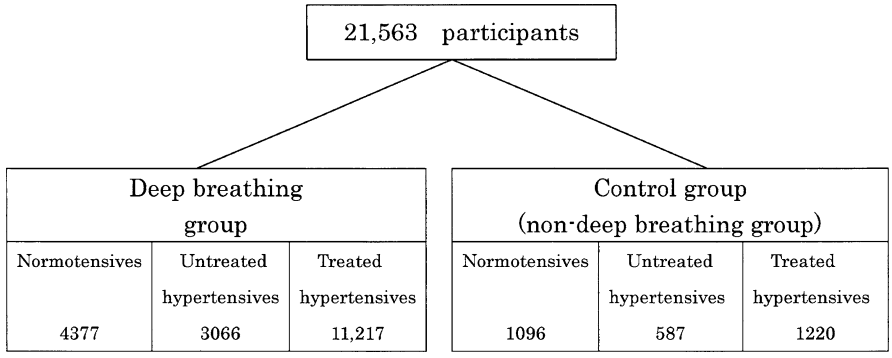

Fig. 1. *Study profile.*

Table 1. Baseline Data of Deep Breathing Group and Control Group

	DBG	CG	*p* value between DBG and CG
Male ratio			test 1
Normotensives	31.30%	33.70%	NS
Untreated hypertensives	42.60%	43.60%	NS
Treated hypertensives	40.60%	40.50%	NS
Age (years)			test 2
Normotensives	57.3±16.5	56.8±17.0	NS
Untreated hypertensives	63.7±12.3	63.5±12.6	NS
Treated hypertensives	67.5±10.7	67.5±10.9	NS
SBP			test 2
Normotensives	124.0±15.8 (n=4,347)	122.5±15.1 (n=1,095)	<0.01
Untreated hypertensives	158.0±16.9 (n=3,064)	156.0±15.9 (n=587)	<0.01
Treated hypertensives	148.7±17.7 (n=11,203)	145.5±16.4 (n=1,220)	<0.001
DBP			test 2
Normotensives	73.5±10.3 (n=4,374)	72.6±10.3 (n=1,095)	<0.05
Untreated hypertensives	89.3±12.3 (n=3,064)	88.4±12.1 (n=587)	NS
Treated hypertensives	82.6±11.5 (n=11,203)	81.3±11.6 (n=1,220)	<0.001
PR			test 2
Normotensives	72.5±10.6 (n=4,342)	71.8±9.8 (n=1,092)	<0.05
Untreated hypertensives	74.4±11.1 (n=3,060)	74.3±11.3 (n=585)	NS
Treated hypertensives	73.5±11.2 (n=11,131)	73.0±11.3 (n=1,209)	NS

DBG, deep breathing group; CG, control group; SBP, systolic blood pressure; DBP, diastolic blood pressure; PR, pulse rate; test 1, χ^2 test; test 2, unpaired t-test; NS, not significant. *p<0.001 by one-way analysis of variance and a post-hoc multiple comparison test.

all the members of JMDPIMC. The study period was from Jan 10 to Jan 31, 2002. The enrolled patients were divided into two groups (Fig. 1). One group was instructed to take 6 DB at about 80% maximum capacity over a period of 30 s (Deep Breathing Group: DBG) and the other was instructed to sit quietly for 30 s without DB (Control Group: CG). Each doctor was asked to enroll at least 5 normotensives, at least 5 untreated hypertensives and at least 10 treated hypertensive patients in the DBG, and at least one of each of these types of subjects in the CG.

Informed consent was obtained from all enrolled patients. Before BP measurement, patients rested in the waiting room for at least 10 min and in the office for 2 min. In the DBG, BP and PR were measured before and after the taking of 6 DB in 30 s. In the CG, BP and PR were measured before and after the 30-s rest in a seated position.

Hypertension was defined as a systolic blood pressure (SBP) of 140 mmHg or more and/or a diastolic blood pressure (DBP) of 90 mmHg or more. Patients who had fever, diarrhea, atrial fibrillation, frequent arrhythmias, liver cirrhosis, glaucoma or chronic renal failure, and those who took minor or major tranquilizers were excluded from the study.

Table 2. Baseline Measurements of SBP, DBP and PR and Measurements after DB or a 30-s Rest

	DB group				Control group			
	Before DB	After DB	*n*	*p* value	First measurements	Second measurements after 30-s rest	*n*	*p* value
NOR								
SBP	124.0±15.8	117.6±14.7	4,373	<0.001	122.4±15.0	119.4±15.0	1,091	<0.001
DBP	73.5±10.3	71.2±10.1	4,373	<0.001	72.6±10.3	71.6±10.0	1,091	<0.001
PR	72.5±10.6	71.8±10.4	4,334	<0.001	71.8±9.8	71.0±9.6	1,087	<0.001
UNT								
SBP	158.0±16.9	148.4±16.7	3,060	<0.001	156.0±15.9	150.1±16.0	586	<0.001
DBP	89.3±12.3	86.3±12.0	3,060	<0.001	88.4±12.1	86.4±12.2	586	<0.001
PR	74.4±11.1	73.2±10.7	3,048	<0.001	74.3±11.3	73.3±10.9	584	<0.001
TRE								
SBP	148.6±17.7	140.3±16.9	11,200	<0.001	145.5±16.4	141.1±16.1	1,217	<0.001
DBP	82.6±11.5	79.8±11.3	11,200	<0.001	81.2±11.6	79.7±11.6	1,217	<0.001
PR	73.5±11.2	72.1±10.9	11,111	<0.001	73.0±11.3	71.9±10.7	1,204	<0.001

SBP, systolic blood pressure; DBP, diastolic blood pressure; PR, pulse rate; DB, deep breathing; NOR, normotensive patients; UNT, untreated hypertensives; TRE, treated hypertensives. Paired *t*-test.

Table 3. Changes in SBP, DBP and PR after DB and after a 30-s Rest

	DB group		Control group		*p* value
	Change of measurements	*n*	Change of measurements	*n*	
NOR					
SBP	−6.4±8.3	4,373	−3.0±7.4	1,091	<0.001
DBP	−2.3±5.9	4,373	−1.1±6.0	1,091	<0.001
PR	−0.8±5.6	4,334	−0.8±4.7	1,087	NS
UNT					
SBP	−9.6±10.2	3,060	−5.9±9.1	586	<0.001
DBP	−3.0±6.7	3,060	−2.0±6.0	586	<0.001
PR	−1.2±5.7	3,048	−1.0±5.0	584	NS
TRE					
SBP	−8.3±9.6	11,200	−4.4±8.3	1,217	<0.001
DBP	−2.8±6.1	11,200	−1.6±5.7	1,217	<0.001
PR	−1.4±5.6	11,111	−1.1±4.8	1,204	<0.05

SBP, systolic blood pressure; DBP, diastolic blood pressure; PR, pulse rate; NOR, normotensive patients; UNT, untreated hypertensives; TRE, treated hypertensives; DB, deep breathing; NS, not significant. Unpaired *t*-test.

Table 4. Changes of Measurements after DB

	SBP reduction after DB		DBP reduction after DB		PR reduction after DB	
Untreated hypertensives	−9.6±10.2	*	−3.0±6.7	NS	−1.2±5.7	NS
Treated hypertensives	−8.3±9.6	*	−2.8±6.1	*	−1.4±5.6	**
Normotensives	−6.4±8.3		−2.3±5.9		−0.8±5.6	

*$p<0.001$, **$p<0.01$ by one-way analysis of variance and a post-hoc multiple comparison test. SBP, systolic blood pressure; DBP, diastolic blood pressure; PR, pulse rate; DB, deep breathing.

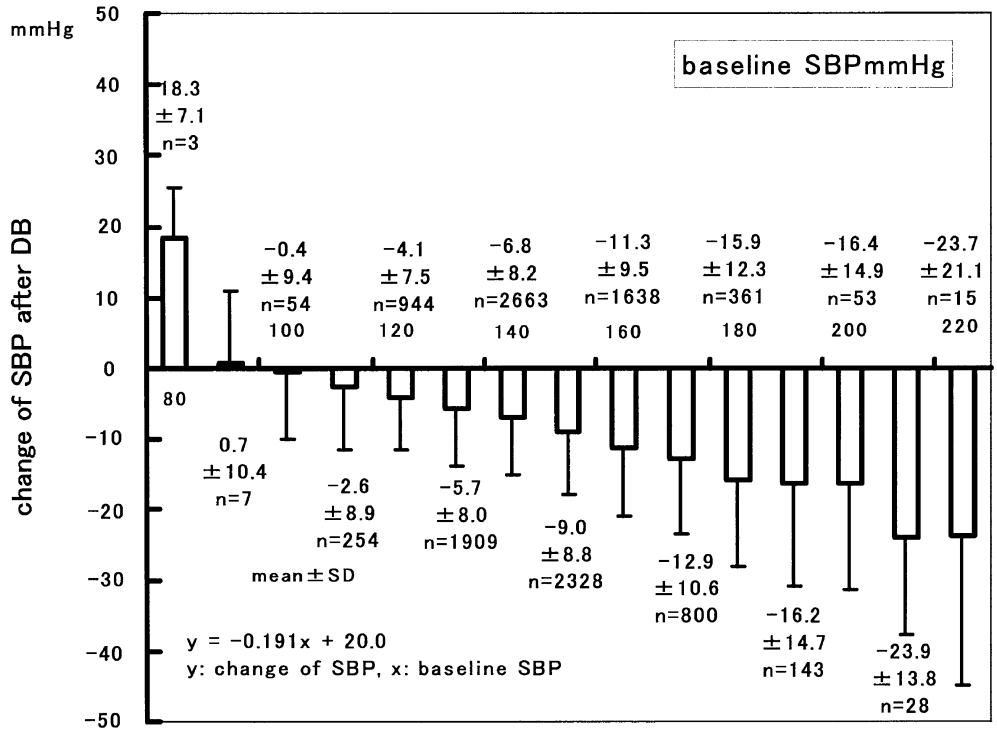

Fig. 2. *Baseline SBP and change of SBP after deep breathing.*

Statistical Analysis

Statistical analyses were carried out with Student's *t*-test, χ^2 test, or one-way analysis of variance and post-hoc multiple comparison test using SPSS Version 10 software. Values of $p<0.05$ were considered to indicate statistical significance. All values were expressed as the mean±SD.

Results

Characteristics of Study Populations

The enrolled cases comprised 25,022 patients from 1,186 clinics and hospitals throughout Japan, and in 21,563 of these cases, all the data necessary for analysis were available. The DBG consisted of 4,377 normotensives, 3,066 untreated hypertensives and 11,217 treated hypertensives. The CG consisted of 1,096 normotensives, 587 untreated hypertensives and 1,220 treated hypertensives (Fig. 1).

There were no significant differences in the sex ratio or age of normotensives, untreated hypertensives, or treated hypertensives between the DBG and CG groups. The percentage of men was significantly lower in the normotensives than in the hypertensives in both the DBG and CG. The mean age was significantly different among the normotensives and hypertensives in both the DBG and CG (Table 1).

Blood Pressure and Pulse Rate

Baseline SBP and DBP were significantly different among the three groups in both the DBG and CG. PR in normotensives was significantly different between the DBG and CG (Table 1).

SBP, DBP and PR were significantly reduced after DB in the normotensive, untreated hypertensive and treated hypertensive patients ($p<0.001$). Moreover, in the CG, the second measurements of SBP, DBP and PR were significant lower than the first measurements (Table 2, $p<0.001$). Both DB and a 30-s rest reduced BP and PR, and the reductions were greater in the DBG than in the 30-s-rest group. A significantly greater reduction in PR was found only in treated hypertensive patients (Table 3). The reductions in BP and PR by DB were greater in hypertensives than in normotensives (Table 4).

The decreases in SBP, DBP and PR following DB were significantly correlated with the baseline SBP ($r=-0.349$, $p<0.001$, $n=18,633$), DBP ($r=-0.300$, $p<0.001$, $n=18,633$), and PR ($r=-0.05$, $p<0.001$, $n=18,518$), respectively. In the treated patients of both groups, similar correlations were found for SBP ($r=-0.351$, $p<0.001$, $n=11,200$), DBP ($r=-0.300$, $p<0.001$, $n=11,200$), and PR ($r=-0.312$, $p<0.001$, $n=11,111$).

The higher the baseline SBP, the greater the reduction in SBP after DB, although patients whose baseline SBP was less than 100 mmHg showed an increase in SBP after DB (Fig. 2).

Table 5. Changes of Measurements before and after Deep Breathing in Pilot Study

	Normotensives (n=118)			Untreated hypertensives (n=81)			Treated hypertensives (n=217)		
	BDB	ADB	p value	BDB	ADB	p value	BDB	ADB	p value
SBP	117.6±15.2	111.1±13.2	<0.001	151.1±20.1	142.9±20.6	<0.001	145.3±17.3	136.5±16.6	<0.001
DBP	70.5±10.1	68.3±10.4	<0.001	87.5±14.6	84.8±11.2	<0.05	81.0±11.4	77.6±10.6	<0.01
PR	69.9±9.8	69.5±10.0	NS	74.9±10.4	71.7±10.0	<0.001	73.0±11.9	71.6±10.9	<0.02

Paired t-test. BDB, before deep breathing; ADB, after deep breathing; SBP, systolic blood pressure; DBP, diastolic blood pressure; PR, pulse rate.

Table 6. Percentage of Measurements Increment before and after Deep Breathing in Pilot Study

	Normotensives	Untreated hypertensives	Treated hypertensives
SBP	15/118 (12.7%)	8/81 (9.9%)	31/217 (14.3%)
DBP	8/118 (6.8%)	13/81 (16.0%)	45/217 (20.7%)
PR	38/118 (32.2%)	13/81 (16.0%)	63/217 (29.0%)

SBP, systolic blood pressure; DBP, diastolic blood pressure; PR, pulse rate.

Discussion

In the present study, we found that DB decreased BP and PR, and these decreases correlated with the baseline BP and PR, respectively. Furthermore, we found that a 30-s rest in a sitting position also decreased BP and PR, but to a lesser degree than DB.

It is not clear why the DBG showed a higher baseline BP than the CG. One possibility is that the instructions on how to perform DB made the patients nervous and increased their baseline BP. Even after adjusting for this difference in baseline BP between the DBG and CG, the reduction in BP was still greater in the former group.

DB is often used to examine the autonomic nervous system. In such studies, the DB method used entails breathing deeply five (*4*) or six times (*5–10*) in 1 min. In the present study, we instructed the patients to take 6 DB at about 80% maximum capacity over a period of 30 s. This protocol was used because, in our pilot study, when patients were asked to 6 DB over a period of 1 min, they sometimes held their breath, resulting in increased BP and PR (Tables 5, 6).

The autonomic nervous system, through stimulation of the arterial baroreceptor, pulmonary stretch receptors, and low-pressure baroreceptors, may play important roles in the changes of BP and PR associated with DB, although the actual mechanisms are unknown.

Bernardi *et al*. reported that baroreflex activity could be enhanced by slow breathing not only in healthy people but also in patients with congestive heart failure, and they noted that BP decreased with slower or deeper breathing due to the relative increase of vagal activity, decreased sympathetic activity and reduced afterload (*11*). Rajeev *et al*. pointed out that the increments of SBP, DBP and PR in response to stress were greater in hypertensives than in normal controls, and that sympathetic nervous system activity was increased in patients with essential hypertension (*8*). Yoshihara *et al*. reported that there was no significant reduction of DBP in sustained hypertensive patients after DB, but that patients with white coat hypertension showed a significant reduction of DBP after DB. They also showed that office SBP fell significantly after DB in both sustained and white coat hypertensives, and that there was no significant difference in the degree of reduction between the two groups; these findings suggested that measurements taken after DB are useful for identifying white coat hypertensive patients in the office (*4*). In the present study, because we did not measure home BP, we were unable to confirm the efficacy of measurement after DB for identifying white coat hypertension at the office. Our study revealed a significant reduction in SBP, DBP and PR in normotensives, untreated hypertensives and treated hypertensives after DB, and also in the CG. We found a baseline-BP-dependent BP decrease by DB. Though the actual reason for the relationship between BP and DB is unknown, a similar result (*12*) has been reported in a study using a device-guided breathing exercise, which suggests the involvement of increased sympathetic activity (*13*, *14*), decreased baroreflex function (*15–17*), and reduced arterial wall compliance (*18*).

In conclusion, the present study showed a baseline BP-dependent BP reduction by DB, suggesting that office BP measurement should be done without DB because DB lowers BP.

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