Original Article

Workplace Hypertension Is Associated with Obesity and Family History of Hypertension

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Job strain, which is a risk for hypertension and increased left ventricular mass, is thought to cause masked hypertension during work even if blood pressure (BP) is normal at health examinations. To study the prevalence of and factors related to workplace hypertension, 265 public officials (mean age, 41.4±10.7 years) measured their own BP at their workplace using semiautomated BP measurement devices. Factors related to workplace hypertension were assessed with multiple regression analysis. Workplace hypertension, defined as a BP no less than 140/90 mmHg, was observed in 23% of subjects (*n*=61). Compared with subjects without workplace hypertension (*n*=204), subjects with workplace hypertension were older (48.5±10.0 *vs.* 39.3±10.0 years), more likely to be men (69% *vs.* 46%), and had a higher body mass index (BMI) (23.4±2.7 *vs.* 21.6±3.2 kg/m^2), higher cholesterol levels (214±33 *vs.* 194±36 mg/dl), and a higher Brinkman index (134±228 *vs.* 59±148). Subjects with workplace hypertension had higher BPs at checkup than did those without it (125±11/79±9 *vs.* 110±11/68±9 mmHg). The increases in BPs at the workplace were independently and significantly correlated with BMI, and a family history of hypertension. BP no less than 130/85 mmHg at health checkup was a good detector of workplace hypertension (sensitivity, 49%; specificity, 91%), suggesting that subjects with high-normal BPs at health checkup might have workplace hypertension. In conclusion, workplace hypertension was found to be associated with age, BMI, a family history of hypertension, and high-normal BPs at health checkup. (*Hypertens Res* 2006; 29: 969–976)

***Key Words*: obesity, job strain, masked hypertension, family history of hypertension, health checkup**

Introduction

Because of the increasing popularity of blood pressure measurement at home using semiautomated blood pressure monitoring devices, the importance of measuring blood pressure outside the doctor's office has gained attention. Self-measurement of blood pressure at home has better prognostic accuracy than office blood pressure measurement (*1*, *2*). On the other hand, masked hypertension, which is characterized by high ambulatory daytime and nighttime blood pressures and normal office blood pressure (*3*), may cause future cardiovascular events in patients being treated for hypertension. Several conventional coronary risk factors, including sex, age, smoking, and job strain, have been suggested to be associated with masked hypertension (*1*), though the exact mechanisms remain to be investigated.

Job strain, which is a combination of high demands and low job control, is related to increased ambulatory blood pressures (*4*) and sustained increases in ambulatory blood pressure even at 3-year follow-up (*5*). Job strain was associated with incident hypertension in an 8-year cohort study of 3,200 initially normotensive employees (*6*). In addition, it has been reported that job-strain–induced hypertension might be harmful because it induces left ventricular hypertrophy (*7*). However, job strain–induced workplace hypertension has not been thoroughly studied in terms of risk factors. Therefore, the aims of this observational study were to study the prevalence and

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most commonly associated clinical features of subjects with job-strain–induced hypertension ("workplace hypertension") and to identify the blood pressure at health checkup that most effectively predicts workplace hypertension.

Methods

Study Design and Participants

We studied 265 public officials (135 men and 130 women) in the Metropolitan Government Office (mean age, 41.4±10.7 years) from March 2005 to May 2005, who all gave written informed consent to the study protocol. All the subjects were white-collar employees involved in either office work or middle management. Blood pressures at health checkup were obtained from 197 subjects.

At the regular checkup no more than 3 months before or after the baseline measurement of blood pressures at the workplace, several conventional coronary risk factors, including sex, age, body mass index (BMI), serum cholesterol, high-density lipoprotein-cholesterol (HDL-C), triglyceride, uric acid, and plasma glucose levels, along with daily alcohol intake, smoking index (Brinkman index, cigarettes per day × smoking years), and existence of family history of hypertension were assessed. The blood sampling at the checkup was performed before or after lunch, and the time of sampling was not prespecified. Daily alcohol intake was categorized into the following four grades according to the self-reported daily amount of alcohol intake: less than 350 ml of beer a couple of days per week, 350 ml of beer a couple of days per week, 350 ml of beer every day, and more than 350 ml of beer every day. Smokers included current and former smokers. Existence of family history of hypertension was defined as hypertension of grandparents, parents, or siblings. We then analyzed each of the factors as a possible determinant of blood pressure at the workplace using simple and multiple regression analyses. Moreover, the increases in blood pressure at the workplace compared with those at checkup were analyzed in terms of the conventional coronary risk factors given above. Finally, the blood pressure levels at checkup that were most predictive of workplace hypertension were evaluated.

Blood Pressure Measurement

At scheduled break points during the 10 AM to 4 PM work day, subjects were told to report to a room located apart from their workplace. After a few minutes of rest, subjects measured their own blood pressure (workplace-BP) once at the upper arm in a sitting position using a semiautomated blood pressure monitoring device (UA777; A&D, Tokyo, Japan). A plain-clothed medical technician was available to provide instruction on how to use the device, if necessary. Smoking was prohibited at least 1 h before the measurement. Blood pressure at health checkup (checkup-BP) was measured once by well-trained health checkup workers with mercury sphygmomanometers at the time of regular checkup no more than 3 months before or after the baseline measurement of workplace-BP and was compared with workplace-BP.

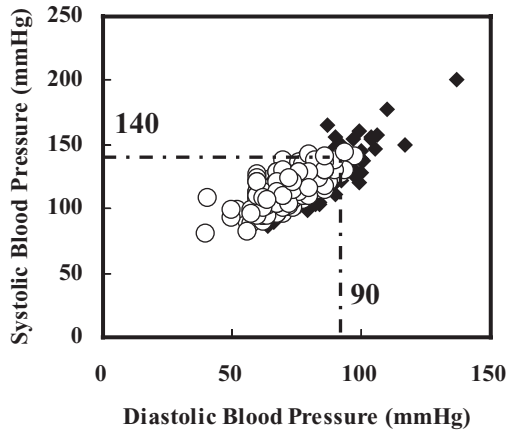

Fig. 1. *Incidence of workplace hypertension, which was defined as a systolic/diastolic blood pressure no less than 140/90 mmHg at the workplace, among the subjects who had both blood pressure measurement at the workplace and corresponding blood pressure measurement at health checkup (*n = *197). Closed squares represent the blood pressures at the workplace, while open circles represent corresponding blood pressures at health checkup.*

We defined workplace hypertension as systolic blood pressure (SBP) ≥140 mmHg or diastolic blood pressure (DBP) ≥90 mmHg or both, and studied the overall prevalence of workplace hypertension. Then, we used three cut-off values of the checkup-BP, namely, 140/90 mmHg, 130/85 mmHg, 120/80 mmHg, and compared the ability of these values to predict workplace hypertension.

Statistical Analysis

Values are expressed as the means±SD. The Mann-Whitney's *U*-test was used to evaluate differences between the clinical data of subjects with workplace hypertension and those without it. Spearman's rank correlation coefficients were calculated to measure linear regressions between workplace-BP or increases in workplace-BP and conventional risk factors. Multiple linear regression analysis was used to identify risk factors that might explain workplace-BP and increases in workplace-BP. First, statistically significant risk factors were identified using multiple regression and forward selections (the criterion for entry was a p value of 0.05). Dummy variables were assigned to the categorical data including sex, daily alcohol intake, and existence of family history by a standard method using the SPSS software program (ver. 12.0.2J; SPSS Inc., Chicago, USA). The possible predictor set was expanded to include sex or age. With this expanded predictor set, stepwise model selection was used to

Table 1. Characteristics of Subjects with and without Workplace Hypertension

	With workplace hypertension (n=61)	Without workplace hypertension (n=204)
Sex (men/women)	41/20	94/110
Age (years)	48.5±10*	39.3±10
Antihypertensive medicine (%)	8.6	2.0
Checkup systolic blood pressure (mmHg)	125±11*	110±11
Checkup diastolic blood pressure (mmHg)	79±9*	68±9
Hypertension at checkup (≥140/90 mmHg) (%)	9.8	1.5
Smokers (%)	40.0	24.3

Values are means±SD or percentage. *p value of <0.05 with Mann-Whitney's U-test. Workplace hypertension, blood pressures ≥140/90 mmHg at the workplace.

identify any additional predictors of workplace-BP.

All statistical analyses were performed with the SPSS software program and probability values <0.05 were considered to indicate statistically significant differences.

Results

Subjects Characteristics

Among the total of 265 subjects, 61 (23%) had workplace hypertension, and among the 197 subjects who had both workplace-BP and corresponding checkup-BP, 45 (23%) had workplace hypertension (Fig. 1). The baseline characteristics of all the subjects are shown in Table 1. Subjects with workplace hypertension (n=61) were older and more likely to be men. They had higher SBP (125±11 *vs*. 110±11 mmHg) and DBP (79±9 *vs*. 68±9 mmHg) at checkup than did those without workplace hypertension (n=204). Antihypertensive medication was being received by 8.6% of subjects with workplace hypertension but by only 2.0% of subjects without workplace hypertension (p=0.0504, Yates' corrected χ^2 test). Six subjects with workplace hypertension had hypertension at checkup (≥140/90 mmHg), whereas three without workplace hypertension had hypertension at checkup. The ratio of smokers in subjects with workplace hypertension was 40.0%, but that in subjects without workplace hypertension was 24.3%.

Risk Factors for Workplace Hypertension

Subjects with workplace hypertension had significantly higher BMI, cholesterol levels, plasma glucose levels, and a higher Brinkman index than did those without it (n=204) (Fig. 2). Moreover, simple linear regression analysis showed that workplace-BP was significantly correlated with the risk factors of age, BMI, serum cholesterol levels, triglyceride levels, uric acid levels, HDL-C levels, and plasma glucose levels along with a higher Brinkman index, a family history of hypertension, and daily alcohol intake (Table 2). Workplace-BP was also significantly correlated with SBP, DBP, and pulse pressures at health checkup (Table 2).

We then used multiple linear regression modeling to identify the statistically significant independent determinants that might predict the workplace-BP. Significant predictors of workplace-BP were SBP at checkup, age, BMI, and a family history of hypertension after adjustment for sex (Table 3).

Factors Contributing to Increases in Workplace-BP Compared with Checkup-BP

The increases in workplace-BP compared with checkup-BP were also correlated with conventional coronary risk factors. The increases in workplace-BP were mildly but significantly correlated with age (r=0.167, p<0.05), BMI (r=0.194, p<0.01), serum cholesterol levels (r=0.208, p<0.01), triglyceride levels (r=0.194, p<0.01), and a family history of hypertension (r=0.154, p<0.05) (Table 4).

Results of multiple linear regression analysis of the relations between increases in workplace-BP and risk factors as predictors are presented in Table 5. Variables concerning the checkup-BP were excluded from this part of the regression analysis, because the checkup-BP is inevitably a confounding factor. The BMI and a family history of hypertension were the strongest predictors of increases in workplace-BP.

Checkup-BP Predicting Workplace Hypertension and Masked Hypertension

Workplace SBP was significantly correlated with checkup-BP (r=0.636, p<0.001) (Table 2). However, when we used 140/90 mmHg as a cut-off value for checkup-BP, only 56% of the subjects (5 of 9) with workplace hypertension were detected (Table 6). Even if we used 130/85 mmHg and 120/80 mmHg as cut-off values for checkup-BP, 63% (22 of 35) and 47% (35 of 74) of the subjects with workplace hypertension were detected, respectively. On the other hand, 21% of subjects with checkup-BP less than 140/90 mmHg had workplace hypertension, which could be called "masked hypertension." Moreover, 14% of the subjects with checkup-BP less than 130/85 mmHg, and 8% of subjects with checkup-BP less than 120/80 mmHg had masked hypertension (Table 6). Judging

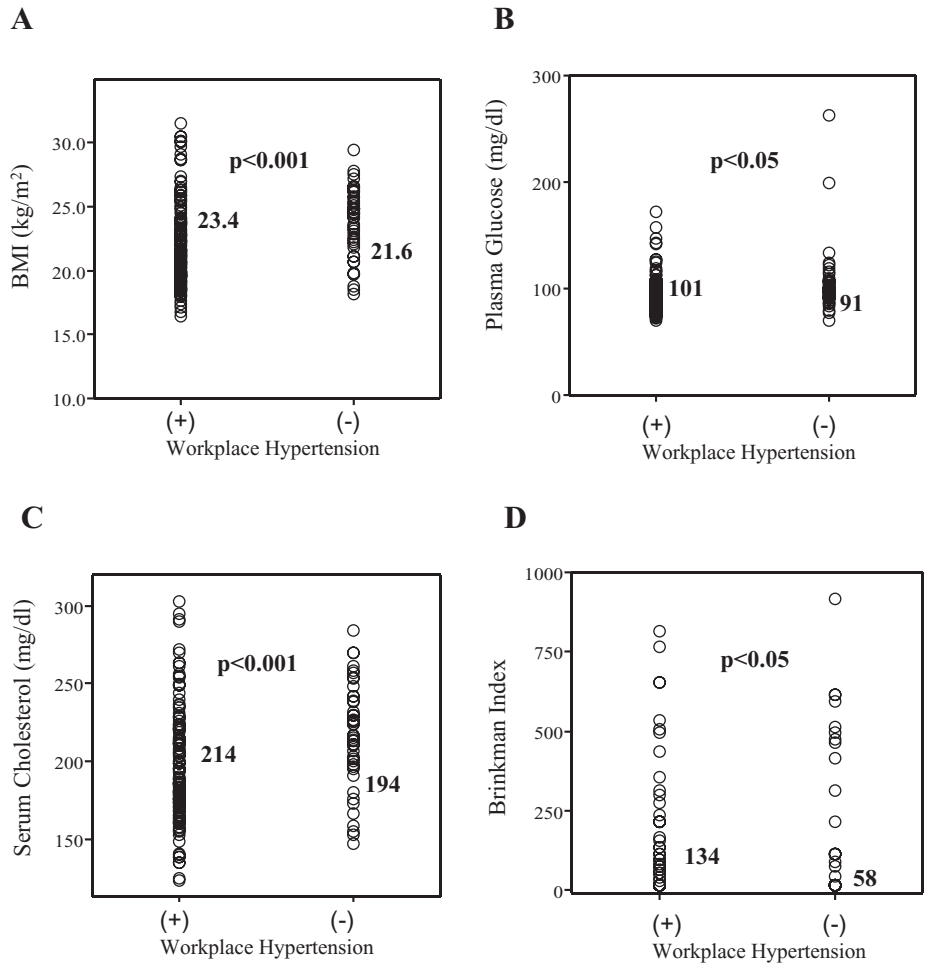

Fig. 2. *Differences in the conventional coronary risk factors between the subjects with workplace hypertension and those without it. A: body mass index (BMI); B: plasma glucose levels; C: serum cholesterol levels; and D: Brinkman index (cigarettes per day × smoking years).*

Table 2. Rank Correlation Coefficients (Workplace Systolic Blood Pressure)

	r	*p* value
Age	0.482	<0.001
Body mass index	0.483	<0.001
Serum cholesterol	0.375	<0.001
Serum triglyceride	0.385	<0.001
Serum uric acid	0.345	<0.001
Plasma glucose	0.283	<0.001
Brinkman index	0.242	<0.001
Family history of hypertension	0.224	<0.01
Daily amount of alcohol intake	0.184	<0.05
Serum high-density lipoprotein-cholesterol	−0.167	<0.05
Checkup systolic blood pressure	0.636	<0.001
Checkup diastolic blood pressure	0.586	<0.001
Checkup pulse pressure	0.295	<0.001

Brinkman index, cigarettes per day × smoking years.

Table 3. Multiple Regression Analysis of Systolic Blood Pressure at the Workplace and Associated Variables

Variables	β coefficient	*t* value	*p* value
Sex	1.407	0.706	0.48
Age	0.289	2.990	0.003
Checkup systolic blood pressure	0.581	6.781	0.005
Body mass index	0.159	2.663	0.009
Family history of hypertension	5.346	2.823	<0.001

Table 4. Rank Correlation Coefficients (Increases in the Workplace Systolic Blood Pressure Compared with Checkup Systolic Blood Pressure)

	r	*p* value
Sex	0.073	NS
Age	0.167	<0.05
Body mass index	0.194	<0.01
Serum cholesterol	0.208	<0.01
Serum triglyceride	0.194	<0.01
Family history of hypertension	0.154	<0.05

NS, not significant.

from the positive and negative predictive values, a checkup-BP of 130/85 mmHg might be reasonable to use for predicting workplace hypertension (sensitivity, 0.49; specificity, 0.91; positive predictive value, 0.63; negative predictive value, 0.86).

Discussion

The present study demonstrated that 1) 23% of employees involved in office work had workplace hypertension, and 2) these employees were older, were more likely to be men, and had higher BMI, higher glucose and cholesterol levels, a higher Brinkman index, and greater checkup-BP than did those without workplace hypertension. Moreover, we have shown that 3) BMI and a family history of hypertension were independent determinants of increases in workplace-BP compared with checkup-BP on multiple regression analysis. Finally, 4) checkup-BP of ≥130/85 mmHg seemed to be a good detector of workplace hypertension. To our knowledge, this is the first study to show a relation between job-strain–induced workplace hypertension and obesity regardless of sex.

Population-based studies have reported that the prevalence of masked hypertension, which is characterized as greater ambulatory blood pressures than corresponding office blood pressures, was 14% (*8*) or 26% (*9*). The overall prevalence of workplace hypertension (≥140/90 mmHg) in the present study was 23%, and the prevalence of workplace hypertension among subjects with a checkup-BP less than 140/90 mmHg, which might be called "masked hypertension," was 21%. The cut-off value of 140/90 mmHg at checkup cannot sufficiently exclude workplace hypertension, as is the case with a cut-off value of 120/80 mmHg at checkup (8%). In other words, a substantial percentage of employees with workplace hypertension are overlooked at health checkup, though the clinical significance of workplace hypertension remains to be investigated. However, two other forms of masked hypertension—*i.e.*, morning surge and nocturnal hypertension—that also cannot be detected in the doctor's office have been shown to be risk factors for cardiovascular disease (*10–12*). Therefore, we should extend the research to investigate whether or not workplace hypertension is also a risk factor for cardiovascular disease.

Pickering *et al*. have shown that patients with masked hypertension are older; have higher BMI, serum creatinine concentrations, and glucose levels; and are more likely to be current smokers (*13*). They have also suggested that masked hypertension is associated with job strain (*14*). Several studies have shown that in most people blood pressures are highest during working hours (*15*) and that job strain is a risk factor for hypertension, especially in hard-working men (*16*). Therefore, workplace hypertension, which is characterized by high ambulatory daytime and working-hour blood pressures and normal checkup-BP, may be closely related to masked hypertension, though the exact mechanisms remain to be investigated. Consistent with this hypothesis, the clinical features of subjects with workplace hypertension in the present study were similar to those of subjects with masked hypertension in the previous studies (*13*, *14*). Moreover, workers reporting low job control have greater blood pressures, even in the evening after work (*17*). Thus, job strain might modulate cardiovascular affective responses over the working day. Elevated sympathetic nerve activity or elevated cortisol levels (*18*) might be involved in the pathogenesis of this type of hypertension. In addition, mental stress induces a fall in left ventricular ejection fractions in a significant proportion of patients with coronary artery disease (*19*). However, we cannot discuss the similarity between masked hypertension and workplace hypertension any further because we did not perform ambulatory monitoring or measure other factors in the present study.

We observed significant correlations between workplace-BP and many risk factors. In addition to the association with masked hypertension and plasma glucose levels (*10*), metabolic syndrome might be involved in workplace hypertension because workplace-BP has been shown to correlate with

Table 5. Multiple Regression Analysis of Increases in the Workplace Systolic Blood Pressure Compared with Checkup Systolic Blood Pressure and Associated Variables

	Model 1	Model 2	Model 3
Sex	−0.734	2.075	—
Age	0.125	—	—
Body mass index	0.530	0.326*	0.614*
Family history of hypertension	3.872**	1.968*	4.347*

β coefficient in each significant model. *$p<0.05$, **$p=0.05$.

Table 6. Predictive Values of Checkup Blood Pressures for Workplace Hypertension

	Cut-off value of checkup blood pressure		
	≥140/90 mmHg	≥130/85 mmHg	≥120/80 mmHg
Sensitivity	0.10	0.49	0.78
Specificity	0.97	0.91	0.74
Positive predictive value	0.56	0.63	0.47
Negative predictive value	0.79	0.86	0.92
1 − Negative predictive value	0.21	0.14	0.08

Fifty-six percent of subjects with the checkup blood pressure of ≥140/90 mmHg had workplace hypertension, and 21% of the subjects with the checkup blood pressure of <140/90mmHg had "masked hypertension."

serum cholesterol levels, serum triglyceride levels, and serum HDL-C levels. Moreover, serum uric acid was recently shown to be related to left ventricular concentric hypertrophy, especially in men (*20*), suggesting that workplace hypertension might be one of the attractive hypotheses explaining the association between left ventricular hypertrophy and uric acid. Furthermore, smoking is known to directly increase blood pressures (*21*). However, in the present study smoking was prohibited for at least 1 h before the measurement and workplace hypertension was observed even in the never-smokers (Fig. 2D). Alcohol is another intriguing factor in regard to workplace hypertension, because regular alcohol intake increases morning and evening blood pressures (*22*), or when combined with coffee intake of more than 3 cups per day, decreases blood pressures (*23*). However, none of these factors were independent determinants of workplace-BP when BMI was included in the model.

The strongest independent predictors of increases in workplace-BP compared with checkup-BP were BMI and a family history of hypertension when we excluded checkup-BP from the analysis. These results are consistent with the report by Steptoe *et al*., in which abdominal obesity and low job control in men were associated with elevated blood pressures during the working day and evening (*24*). When we included checkup-BP in the analysis, checkup-BP ≥130/85 mmHg was a good predictor of workplace hypertension (sensitivity, 49%; specificity, 91%), though checkup-BP ≥140/90 mmHg was a poor predictor of workplace hypertension (sensitivity 10%). These results suggest that subjects with high-normal blood pressures (from 130/85 to 139/89 mmHg) at health checkup might already have workplace hypertension. Consistent with the above present results, in the TROPHY study, in which participants were overweight and had a high incidence of dyslipidemia, hypertension was shown to develop in nearly two-thirds of untreated patients with high-normal blood pressures over a period of 4 years (*25*). The Japanese criteria for metabolic syndrome based on the results of Takeuchi *et al*. (*26*), as well as those by the Third Report of the National Cholesterol Education Program Expert Panel on the Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP-ATPIII) (*27*), include abdominal circumference and blood pressure ≥130/85 mmHg, which might be appropriate because obese subjects with blood pressures ≥130/85 mmHg at health checkup may have workplace hypertension. Interestingly, the prevalence of metabolic syndrome is approximately 24% and increases with age (*28*). Moreover, the most important factor in metabolic syndrome is thought to be hypertension (*29*). Collectively, ageing and obesity might synergistically produce metabolic syndrome (*25*), and job-strain–induced workplace hypertension might be one of the earlier manifestations of metabolic syndrome. In other words, if subjects with a family history of hypertension have workplace hypertension, they should try to lose weight as they grow older, in order to prevent incident hypertension, which may be consistent with the concept of "prehypertension" presented in the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) (*30*). However, an interventional study might be necessary to prove it. Finally, heart rate at the workplace was not correlated with workplace-BP or with increases in workplace-BP. Job strain may not be directly related to sympathetic nerve activity because job strain is

affected by employment grade and decision latitude (*31*).

In conclusion, workplace hypertension is associated with age, BMI, and a family history of hypertension and can be detected based on high-normal blood pressures at health checkup. The present study suggests that we should emphasize workplace blood pressure measurement.

Limitations

Although ambulatory blood pressure monitoring would be more appropriate for assessing workplace-BP, in the present study, blood pressures were measured by the subjects themselves using a semiautomated home blood pressure measurement device at the workplace. However, self-blood pressure measurement at the workplace may be an alternative and feasible way to estimate blood pressure level during daily activity.

In the present study, an assessment of stress was not conducted. In particular, occupational stress should have been evaluated as job strain, which is a combination of high demands at work with low decision latitude or control. Socioeconomic status and marital status have also been reported to be involved (*32*). Moreover, the Karasek demand-control questionnaire may be necessary to assess job strain quantitatively (*33*). However, we could assume that the demand of the subjects was relatively homogeneous, because all the subjects were white-collar public officials involved in either office work or middle management and their working hours were similar. Finally, for psychosomatic assessment of job-strain, a special demand-control questionnaire has been designed for use in conjunction with a personal digital assistant (PDA), and we are planning to employ this questionnaire in a future study.

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