

Blood pressure control by home monitoring: meta-analysis of randomised trials

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Abstract

Objective To determine the effect of home blood pressure monitoring on blood pressure levels and proportion achieving targets in people with essential hypertension.

Design Meta-analysis of 18 randomised controlled trials.

Participants 1359 people with essential hypertension allocated to home blood pressure monitoring and 1355 allocated to the "control" group seen in the healthcare system for 2-36 months.

Main outcome measures Differences in systolic (n = 13 studies), diastolic (n = 16), or mean (n = 3) blood pressures, and proportion of patients achieving targets (n = 6), between intervention and control groups.

Results Systolic blood pressure was lower in people with hypertension who had home blood pressure monitoring than in those who had standard blood pressure monitoring in the healthcare system (standardised mean difference 4.2 (95% confidence interval 1.5 to 6.9) mm Hg), diastolic blood pressure was lower by 2.4 (1.2 to 3.5) mm Hg, and mean blood pressure was lower by 4.4 (2.0 to 6.8) mm Hg. The relative risk of blood pressure above predetermined targets was lower in people with home blood pressure monitoring (risk ratio 0.90, 0.80 to 1.00). When publication bias was allowed for, the differences were attenuated: 2.2 (-0.9 to 5.3) mm Hg for systolic blood pressure and 1.9 (0.6 to 3.2) mm Hg for diastolic blood pressure.

Conclusions Blood pressure control in people with hypertension (assessed in the clinic) and the proportion achieving targets are increased when home blood pressure monitoring is used compared with standard blood pressure monitoring in the healthcare system. The reasons for this are not clear. The difference in blood pressure control between the two methods is small but likely to contribute to an important reduction in vascular complications in the hypertensive population.

Introduction

High blood pressure is one of the most readily preventable causes of stroke and other cardiovascular complications.¹⁻⁴ It can be easily detected, and most cases have no underlying detectable cause; the most

effective way to reduce the associated risk is to reduce the blood pressure. Unlike many other common, chronic conditions, we have very effective ways of treating high blood pressure and we have clear evidence of the benefits of such interventions.¹ However, hypertension is still underdiagnosed and undertreated.⁵

Blood pressure is usually measured and monitored in the healthcare system by doctors or nurses in hospital outpatient departments and, increasingly, in primary care settings. Measuring blood pressure at home is also becoming increasingly popular with both doctors and patients.^{6,7} Some national and international guidelines also recommend home monitoring in certain circumstances.⁸

We reviewed the literature on home blood pressure monitoring and did a meta-analysis of the effect of home blood pressure monitoring on blood pressure levels and the control of hypertension in randomised trials that compared home or "self" blood pressure monitoring and usual blood pressure monitoring in the healthcare system.

Methods

Identification and selection of trials

To identify published trials that met the inclusion criteria we searched Medline, Embase, the Cochrane Database of Systematic Reviews, the Database of Abstracts of Clinical Effectiveness, the Health Technology Assessment Database, the NHS Economic Evaluation Database, the TRIP database, and the websites of the Centre for Reviews and Dissemination and the Agency for Healthcare Research and Quality (see bmj.com). We tried to identify randomised controlled trials of home or self blood pressure monitoring in people with high blood pressure.

We included studies in which the intervention under test was at least one measurement of blood pressure at home by study participants or their family members.⁹⁻²⁹ We excluded studies that were not randomised controlled trials and those that used "ambulatory" blood pressure monitoring rather than "home" or "self" blood pressure monitoring.

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Appendices A-D are on bmj.com

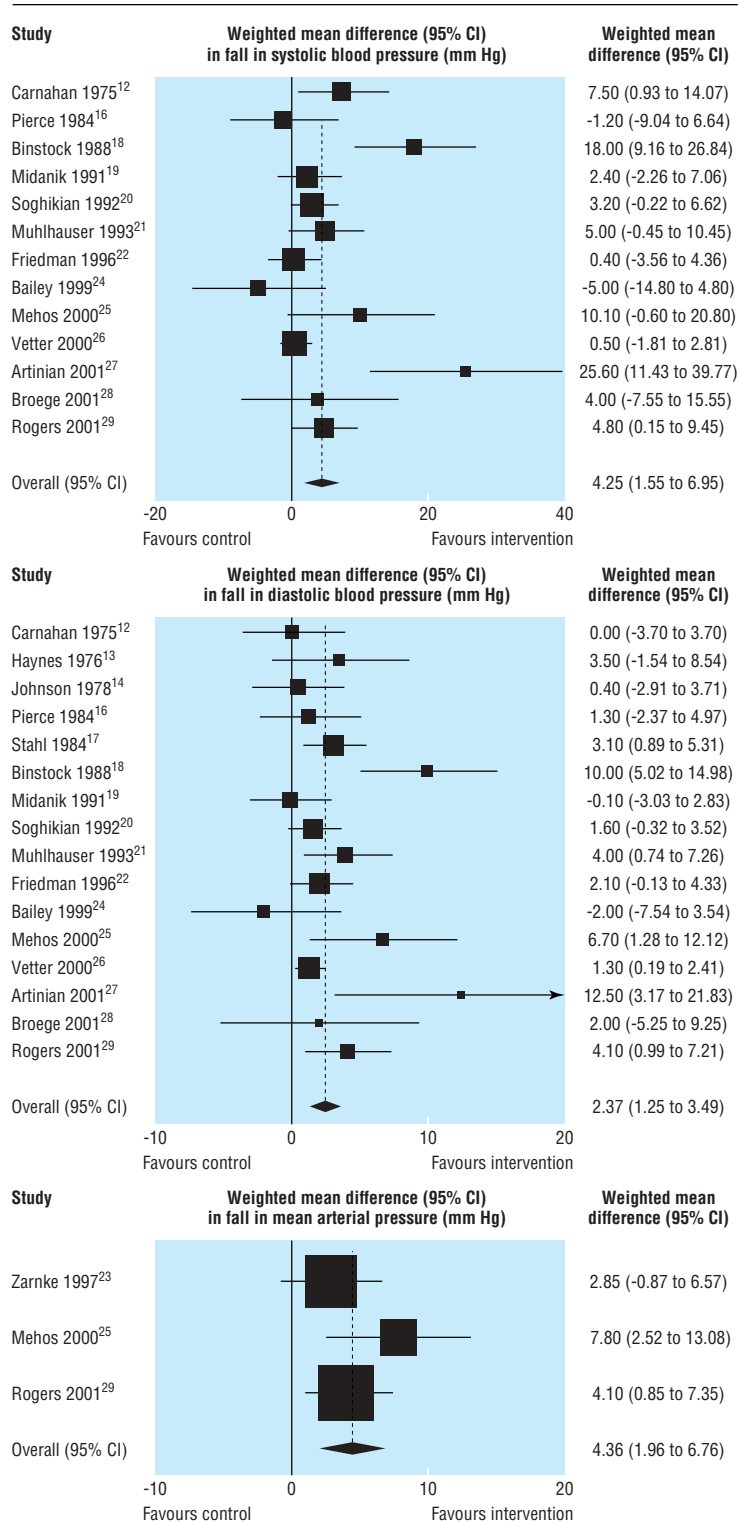


Fig 1 Standardised mean differences (95% confidence interval) in systolic (top), diastolic (middle), and mean (bottom) blood pressures achieved in people monitoring blood pressure at home compared with people whose blood pressure was monitored by health professionals in clinical settings

Outcome measures

We assessed change in blood pressure (systolic, diastolic, and mean) between intervention and control arms as mean (SD) and change in the proportion of people with blood pressure above target. We used target blood pressure as defined in each paper.

Statistical analysis

We used a random effects model. Where standard deviation of the change was not reported or could not be calculated from the 95% confidence interval, we estimated it (see bmj.com). We used relative risk to estimate the effect of intervention on the percentage of patients with blood pressure above target at follow up.

We assessed potential publication bias by using a funnel plot and Egger's test.³⁰ Publication bias is due to small negative studies failing to be accepted for publication, which then causes the funnel plot to display asymmetry. We recalculated the combined estimate after estimating from the asymmetry of the funnel plot the number of "missing" studies and their effect sizes and standard errors, a method known as "trim and fill."^{31 32}

Results

We identified 18 randomised controlled trials that compared blood pressure control or proportion of people with blood pressure above target. Six were based in hospital outpatient clinics,^{12 17 19 20 23 29} eight in communities and general practices,^{14 16 21 22 24-27} and four in mixed settings.^{13 15 18 28} Treatment in the "control" group was mainly "usual" or "standard" care,^{13-17 19 20 22-27 29} but some trials had nurse clinics,^{12 28} educational interventions,¹⁸ or flagged medical records.²¹ Trials used different methods of "home" or "self" blood pressure monitoring. In total, 1359 people were randomised to "home" or "self" blood pressure monitoring and 1355 to a "control" group of blood pressure monitoring by health professionals in clinical settings. Two trials used a factorial design,^{14 16} four had more than two randomised groups,^{15 17 18 27} and one was randomised in clusters.²¹ Only in eight trials was outcome assessment stated to have been blind,^{12-14 22 23 27 29} and only in nine was randomisation concealed.^{13-16 18 19 22 27 29} The duration of the intervention varied between two months²⁹ and 36 months.¹⁷

Systolic blood pressure—The overall effect of the intervention on systolic blood pressure was a reduction of 4.2 (95% confidence interval 1.5 to 6.9) mm Hg, with highly significant heterogeneity between studies ($P < 0.001$) (fig 1, top panel). The funnel plot showed some asymmetry, and Egger's test for publication bias was significant ($P = 0.038$) (fig 2, top panel). The trim and fill method estimated three missing studies and gave a revised estimate of 2.2 (-0.9 to 5.3) mm Hg.

Diastolic blood pressure—The overall effect of the intervention on diastolic blood pressure was a reduction of 2.4 (1.2 to 3.5) mm Hg, with significant heterogeneity between studies ($P = 0.014$) (fig 1, middle panel). The funnel plot showed some asymmetry (fig 2, bottom panel) (Egger's test for publication bias, $P = 0.095$). The trim and fill method estimated two missing studies and gave a revised estimate of 1.9 (0.6 to 3.2) mm Hg.

Mean arterial pressure—The overall effect was 4.4 (2.0 to 6.8) mm Hg, with no significant heterogeneity ($P = 0.319$) (fig 1, bottom panel).

Blood pressure above target—Different definitions of blood pressure control were used (see bmj.com). When compared with the "control" group, the overall relative risk in the intervention group was 0.90 (0.80 to 1.00),

with no significant heterogeneity between studies ($P = 0.34$) (fig 3).

Discussion

Limitations of the study

The studies included in the quantitative review were done in a variety of settings, with different methods, using different criteria and different comparative groups. Any potentially consistent effect might have been underestimated. Furthermore, despite our adjustments with statistical methods, the likelihood of publication bias cannot be excluded. The analysis of hypertension targets may not be easily extrapolated to today's recommended targets of national and international guidelines, because different thresholds were used in different studies.

Implications

Home blood pressure monitoring has been shown to be feasible; acceptable to patients, nurses, and doctors in general practice; and more suitable for the screening of "white coat" hypertension than ambulatory blood pressure monitoring.^{33, 34} The white coat effect is important in the diagnosis and treatment of hypertension, even in a primary care setting, and is not a research artefact.³⁵ Either repeated measurements by the health professional or ambulatory or home measurements may substantially improve estimates of blood pressure and management and control of hypertension. Home blood pressure measurements are the most acceptable method to patients and are preferred to either readings in the surgery or ambulatory monitoring.^{36, 37} They provide accurate blood pressure measurements in most patients, although some

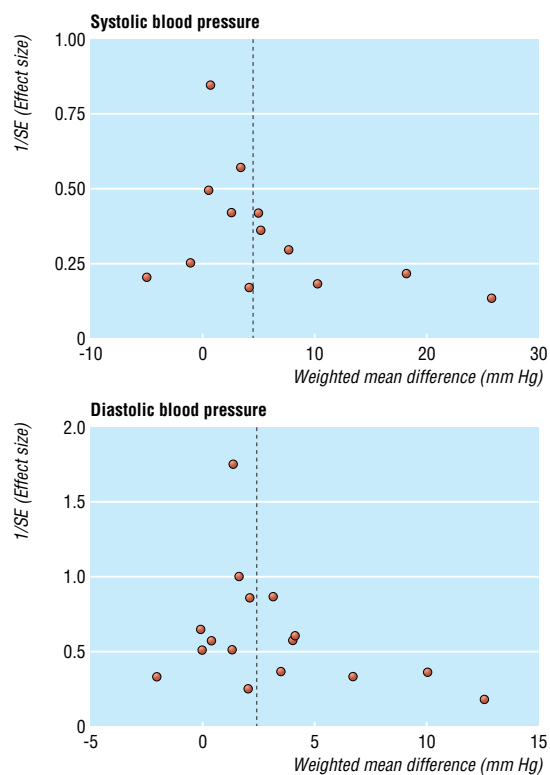


Fig 2 Funnel plots for systolic and diastolic blood pressure

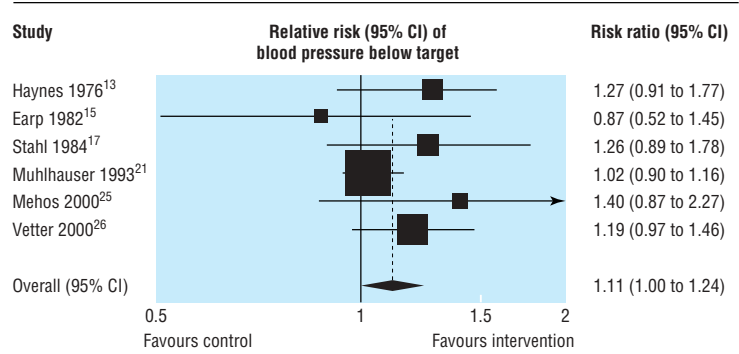


Fig 3 Standardised relative risk of blood pressure above target in people monitoring blood pressure at home compared with people whose blood pressure was monitored by health professionals in clinical settings

patients of low educational level may have poor reporting accuracy.³⁷ Finally, blood pressure monitoring at home might help to improve awareness and concordance, and thus overall effective management.

After we submitted our manuscript, a multicentre randomised trial was published that compared the use of blood pressure measurements taken in the physician's office and at home and the potential impact on the management of hypertension.³⁸ After a year home blood pressure levels were lower than office blood pressures. Adjustment of antihypertensive treatment on the basis of home blood pressure instead of office blood pressure led to less intensive drug treatment and lower costs. Less good blood pressure control as judged by office blood pressure targets was obviously recorded. At variance with this trial, our results indicate that the practice of monitoring blood pressure "at home" leads to a better control of blood pressure "in the clinic." Nevertheless, the results of our systematic review and of the latest trial highlight the need for further evidence from prospective studies of outcome to inform potential modifications of treatment guidelines.

Conclusions

We conclude that blood pressure monitoring by patients at home is associated with better blood pressure values and improved control of hypertension than usual blood pressure monitoring in the healthcare system. It could be considered as a useful, though adjunctive, practice to involve patients more closely in the management of their own blood pressure and help to manage their hypertension more effectively.

FPC is a member of the St George's Cardiovascular Research Group.

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Competing interests: Bazian Ltd is an independent company that specialises in evidence based reviews and training. It has a policy of strict scientific integrity and does not accept contracts that threaten impartiality when assessing and reviewing research. Bazian Ltd provides managing editorship to publications of the BMJ Publishing Group.

Ethical approval: Not needed.

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What is already known on this topic

Blood pressure is usually measured and monitored in the healthcare system by health professionals

With the introduction and validation of new electronic devices, self blood pressure monitoring at home is becoming increasingly popular

No evidence exists as to whether use of home monitoring is associated with better control of high blood pressure

What this study adds

Patients who monitor their blood pressure at home have a lower "clinic" blood pressure than those whose blood pressure is monitored in the healthcare system

A greater proportion of them also achieve blood pressure targets when assessed in the clinic

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Corrections and clarifications

We inadvertently omitted the first author's name in the Dr Foster's Case Notes about social class and elective caesareans, and we also listed the authors in the wrong order (12 June, p 1399). The correct authorship (also amended on bmj.com) is Katherine Barley, Dr Paul Aylin, Dr Alex Bottle, and Professor Brian Jarman.

FDA rejects over the counter status for emergency contraceptive

In this News article by Janice Hopkins Tanne, we stated that levonorgestrel (Levonelle-2) is taken in a split dose—two tablets, 12 hours apart (22 May, p 1219). The manufacturer has informed us that the tablets can now be taken together.

ABC of burns: pathophysiology and types of burns

The first sentence of the section "Electrical injuries" in this article by Shehan Hettiaratchy and Peter Dzielwski (12 June, pp 1427-9) led one reader, a self confessed pedant, to contact us. He rightly objected to the use of the word electrocution (which appeared later too). According to *Chambers 21st Century Dictionary*, "to electrocute" means "to kill someone or something by electric shock." The first sentence should probably more correctly read: "Some 3-4% of burn unit admissions are caused by electrical [not 'electrocution'] injuries." And for any other pedants out there, the phrase "are caused by" might be better replaced with "are the result of."