Does self monitoring reduce blood pressure? Meta-analysis with meta regression of randomised controlled trials.

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Abstract short version

Introduction: Self monitoring of blood pressure (BP) is an increasingly common part of hypertension management. The objectives of this systematic review were to evaluate the systolic and diastolic BP reduction, and achievement of target BP, associated with self monitoring.

Methods: Medline and six other databases were searched for studies where the intervention included self monitoring of BP and the outcome was change in office/ambulatory BP or proportion with controlled BP. Two reviewers independently extracted data. Meta analysis using a random effects model was combined with meta-regression to investigate heterogeneity in effect sizes.

Results: 25 eligible RCTs were identified. Office systolic (20 RCT's, 5898 patients) and diastolic BP (23 RCTs, 6038 patients) were significantly reduced in those who self-monitored compared to usual care (weighted mean difference systolic: -3.82mmHg (95 % CI -5.61, -2.03) /diastolic -1.45 mmHg (-1.95, -0.94)). Self monitoring increased the chance of meeting office BP targets (12 RCTs, 2260 patients; RR = 1.09 (1.02, 1.16)). There was significant heterogeneity between studies for all three comparisons which could be partially accounted for by the use of additional co-interventions.

Conclusion: Self-monitoring reduces blood pressure by a small but significant amount. Meta-regression could only account for part of the observed heterogeneity.

Abstract long version

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Methods: MEDLINE, Embase, Cochrane database of systematic reviews, database of abstracts of clinical effectiveness, the health technology assessment database, the NHS economic evaluation database, and the TRIP database were searched for studies where the intervention included self monitoring of BP and the outcome was change in office/ambulatory BP or proportion with controlled BP. Two reviewers independently extracted data. Meta analysis using a random effects model was combined with meta-regression to investigate heterogeneity in effect sizes.

Results: 25 eligible RCTs (27 comparisons) were identified. Office systolic (20 RCT's, 21 comparisons, 5898 patients) and diastolic BP (23 RCTs, 25 comparisons, 6038 patients) were significantly reduced in those who self-monitored compared to usual care (weighted mean difference (WMD) systolic -3.82mmHg (95 % confidence interval -5.61, -2.03) /diastolic -1.45 mmHg (-1.95, -0.94)). Self monitoring increased the chance of meeting office BP targets (12 RCTs, 13 comparison, 2260 patients, RR = 1.09 (1.02, 1.16)). There was significant heterogeneity between studies for all three comparisons which could be partially accounted for by the use of additional co-interventions.

Conclusion: Self-monitoring reduces blood pressure by a small but significant amount. Meta-regression could only account for part of the observed heterogeneity.

Keywords: Blood Pressure Monitoring, Hypertension, Meta-analysis, Self-Monitoring

Key messages:

1) Self-monitoring of blood pressure results in small reductions in office blood pressure but there is significant heterogeneity of results between studies
2) Metaregression to investigate this heterogeneity found that additional co-interventions such as telemonitoring or education explained part but not all of the heterogeneity in studies with achievement of blood pressure target as their outcome.
3) Other factors not studied may play an important role in the remaining heterogeneity and may be best studied by an individual patient meta-analysis.

Abbreviations

mmHg; Millimetres of Mercury

BP; Blood Pressure

RCT(s); Randomised Controlled Trial(s)

SBP: systolic Blood Pressure

DBP: Diastolic Blood Pressure

WMD; Weighted Mean Difference

ABPM: Ambulatory Blood Pressure Measurement

RR: Relative Risk

Introduction

Hypertension is a key risk factor for cardiovascular disease, the leading cause of death worldwide.[1] Therapeutic reduction of blood pressure leads to significant reduction in both stroke and coronary heart disease risk and is cost effective, especially for individuals at higher risk of cardiovascular events.[2, 3] However, international community based surveys indicate that only a minority of people treated for hypertension are controlled to recommended treatment levels.[4]

Self monitoring of hypertension has been proposed as a method for reducing blood pressure over and above standard care by increasing the involvement of individuals in their own treatment and therefore aiming to increase adherence, reduce clinical inertia and provide patients and professionals with common information about the efficacy of treatment.[5, 6] Self measurement is a better predictor of end organ damage than office measurement [7] and is well tolerated by patients.[8, 9]

Previous systematic reviews have found self monitoring of blood pressure to be associated with lower office systolic blood pressure (around 4 mmHg) as compared to conventional care but also found large variation in effect size with significant heterogeneity between studies.[5, 10] No reviews have reported the effect of self monitoring using ambulatory blood pressure as the outcome. The heterogeneity previously reported may reflect the substantial variation in a number of key variables such as the study setting, the methodologies employed (e.g., length of follow-up, measurement of BP (how, when and by whom), co-interventions, the BP definitions utilised), and the classification criteria for home, self, and usual care. Since these previous meta-analyses were performed, a number of new trials have been published.

The aim of this study was therefore to provide an updated systematic review of the evidence for self monitoring in hypertension and to explore any heterogeneity found using meta regression. The objectives were to determine the effect of self monitoring of blood pressure in adults on blood pressure and blood pressure control, compared to usual care (no self monitoring of BP). The outcomes used were office and ambulatory systolic and diastolic blood pressure, and number of patients meeting office target blood pressure. [The protocol for this review can be found in appendix 1 (include as web appendix)].

Methods

Searching

Electronic databases (Medline, Embase, Cochrane database of systematic reviews, database of abstracts of clinical effectiveness, the health technology assessment database, the NHS economic evaluation database, and the TRIP database) were searched in February 2009 for articles published up to and including January 2009, using a search strategy (Appendix 2) based on those used in previous meta-analyses which was designed to capture all randomised controlled trials (RCTs) concerning self monitoring and self management of hypertension.[5, 10] Additionally, reference lists from included studies and previous meta-analyses were searched. Reference titles and abstracts of publications resulting from the search were scrutinised independently by two reviewers and potentially eligible studies reviewed in detail to assess eligibility.

Selection

RCTs were eligible if the intervention tested included self measurement of BP without medical professional input, if usual care did not include patient self-monitoring, and if

a blood pressure outcome measure was available that had been taken independently of the self measurement (either systolic or diastolic office pressure or ambulatory monitoring (mean day time ambulatory pressure)). Non randomised designs were excluded. No additional quality criteria in terms of methodology or study size were applied.[11]

Data extraction

Data were extracted independently using a coding form [included as web appendix 3] by two reviewers (RM and EB) concerning patient characteristics (gender, age), study characteristics (length of follow up), type of self monitoring (home, community), co-interventions (any procedure over and above self monitoring that was included in the intervention including patient education, nurse led support, telemonitoring), and outcomes (see below). Where data were missing from published reports, for instance standard deviations of change, authors were contacted to request such information. Where studies reported more than one outcome time (e.g. 6 and 12 months), data concerning the longest follow up was extracted. In cases of disagreement that could not be resolved by consensus, a third reviewer (JM) adjudicated.

Outcomes

The outcomes assessed were change in mean office SBP and DBP, change in mean day-time ambulatory SBP and DBP between baseline and follow up for both intervention and control arms, and change in proportion of people with office measured BP controlled below target between intervention and control arms. Data were also collected on whether adjustments were made for self-monitored readings compared to office readings.

Quantitative data synthesis

Analyses were performed with STATA 10.1 (Statacorp) using a random-effects model (metan command). Weighted mean differences (WMD) were calculated for the overall mean change in systolic and diastolic blood pressure (both office and ABPM) between intervention and control, with relative risk (RR) used when percentage of patients with BP above target at final follow-up was reported. The weighting depended on the standard deviation of the change in BP from baseline to final reading and this value was not always reported but standard deviations at baseline and final measurements were given. Elementary theory of differences of correlated variables was used to estimate the standard deviation of change on those occasions. The correlation between baseline and final result was estimated from studies where all three standard deviations were reported and then used in conjunction with the latter two standard deviations to estimate the standard deviation of change when not available. Where either of the latter two standard deviations were missing then an average value from the other studies was imputed. [The data used and an explanation of the standard deviation estimation can be found in web appendix 4].

Clinical heterogeneity was assessed using a chi-square test for systematic variation and I^2. Heterogeneity was further explored using meta-regression with backward elimination to analyse the associations between treatment effect and the study characteristics (metareg command). Where a significant moderator of the heterogeneity was found, studies were grouped using this moderator and if heterogeneity of effect size persisted with respect to blood pressure change, further meta regression was performed within groups. A priori, on the basis of results from

previous studies suggesting an effect on outcome, we included terms for age (continuous) and sex of participants,[12, 13] length of follow up (continuous),[6] use of additional co-interventions (where these were part of the intervention in addition to self monitoring),[10] adjustment made for self-monitored BP readings, and inclusion criteria for diastolic blood pressure (DBP of ≥90 v ≥95 mmHg) in the regression models.[5] Meta-regression was not used for the ambulatory BP outcome, due to the small number of studies involved. A series of sensitivity analyses were performed to assess the impact of each study on the overall outcome with recalculation of both the weighted mean differences and meta regression as each study was removed one at a time from the analysis. A specific sensitivity analysis considered whether studies with multiple arms influenced the degree of heterogeneity as measured by I^2.

Publication bias was assessed by producing funnel plots of effect size and of sample size against WMD to provide a visual review of any potential bias.

Results

The search results are presented in Figure 1. Of 630 studies included in the original search results, 25 studies including 27 comparisons were eligible for the meta analysis (Table 1). Two studies included three arms and so were included twice.[14, 15] Of these, 20 RCTs (21 comparisons, 5898 patients) contained extractable data on change in office systolic blood pressure, 23 RCTs (25 comparisons, 6038 patients) data for change in office diastolic blood pressure, 12 RCTs, (13 comparisons, 2260 patients) data for achievement of office blood pressure target and three studies for change in mean day time ambulatory BP (SBP and DBP) (3 comparisons, 572 patients).

Nine studies included follow up of one year or more and the mean age of participants ranged from 47 to 77 with 18 studies having a mean age of less than 60 (table 1). Six studies included 200 or more patients per randomised group. Thirteen studies included no additional intervention other than self monitoring. Additional co-interventions over and above self monitoring included patient education (7 studies), phone contact or home visits (7 studies), family involvement (1 study) and telemetry (6 studies). Seven studies included more than one additional co-intervention. The treating physician was aware of self blood pressure readings in 16 studies.

Office Systolic Blood Pressure

Systolic blood pressure was significantly reduced in those who received self-monitoring compared to usual care (weighted mean difference = -3.82mmHg, (95 % CI -5.61 to -2.03) Figure 2). However, there was a high level of heterogeneity between the studies (I^2 = 71.9%, p<.001). Subsequent meta-regression demonstrated that of the six variables investigated as moderators for this heterogeneity, none approached significance (Table 2).

Sensitivity analyses, which examined the influence of each individual study on the overall effect size estimate by removing each study in turn from the analysis, revealed a range of weighted mean differences of between -3.14 and -4.11 mmHg, with no single study affecting the overall heterogeneity. In particular the Green study which was included twice did not have any distorting effect.

Office Diastolic Blood pressure

Diastolic blood pressure was significantly reduced in those who received self-monitoring compared to usual care (weighted mean difference = -1.45mmHg (95 % CI -1.95 to -0.94), Figure 3). Again, there was significant (albeit this time moderate) heterogeneity between the studies (I^2 = 42.1%, p<0.01). Meta-regression demonstrated that none of the six variables investigated as moderators approached significance (Table 2).

The range of weighted mean differences seen in the sensitivity analysis removing each study in turn from the analysis was between -1.23 and -1.62 mmHg. On five occasions, removing a single included study had an effect on the resultant meta-analyses and meta-regressions of the remaining studies: with Haynes[16] removed gender approached significance as a moderator (p=0.075) and with Binstock,[17] Green (a),[14] Parati[18] and Marquez-Contreras[19] removed, co-interventions approached significance as a moderator (p=0.056, p=0.069, p = 0.05, p=0.091, respectively). A sensitivity analysis of the two trials included twice examining their effect on z scores and I^2 was consistent with the magnitude of the individual effect sizes and suggested no distortion caused by including both arms of these trials.

Office Target Blood Pressure

Self monitoring of blood pressure (12 RCTs, 13 comparisons) increased the chance of meeting target compared to usual care (relative risk = 1.09 (95% CI 1.02 to 1.16), Figure 4). There was significant heterogeneity between the studies (I^2 = 73.6%, p <.01) which was moderated by the presence of a co-intervention (t = 2.39, p<0.05) in the meta-regression (Table 2). Where self monitoring was accompanied by an additional co-intervention, participants were more likely to meet target BP compared

to where there was none (RR = 1.34, (95% CI 1.2 to 1.51), vs RR = 0.98, (95% CI 0.91 to 1.05)). However, none of the other included moderators could explain the heterogeneity which remained in both groups.

Sensitivity analyses showed that removing each study individually made little difference to the overall relative risk (range 0.97 to 1.03). None of these analyses affected the remaining heterogeneity in the relative risk.

Fewer than half of the studies reported achievement of target blood pressure as an outcome. To determine if there was bias related to choice of outcome, the SBP and DBP office analyses were re-run including only those studies that also reported target BP. These analyses had little impact on the overall effect size (SBP WMD = -3.2mmHg (95% CI -5.65 to -0.75), DBP WMD = -1.45mmHg (95% CI -2.57 to -0.47)) suggesting little if any bias in terms of chosen outcome for the target analysis.

Day-time Ambulatory Blood Pressure

Mean day-time ambulatory blood pressure was reduced but not significantly in those who received self-monitoring compared to usual care (three studies, weighted mean difference = SBP: -2.04mmHg (95 % CI -4.35 to 0.27), I^2 <0.05%, p=0.89 figure 5a, and DBP: -0.79mmHg (95% CI -2.35 to .77), I^2 <0.05% p=0.96), figure 5b). The I^2 suggested homogeneity but has limited power with only three studies. Sensitivity analyses removing each study in turn showed that the Parati study (which included telemonitoring)[18] had the greatest effect altering the WMD by about 0.5 mmHg in both the SBP and DBP analyses. However, none of these analyses altered the non-

significant nature of the results. An analysis for target ambulatory BP was not undertaken as these data were only reported in the Parati study.

Publication Bias

Funnel plots [see web appendix 5] imply several unpublished negative studies may exist but that these are likely to have small (<100) sample sizes and thus little effect on the overall results.

Discussion

This review has found that self monitoring has a small but significant effect on blood pressure control: As with previous meta-analyses, significant heterogeneity was apparent between all studies with office blood pressure as the outcome.[5, 10] Meta-regression to investigate this heterogeneity was not explanatory for the comparisons with office blood pressure as an outcome but sensitivity analyses considering office diastolic pressure showed that five studies individually influenced this heterogeneity. In four cases absence of these studies resulted in co-interventions becoming a significant moderator of this heterogeneity. In the case of the target blood pressure analysis, meta-regression showed that studies including additional co-interventions were more likely to result in blood pressure control and that this explained some but not all of the heterogeneity. Where ambulatory blood pressure was the end point, a smaller and non significant reduction in daytime ambulatory blood pressure was observed. This may reflect a lack of power with only three studies included.

This meta-analysis, unlike previous work, provides some explanation of the heterogeneity observed between studies, particularly in terms of the co-interventions

used.[5, 10] The range of co-interventions utilised in the included trials was wide and included patient education, health professional support (phone calls, pharmacist involvement, additional clinic visits or home visits), patient led drug titration, techniques designed to increase medication compliance, and use of a website and telemonitoring with automated feedback. It is perhaps unsurprising that these could enhance the effect of self monitoring given that multi faceted interventions are more likely to result in improvements in outcome, and this was seen definitively in the target blood pressure analysis.[20]

Blood pressure drops with repeated measurement,[21] and it has been previously suggested that habituation to measurement might be the mode of action of self monitoring. The smaller effect size seen in the ambulatory monitoring analysis provides some support for this argument, but included only three studies hence should be interpreted with caution.[18, 22, 23] Furthermore, if habituation had a large effect it might have been expected that the length of study would have moderated some of the heterogeneity in the meta regression, but this was not observed.

The recent scientific statement from the American Heart Association, American Society for Hypertension and Preventive Cardiovascular Nurses Association recommends that the target self blood pressure goal for treatment is <135/85mmHg or <130/80mmHg in high-risk patients.[24] The evidence underlying these recommendations is not robust: the majority of trials included in this meta-analyses report target “office blood pressure” of 140/85-95 mmHg but many do not explicitly state whether the same target levels were applied to the self monitoring. The importance of this can be seen from the results from the THOP trial where the same

target was used for both self and office measurements and it was found that basing treatment decisions on self readings led to higher blood pressures than basing them on office readings.[25]

The current paper includes more than double the number of patients in previous meta-analyses and has resulted in a reduction in the point estimates of effect size for both systolic and diastolic blood pressure. The relatively small effect of self monitoring is likely to result in a lack of power in most included studies (only one of which had enough patients to detect a 3mmHg difference between groups). This fact, along with the evidence from the funnel plots, increases the possibility of unpublished negative studies such as has been postulated previously.[5]

Despite a range of potential moderators chosen *a priori* to explore the heterogeneity between studies including age, sex, length of follow up, and inclusion diastolic blood pressure, observed heterogeneity remained largely unexplained by this analysis which suggests that other factors may play a role. Possibilities which might be further investigated include: the timing of self monitored readings (variation of blood pressure during the day may impact on patient's perceptions of their BP), the setting of self monitoring (home, at a GP surgery or in the community), and changes in treatment during the study. Further work should also explore the types of co-interventions and how differing combinations of these might optimise the impact on reducing BP and helping patients reach target levels. This might best be done in an individual patient data meta analysis.

Conclusion

Self monitoring of blood pressure has a small but significant effect on reduction of office blood pressure when compared to usual care. Co-interventions explain part of the observed heterogeneity between studies which used achievement of target blood pressure as an outcome but most remains unaccounted for. Future investigators should consider carefully the design of their intervention and the use of outcomes such as ambulatory monitoring that are less likely to be affected by habituation to blood pressure measurement.

Contributorship

EB, RM and JM performed the searches and extracted the data. EB, RM and RH performed the analyses. All authors participated in the writing of the final document and approved the final version. RM will act as guarantor for the study.

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Competing interests

The authors declare that they have no competing interests regarding this paper

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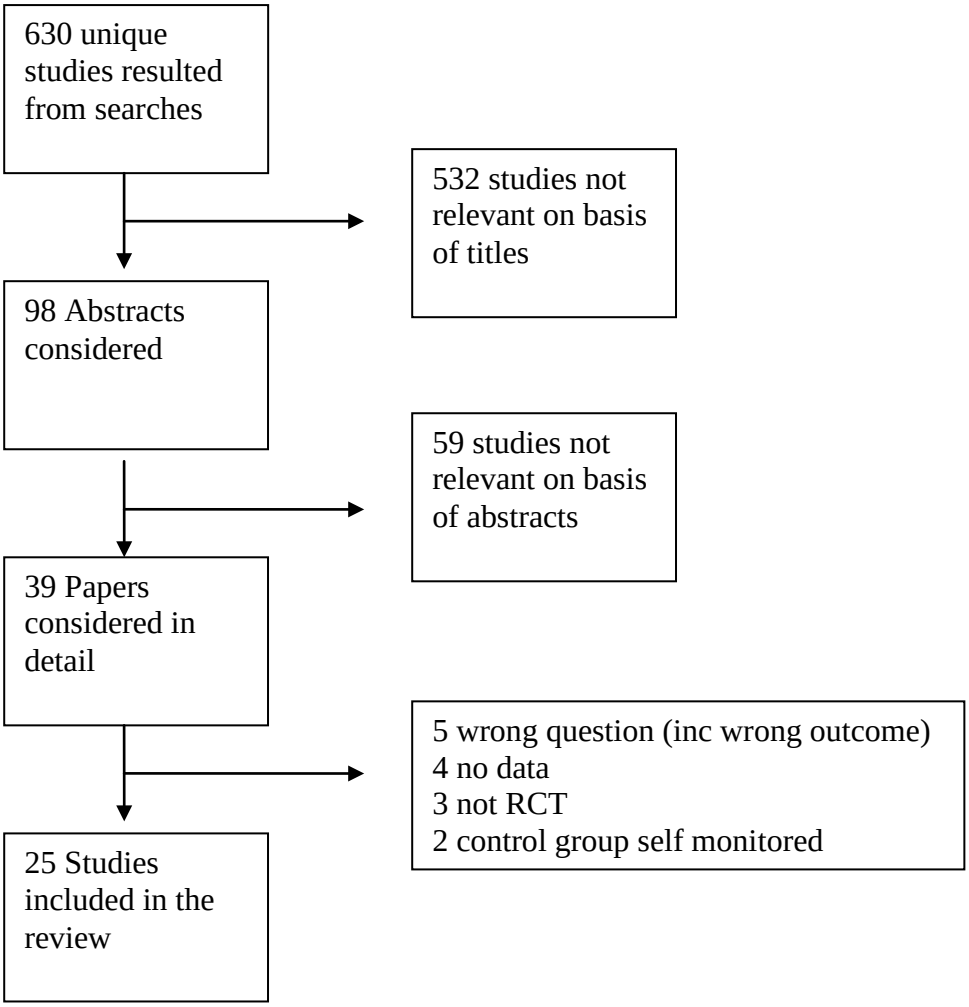

Figure 1 Flow chart of search results

Figure 2: Overall Office Systolic BP results

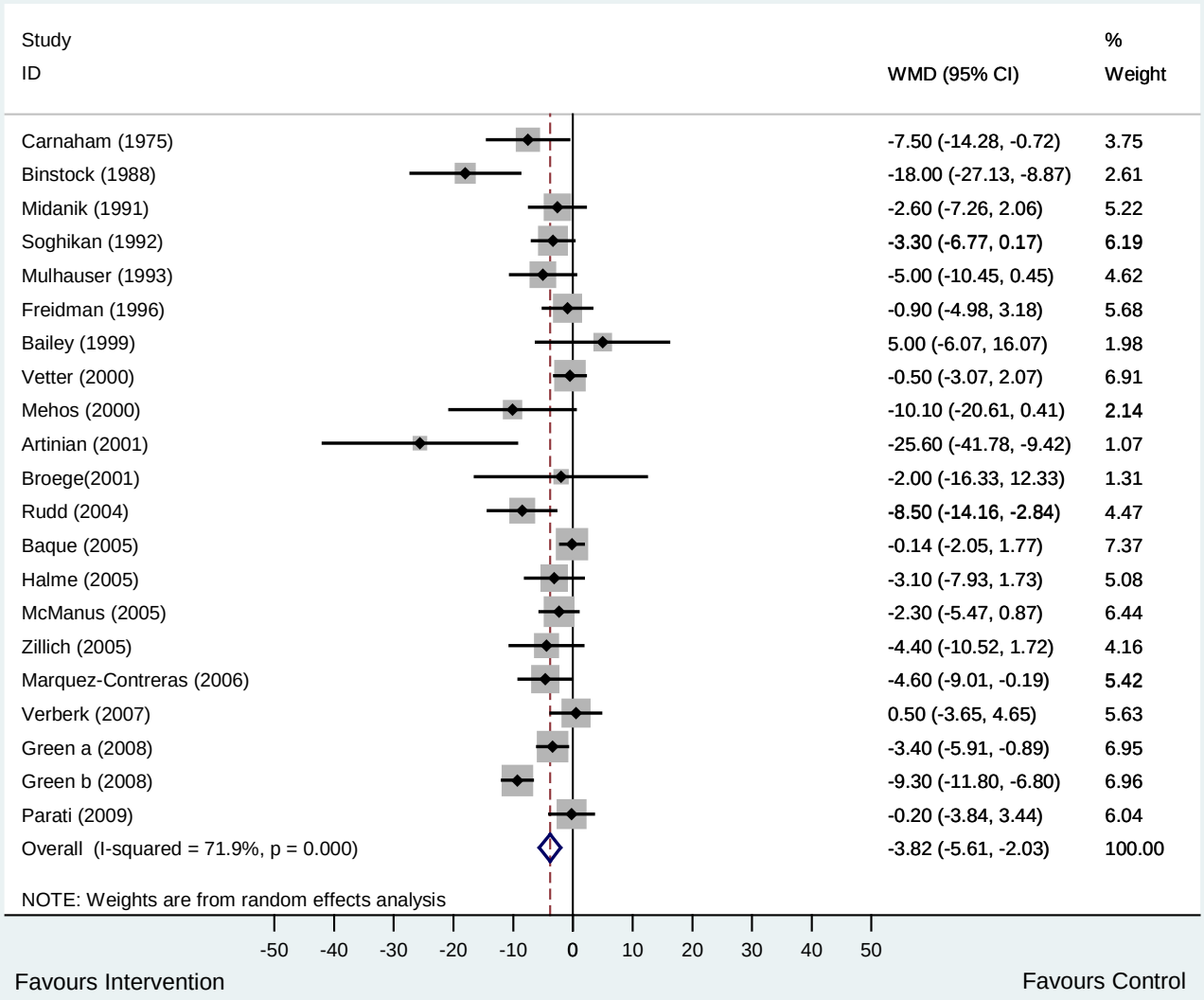

Figure 3:Overall Office Diastolic BP results

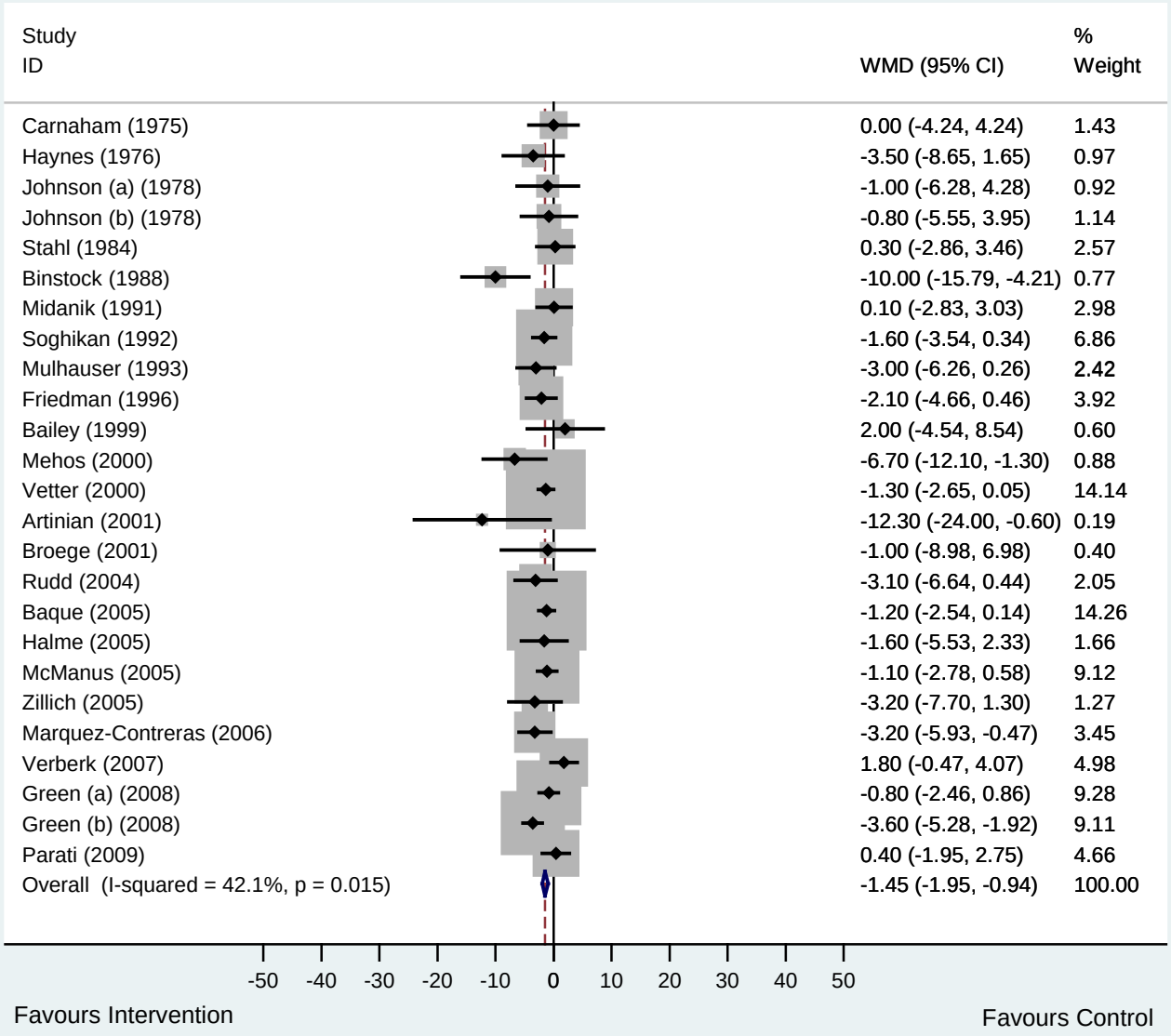

Figure 4: Office Target BP results

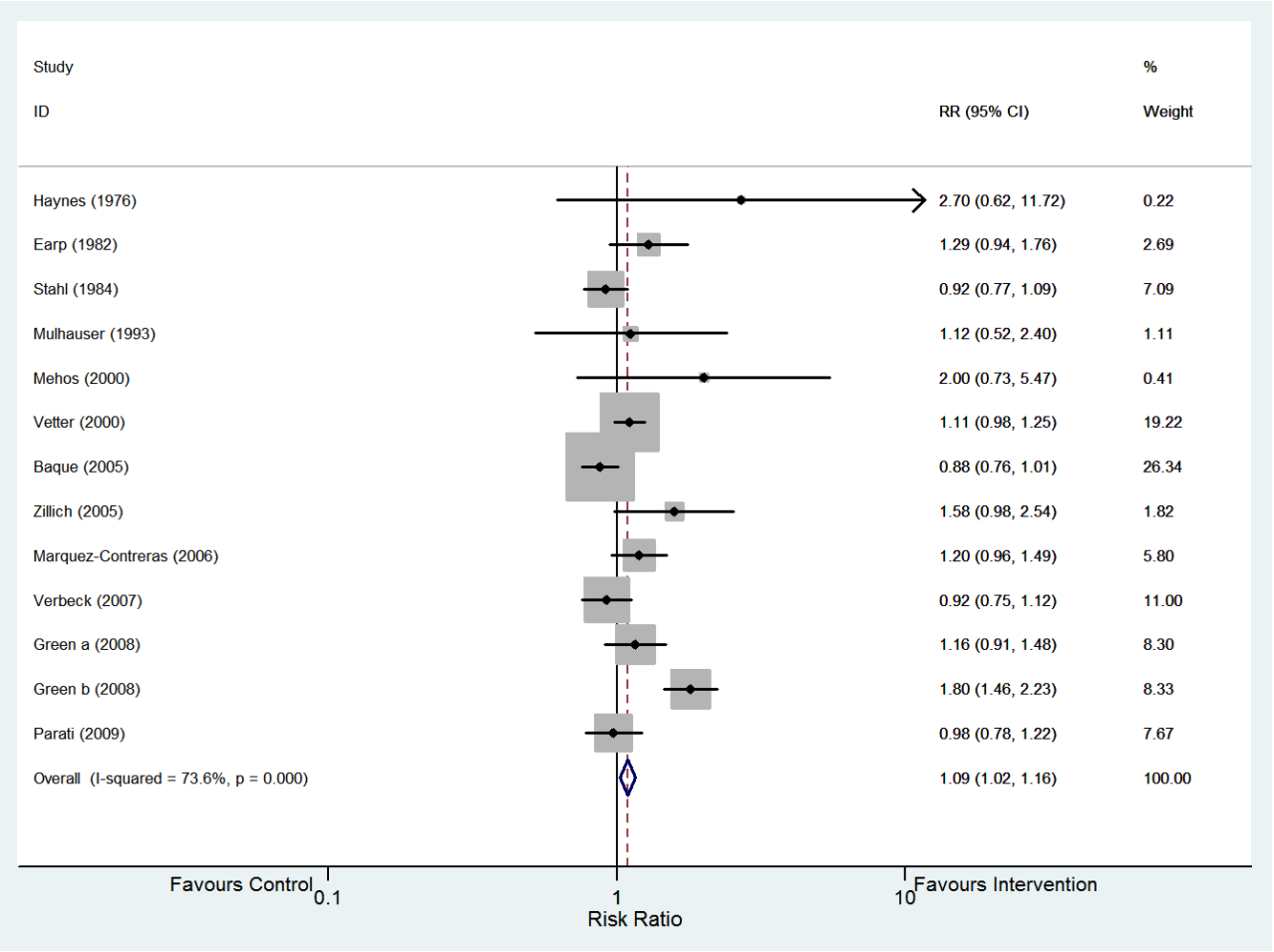

Figure 5a: Daytime Ambulatory SBP results

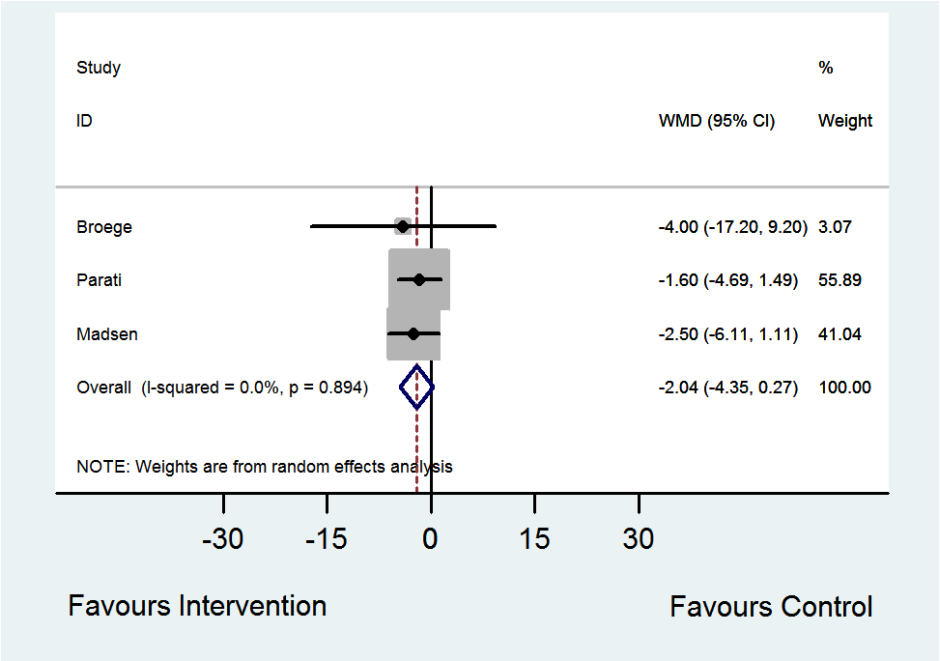

Figure 5b: Daytime Ambulatory DBP results

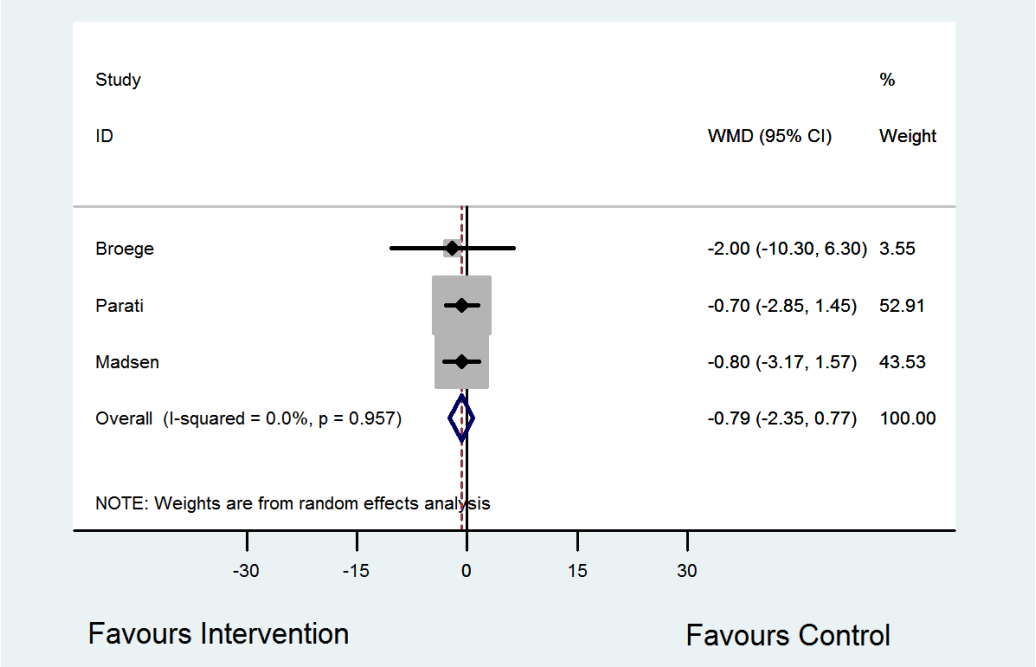

Table 1 Summary of randomised studies of self monitoring of blood pressure

Study	Setting and subjects	Mean Age (years)	Intervention subjects	Control Subjects	Length of follow up	Type & frequency of BP self measurement	Description of the control group	Intervention group regimen over and above control plus self-monitoring	Adjustment made for self-measurement readings	Was physician adjusting medication aware of self measurement readings?
Carnahan 1975 US [26]	Hospital clinic, patients starting treatment for hypertension, with DBP≥90	55	49	48	2-8 clinic visits per 6 months	Manual sphyg with built in stethoscope Twice daily (upper arm)	Medication adjustment by fixed titration schedule based on clinic BP values done by nurse	No additional co-intervention	None specified	No: Nurse run clinic blind to home BP
Haynes 1976 US [16]	Non compliant men recruited via workplace screening programme; DBP ≥ 90mmHg following initial treatment	No age quoted	20	18	0 & 6 months	Manual anaeroid Daily (upper arm)	Not specified	Patient education and tailored to their rituals	None specified	Not clear
Johnson a * 1978 Canada [15]	Subjects recruited from screening in local shopping centre, DBP ≥95 mmHg despite treatment	54	36	36	0, 2wks, & 6 months	Manual sphyg Daily (upper arm)	Neither home visits or self-recording	No additional co-intervention	None specified	Yes
Johnson b* 1978 Canada[15]	Subjects recruited from screening in local shopping centre, DBP ≥95 mmHg despite treatment	54	35	36	0, 2wks, & 6 months	Manual sphyg Daily (upper arm)	Neither home visits or self-recording	Home visits every 4 weeks	None specified	Yes

Study	Setting and subjects	Mean Age (years)	Intervention subjects	Control Subjects	Length of follow up	Type & frequency of BP self measurement	Description of the control group	Intervention group regimen over and above control plus self-monitoring	Adjustment made for self-measurement readings	Was physician adjusting medication aware of self measurement readings?
Earp 1982 US [27]	Treated hypertensives with a medication change in previous 2 mths recruited from hospital and community clinics	48	99	63	24 months; 5-6 visits	Sphygmomanometer type unclear	Routine medical care	Home visit and significant others involved	None specified	Not clear
Stahl 1984 US [28]	Hospital clinic. Raised DBP under care of nurse practitioner	47.5	144	173	36 months, variable number of visits	Mercury Sphyg	Not specified	No additional co-intervention	None specified	yes
Binstock 1988 US [17]	Treated hypertensives	Not stated	23	32	0 & 12 months	Not stated. Readings done at home	Education programme	educational programme plus self-monitoring	None specified	Not stated
Midanik 1991 US [29]	Untreated with BL DBP 90-95mmHg and SBP< 180mmHg	47	102	102	0 & 12 months	Digital device. 2 consecutive readings, twice a week	Usual care	No additional co-intervention	None specified	Yes
Soghikhan 1992 US [12]	Health Maintenance Organisation Centres. Hypertension patients	54	215	215	0 & 12 months	Electronic sphyg Twice weekly	Usual care	No additional co-intervention	None specified	Yes

Study	Setting and subjects	Mean Age (years)	Intervention subjects	Control Subjects	Length of follow up	Type & frequency of BP self measurement	Description of the control group	Intervention group regimen over and above control plus self-monitoring	Adjustment made for self-measurement readings	Was physician adjusting medication aware of self measurement readings?
Muhlhauser # 1993 Germany [30]	Primary Care. BP> 160 and/or 95mmHg	51	86	74	0 & 18 months	Twice daily until satisfactory values achieved then less frequently	Normal care	Patient education	None specified	Yes
Friedman 1996 US [31]	Community physicians' clinics. Treated hypertensives with SBP ≥ 160mmHg and/or DBP ≥ 90mmHg	77	133	134	0 & 6 months	Automated Weekly (?upper arm)	Usual care	Patient education and telemetry	None specified	"TLC" data transmitted to patient's own physician
Bailey 1999 Australia [32]	Primary care. Hypertensive patients not practising self-measurement, with or without current treatment	55	31	29	0 & 8 weeks	Electronic Twice daily (upper arm)	ACE inhibitor or diuretic	No additional co-intervention	None specified	Yes
Vetter 2000 Switzerland [33]	Primary care. Newly diagnosied or known hypertensives with BP 160/200/ 95-215mmHg	58	296	326	0, 2 & 8 weeks	Automated (wrist) Twice daily	Losartan 15mg	No additional co-intervention	None specified	Not applicable (patients were only reviewed at the beginning and end of the 8 week study period)

Study	Setting and subjects	Mean Age (years)	Intervention subjects	Control Subjects	Length of follow up	Type & frequency of BP self measurement	Description of the control group	Intervention group regimen over and above control plus self-monitoring	Adjustment made for self-measurement readings	Was physician adjusting medication aware of self measurement readings?
Mehos 2000 US [34]	Primary care patients with treated hypertension and BP between 140-179/90-109mmHg	59	18	18	0 & 6 months	Manual electronic Daily Upper arm	Routine care with no restrictions on number of office visits.	Phone call from pharmacist	None specified	Yes
Artinian 2001 US [35]	Family Community Centre. African-American men and women with BP≥ 140 and/or 90 (diabetic range ≥ 130/85)	59	6	9	0 & 3 months	Electronic, at home, minimum 3 times/week	Usual care; visits to primary care provider at intervals requested by the primary care provider.	Telemetry, patient education and nurse visit	None specified	Yes
Broege 2001 US [22]	Hypertension centre or community health centre. Hypertensive patients with BP< 150/90 if on treatment or >150/90 off treatment	73	20	20	0, 1, 2 & 3 months	Semi-automatic, 3 times morning and evening	Usual clinic treatment	Monthly clinic visit and nurse phone call	No adjustment	Yes

Study	Setting and subjects	Mean Age (years)	Intervention subjects	Control Subjects	Length of follow up	Type & frequency of BP self measurement	Description of the control group	Intervention group regimen over and above control plus self-monitoring	Adjustment made for self-measurement readings	Was physician adjusting medication aware of self measurement readings?
Rudd 2004 US [36]	Primary Care clinics. Hypertensive patients with BP ≥ 140/90 or on anti-hypertensives, eligible for treatment under JNC VI criteria	59.5	74	76	0, 3, & 6 months	Automated, twice daily, at home	Routine care as received before study	Patient education and nurse phone call	Adjustment of 10/5mmHg	Yes
Baque # 2005 Spain [37]	Primary Care centres. Hypertensive patients with BP ≥ 140/90mmHg	61	622	703	0, 6, 8, 14, 16 & 24 wks	Automated, 15 days at weeks 6-8, and 14-16. 3 measurements in morning prior to medication, 2 in evening prior to supper.	None specified	No additional co-intervention	None specified	Encouraged to share with physician.
Halme 2005 Finland [38]	Primary Health Care. Patients with essential hypertension, taking anyti-hypertensive treatment or BP ≥ 140/90	57	113	119	0 & 6 months	Automatic home readings. 1 week every 2 months, twice daily	Usual care; at regular local practice	No additional co-intervention	Adjustment of 5/5mmHg	Yes

Study	Setting and subjects	Mean Age (years)	Intervention subjects	Control Subjects	Length of follow up	Type & frequency of BP self measurement	Description of the control group	Intervention group regimen over and above control plus self-monitoring	Adjustment made for self-measurement readings	Was physician adjusting medication aware of self measurement readings?
McManus 2005 UK [6]	Primary Care. Treated hypertensives with BP 140-200/85-100mmHg	62	214	227	0, 6, & 12 months	Electronic Upper Arm monthly in practice waiting room	Usual care	No additional co-intervention	No adjustment	Patients encouraged to share readings (approx 50% did)
Zillich # 2005 US [39]	Community pharmacies. Treated hypertensives with BP 145-179/95-109 (diabetic = 135-179/90-109mmHg)	65	64	61	0, 4, & 12 wks	Automatic. 2 readings separated with 5 min rest, once daily in the morning	3 pharmacy visits over 3mths where BP measured nad referred to physician if >140/90mmHg	Patient education. Additional visit to implement treatment developed based on self readings.	No adjustment	Yes
Marquez-Contreras 2006 Spain [19]	Primary care centres. Mild-moderate hypertension, requiring treatment (not all on treatment at BL)	59	100	100	0, 1, 3, & 6 months	Automatic. 3 days a week, twice before breakfast and twice before supper	Usual treatment from GP	No additional co-intervention	None specified	No, readings given to investigator who altered medications.
Verberk 2007 Netherlands [13]	Setting, not clear. Office BP>139 and/or 89mmHg	55	214	216	0 & 12 months	Automated. 6 times a day for 7 days	Step-wise anti-hypertensive treatment based on office readings.	No additional co-intervention	No adjustment	Yes

Study	Setting and subjects	Mean Age (years)	Intervention subjects	Control Subjects	Length of follow up	Type & frequency of BP self measurement	Description of the control group	Intervention group regimen over and above control plus self-monitoring	Adjustment made for self-measurement readings	Was physician adjusting medication aware of self measurement readings?
Green* a 2008 USA [14]	Medical Centres. Uncontrolled treatment hypertension	59	259	258	0 & 12 months	Automated. At least two days per week, twice per occasion	Usual care	Received hypertension pamphlet and patient web-site pamphlet Use of website plus patient education	Adjustment of 5/5mmHg	Yes
Green * b 2008 USA [14]	Medical centres. Uncontrolled treatment hypertension	59	261	258	0 & 12 months	Automated. At least two days per week, twice per occasion	Usual care	Received hypertension pamphlet and patient web-site pamphlet Use of website and pharmacist plus patient education	Adjustment of 5/5mmHg	Yes
Madsen 2008 Denmark [23]	General practices. Newlty diagnosed or treated but not controlled, office BP >150/95mmHg	56	113	123	0 & 6 months	Semi-automatic. 3x/wk in 1st 3 months, then once a wk during last 3 months. 3 readings each time.	Usual care	telemonitoring	Adjustment of 5/5mmHg	yes
Parati 2009 Italy [18]	Uncontrolled essential hypertension, BP ≥ 140/90, plus ABPM≥ 130/80 with or without treatment	57.5	187	111	0, 4, 12 & 24 wks	Variable	Office based BP management	Nurse phone call and telemetry	Adjustment of 5/5mmHg	yes

*study had three groups so included twice, once for each comparison Sphyg = sphygmomanometer # studies were cluster randomised by practice

Table 2: Results from the main meta-regression analyses.

Systolic Office Meta-regression				
	Overall backward elimination model			Single moderator model
Moderator	Coeff	p	95% CI	p
Follow-up	-0.17	0.57	-0.77 to .44	0.42
Age	0.39	0.31	-0.40 to 1.18	0.80
Male	0.09	0.43	-0.14 to .31	0.66
DBP	0.50	0.88	-6.55 to 7.56	0.93
Co-Interventions	-4.10	0.25	-11.47 to 3.26	0.28
Adjusted BP	-2.16	0.56	-9.89 to 5.56	0.48
constant	-24.65	0.28	-72.06 to 22.75	
Diastolic Office Meta-regression				
	Overall backward elimination model			Single moderator model
Moderator	Coeff	p	95% CI	p
Follow-up	0.04	0.68	-0.16 to 0.24	0.55
Age	0.02	0.90	-0.26 to 0.30	0.22
Male	0.04	0.31	-0.04 to 0.12	0.22
DBP	-0.41	0.75	-3.04 to 2.24	0.59
Co-Interventions	-1.67	0.24	-4.52 to 1.19	0.13
Adjusted BP	-0.96	0.52	-3.99 to 2.10	0.83
constant	-2.57	0.77	-20.06 to 15.09	
Target Office Meta-regression				
	Overall backward elimination model			Single moderator model
Moderator	Coeff	p	95% CI	p
Follow-up	-0.0002	0.99	-0.06 to 0.06	0.65
Age	0.008	0.83	-0.08 to 0.10	0.43
Male	-0.005	0.72	-0.04 to 0.03	0.60
DBP	-0.087	0.81	-0.94 to 0.76	0.92
Co-Interventions	0.41	0.14	-0.17 to 0.99	0.04
Adjusted BP	0.19	0.54	-0.52 to 0.90	0.33
constant	-0.60	0.84	-7.31 to 6.12	

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