Research Square

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Effectiveness of a smartphone application (“BP Fit”) for community-based management of hypertension in urban primary care: a quasi-experimental study

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Abstract

Background

Hypertension affects an estimated 1.3 billion adults worldwide and is poorly controlled in low- and middle-income countries such as India, where sustained self-management and adherence are major challenges. Mobile health (mHealth) tools may support hypertension control, but robust evaluations from Indian primary care are scarce. This study evaluated the effectiveness of a comprehensive smartphone application, “BP Fit,” on blood pressure, medication adherence, quality of life and lifestyle behaviours.

Methodology:

A quasi-experimental study was conducted with 272 hypertensive patients attending an urban health centre in Mysuru, India, over six months. Participants were allocated to an experimental group using BP Fit plus standard care (n = 136) or a control group receiving standard care alone (n = 136). Blood pressure was measured monthly for six months; medication adherence (Hill-Bone scale) and quality of life (WHOQOL-BREF) were assessed before and after the intervention, and lifestyle behaviours were compared. Data were analysed with independent t-tests, chi-square tests and Mann-Whitney U tests.

Results

By six months, the experimental group had significantly lower blood pressure than controls (systolic median 130 vs 147.5 mm Hg; diastolic 80 vs 90 mm Hg; both $p < 0.001$), whereas control blood pressure did not improve. Medication adherence was higher in app users (post-test median 31 vs 29; $p < 0.001$), and all four quality-of-life domains were significantly better at post-test (all $p < 0.001$). App users also reported greater adherence to dietary restriction (63.2% vs 29.4%), lower smoking (19.9% vs 45.6%) and lower alcohol use (23.5% vs 47.1%) (all $p < 0.001$). The groups differed at baseline in age and marital status.

Conclusion

Use of the BP Fit application over six months was associated with improved blood-pressure control, medication adherence, quality of life and healthier lifestyle behaviours among hypertensive patients. These findings support the potential of comprehensive mHealth interventions to strengthen hypertension management in Indian primary care, while baseline group differences warrant confirmation in a randomised trial.

Introduction

Non-communicable diseases are the leading cause of death worldwide, and raised blood pressure is the single largest modifiable contributor to cardiovascular morbidity and mortality. The World Health Organization estimates that about 1.3 billion adults live with hypertension, more than three-quarters of them in low- and middle-income countries [1–3]. Control remains inadequate: nearly half of affected adults are unaware of their condition, only about two in five are treated, and roughly one in five achieve control below 140/90 mmHg [1].

India carries a disproportionate share of this burden, with adult prevalence of about 25–30% and awareness, treatment and control lagging behind global targets despite programmes such as the India Hypertension Control Initiative [4–6]. Effective management depends on sustained lifestyle modification - including the Dietary Approaches to Stop Hypertension (DASH) pattern, salt restriction, physical activity, and reduced tobacco and alcohol use - and on pharmacological therapy with good adherence [7–9]. Yet non-adherence and difficulty sustaining lifestyle change are principal reasons blood pressure remains uncontrolled even when treatment is prescribed [8].

Because most people with hypertension in India are detected and followed up outside tertiary hospitals, community-based and decentralised models of care are increasingly recognised as central to closing this treatment gap. Delivering screening, monitoring and long-term management within communities - through primary health centres, urban field-practice areas and, increasingly, non-physician health workers - can improve accessibility, strengthen patient engagement, and support continuity of care. Understanding how such community-based delivery shapes uptake, adherence and the sustainability of hypertension care is essential for successful implementation and scale-up. Digital health tools, including mobile health (mHealth) applications and telemonitoring, are well suited to extend the reach of community-based care and to support education and behavioural change, yet important evidence gaps remain regarding their effectiveness, scalability and integration into routine health systems, particularly in low-resource settings.

Trials and meta-analyses indicate that smartphone-based interventions can improve medication adherence and, in several studies, lower blood pressure [10–16]. However, effects are heterogeneous, most applications focus narrowly on blood-pressure logging, and rigorous evaluations delivered within Indian community primary care remain scarce [12]. Building on our group's programme of developing and validating context-appropriate smartphone applications - including applications for chemotherapy adherence [20] and adolescent mental health [21] - and on the development and pilot validation of the BP Fit application, we conducted a six-month quasi-experimental study to evaluate the effectiveness of BP Fit, versus standard care alone, on blood pressure, medication adherence, quality of life and lifestyle behaviours among hypertensive patients attending a community-based urban primary-care clinic in Mysuru, India. By evaluating a locally developed, comprehensive application delivered within routine field-practice care, the study contributes to the evidence on scalable, community-based digital models for hypertension control, in line with Sustainable Development Goal 3 (good health and well-being).

Methodology

Study design and setting

This quasi-experimental study was conducted over six months in the non-communicable disease clinic of an urban health training centre attached to the Department of Community Medicine, JSS Medical College, Mysuru, Karnataka, which serves a defined field-practice population that includes approximately 712 hypertensive patients on regular follow-up.

Participants and group allocation

Adults older than 18 years with diagnosed hypertension, receiving antihypertensive medication, owning and able to use a smartphone, and providing informed consent were eligible. Patients with severe complications, terminal or bed-bound illness, or psychological conditions that could compromise study rigour were excluded. Participants were recruited by purposive sampling and allocated to an experimental group using the BP Fit application in addition to standard care (n = 136) or a control group receiving standard care alone (n = 136), giving a total of 272 participants (Fig. 1).

Sample size

The sample size was calculated to detect the expected mean differences in systolic and diastolic blood pressure between groups (− 3.4 and − 0.5 mm Hg, respectively) reported by McManus et al. [10], with 80% power and a 5% two-sided significance level, yielding at least 120 participants per group. Allowing for a 10% dropout, 136 participants were required in each group (272 in total).

Intervention: the BP Fit application

The experimental group used BP Fit, a comprehensive Android application for hypertension self-management developed through a structured, user-centred process and validated in an earlier phase of this work. It integrates a personal profile, entry of pulse rate and blood pressure (including contactless camera-based pulse measurement), medication logging with reminders, diet-intake and daily calorie reporting, physical-activity tracking, goal setting, data visualisation and hypertension education (Fig. 2). Participants installed the application, received brief training, and were encouraged to record their readings and use the self-management features throughout the six-month period; the application is available on the Google Play Store.

Outcomes and measures

The primary outcome was blood pressure, measured with a standardised technique at monthly clinic visits over six months. Secondary outcomes were medication adherence, assessed with the Hill-Bone Compliance to High Blood Pressure Therapy Scale [18]; health-related quality of life, assessed with the

WHOQOL-BREF across four domains (physical, psychological, social and environmental) [19]; and lifestyle behaviours, including adherence to dietary restriction, diet type, smoking, alcohol use and physical activity. Data were collected using a structured study proforma developed by the investigators for this study, which captured sociodemographic details, clinical profile, anthropometry, personal and past medical history, and lifestyle behaviours, and which incorporated the previously validated and published Hill-Bone Compliance to High Blood Pressure Therapy Scale [18] and the WHOQOL-BREF [19]. The full proforma is provided as Additional file 1.

Data analysis

Data were entered in Microsoft Excel and analysed with SPSS version 26. Continuous variables are summarised as mean ± standard deviation or median (interquartile range, IQR) according to distribution, and categorical variables as frequencies and percentages. Independent-samples t-tests were used for normally distributed continuous variables, chi-square tests for categorical variables, and Mann-Whitney U tests for non-normally distributed variables including blood pressure, adherence and quality-of-life scores. All tests were two-tailed with significance set at $p < 0.05$. Key analyses were verified by independent re-computation from the raw participant-level data.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of JSS Medical College, JSSAHER, Mysuru [JSS/MC/PG/IEC-85/2022-23]. Written informed consent was obtained from all participants before enrolment.

Results

All 272 enrolled participants (136 per group) completed the six-month follow-up with no loss to follow-up. The experimental group was significantly older than the control group (mean 53.2 vs 46.3 years; $p < 0.001$), and the groups differed in marital status ($p = 0.001$), with more married participants in the experimental group. The groups were otherwise comparable in gender, body mass index, waist–hip ratio, comorbidities, education, occupation and duration of hypertension and treatment (all $p > 0.05$) (Table 1).

Table 1
Baseline sociodemographic and clinical characteristics of the study participants and between-group comparability.

Parameter	Exp n	Exp %	Ctrl n / %	p-value
Age, years (mean ± SD)	53.2 ± 12.3		46.3 ± 15.1	< 0.001
Gender				
Male	79	58.1%	78 / 57.4%	0.902
Female	57	41.9%	58 / 42.6%	
BMI category				
Underweight	16	11.8%	14 / 10.3%	0.469
Normal	35	25.7%	43 / 31.6%	
Overweight	19	14.0%	24 / 17.6%	
Obese	66	48.5%	55 / 40.4%	
Abnormal waist–hip ratio	31	22.8%	27 / 19.9%	0.554
Comorbidities				
None	94	69.1%	108 / 79.4%	0.239
Diabetes	36	26.5%	24 / 17.6%	
CVD / dyslipidaemia / thyroid	6	4.4%	4 / 2.9%	
Marital status				
Married	108	79.4%	82 / 60.3%	0.001
Unmarried	6	4.4%	28 / 20.6%	
Widowed / divorced / separated	22	16.2%	26 / 19.1%	
Duration of hypertension				
< 5 years	91	66.9%	80 / 58.8%	0.205
5–10 years	30	22.1%	43 / 31.6%	
> 10 years	15	11.0%	13 / 9.6%	
Education				
Illiterate / primary	80	58.8%	68 / 50.0%	0.526
Secondary / higher	56	41.2%	68 / 50.0%	

Values are frequency (n) and percentage (%) unless stated otherwise; age is mean ± SD. p-values from the chi-square test (categorical) or independent-samples t-test (age). p < 0.05 is significant.

Lifestyle behaviours

Lifestyle behaviours differed markedly between the groups. Participants using BP Fit were more than twice as likely to follow dietary restriction (63.2% vs 29.4%; p < 0.001) and predominantly followed a mixed diet (91.2% vs 44.9%; p < 0.001). Current smoking was substantially lower in app users (19.9% vs 45.6%; p < 0.001), as was current alcohol use (23.5% vs 47.1%; p < 0.001). Daily physical activity did not differ significantly between the groups (p = 0.110) (Table 2).

Table 2
Lifestyle behaviours in the experimental and control groups.

Lifestyle behaviour	Exp n	Exp %	Ctrl n / %	p-value
Following diet restriction (DASH)	86	63.2%	40 / 29.4%	< 0.001
Mixed (non-vegetarian) diet	124	91.2%	61 / 44.9%	< 0.001
Current smoker	27	19.9%	62 / 45.6%	< 0.001
Current alcohol use	32	23.5%	64 / 47.1%	< 0.001
Physical activity > 30 min/day	54	39.7%	39 / 28.7%	0.110

Values are frequency (n) and percentage (%). p-values from the chi-square test; p < 0.05 is significant.

Blood pressure over six months

Blood pressure diverged progressively between the groups over the six-month period (Table 3, Fig. 3). In the experimental group, median systolic blood pressure fell from 140 mm Hg at month 1 to 130 mm Hg at month 6, and median diastolic blood pressure from 90 to 80 mm Hg (both within-group reductions p < 0.001). In the control group, systolic blood pressure did not improve and rose to a median of 147.5 mm Hg by month 6, while diastolic pressure remained at 90 mm Hg. Between-group differences became statistically significant and widened over time, reaching p < 0.001 for both systolic and diastolic blood pressure at month 6 (Mann-Whitney U test).

Table 3
Monthly systolic and diastolic blood pressure by group over six months.

Timepoint	Exp median	IQR	Ctrl median	IQR	Between-group p
Systolic blood pressure (mm Hg)					
Month 1	140	25	130	30	0.002
Month 2	140	20	134	29	0.080
Month 3	138	22	140	30	0.768
Month 4	135.5	17	139	16	0.571
Month 5	130	17	142.5	28	0.001
Month 6	130	14	147.5	30	< 0.001
Diastolic blood pressure (mm Hg)					
Month 1	90	10	90	18	0.172
Month 2	88	10	90	6	0.005
Month 3	88	9	89.5	19	0.024
Month 4	86.5	10	90	16	0.001
Month 5	83	8	90	16	< 0.001
Month 6	80	8	90	18	< 0.001

Values are median (IQR) in mm Hg. Between-group p-values from the Mann-Whitney U test; p < 0.05 is significant.

Medication adherence and quality of life

Medication adherence improved more in app users, whose post-test median Hill-Bone score reached 31 (IQR 3) compared with 29 (IQR 5) in controls ($p < 0.001$). Health-related quality of life was significantly better in the experimental group at post-test across all four WHOQOL-BREF domains - physical, psychological, social and environmental (all $p < 0.001$) - with the experimental group improving on every domain while the control group showed little or no change in the physical and social domains (Table 4, Fig. 4).

Table 4
Medication adherence and WHOQOL-BREF quality-of-life scores before and after the intervention, with between-group comparison at post-test.

Measure	Exp baseline	Exp post	Ctrl baseline	Ctrl post	p (post)
Hill-Bone adherence	27 (4)	31 (3)	27 (6)	29 (5)	< 0.001
WHOQOL-BREF domains					
Physical	63 (13)	69 (12)	56 (13)	56 (19)	< 0.001
Psychological	63 (25)	69 (25)	56 (19)	63 (19)	< 0.001
Social	69 (13)	69 (6)	56 (19)	56 (19)	< 0.001
Environmental	66 (25)	75 (25)	63 (19)	63 (13)	< 0.001

Values are median (IQR). Between-group p-values (post-test) from the Mann-Whitney U test; p < 0.05 is significant.

Discussion

In this six-month quasi-experimental study of 272 hypertensive patients, use of the BP Fit application alongside standard care was associated with clinically important improvements in blood-pressure control, medication adherence, quality of life and lifestyle behaviours relative to standard care alone. The divergence in blood pressure was particularly striking: median systolic pressure in app users fell by about 10 mm Hg while control values drifted upward, producing a large and highly significant between-group difference by six months.

Blood-pressure control

The blood-pressure findings are consistent with, and at the larger end of, the effects reported in the mHealth literature. Meta-analyses have concluded that smartphone-based and mobile self-management interventions can significantly reduce systolic and diastolic blood pressure [14,15], and self-monitoring with feedback improved control in the TASMINH4 trial [10]. The magnitude observed here may reflect the multicomponent nature of BP Fit - combining monitoring, reminders, education and lifestyle support - and the progressive divergence over months is biologically plausible for a behaviourally mediated intervention. The upward drift of control-group blood pressure also underscores the difficulty of maintaining control with usual care alone in this setting.

Adherence, quality of life and lifestyle

Improved medication adherence among app users accords with randomised trials and meta-analyses of hypertension applications [13,14,16] and with our group's earlier findings in cancer and mental-health applications [20,21]. The consistent gains across all quality-of-life domains extend previous reports that comprehensive applications improve patient-reported outcomes [12,17]. App users also reported

healthier lifestyles - greater dietary restriction and lower smoking and alcohol use - which are central to non-pharmacological blood-pressure control [7,9] and plausibly contributed to the blood-pressure differences; the app's diet, activity and education modules provide a mechanism for these changes.

Implications for community-based hypertension care and scale-up

These findings are directly relevant to community-based and decentralised models of hypertension care. BP Fit was delivered within a routine urban field-practice setting rather than a specialised hospital clinic, indicating that a comprehensive, locally developed application can be embedded in community primary care to support monitoring, adherence and lifestyle change close to where patients live. Because the tool is self-contained and runs on a common smartphone platform, it is potentially scalable to other primary health centres and to delivery supported by non-physician health workers, and could be integrated with existing national efforts such as the India Hypertension Control Initiative [6]. Realising this potential will require attention to digital equity for patients without smartphones, adequate training and supervision of frontline staff, and formal evaluation of cost-effectiveness, resource requirements and implementation strategies - evidence that is essential to guide sustainable scale-up and integration into routine health systems and to advance the targets of Sustainable Development Goal 3. Future work should therefore include a formal cost-effectiveness analysis and an implementation evaluation - assessing resource requirements, delivery by non-physician health workers, and integration into routine primary care - to inform sustainable scale-up; such an evaluation is planned as the next phase of this programme.

Strengths and limitations

Strengths include a relatively large sample of 272 participants, a six-month follow-up with monthly blood-pressure measurement, complete follow-up with no attrition, use of validated adherence and quality-of-life instruments, and independent re-computation of the analyses. The principal limitation is the quasi-experimental design without randomisation: the groups differed at baseline in age and marital status, and the marked between-group differences in lifestyle behaviours may partly reflect selection or unmeasured confounding rather than the intervention alone, so causal inference should be cautious. The intervention was unblinded and several lifestyle outcomes were self-reported, raising the possibility of social-desirability bias, and the single urban site with a smartphone-ownership requirement limits generalisability to rural and lower-resource populations. An adequately powered randomised controlled trial with adjustment for baseline differences and objective adherence measures is warranted to confirm these findings.

Conclusion

Over six months, use of the BP Fit smartphone application was associated with significantly better blood-pressure control, medication adherence, quality of life and lifestyle behaviours among hypertensive patients than standard care alone. Delivered within routine community primary care, these results add to the growing evidence that comprehensive, locally developed mHealth tools can strengthen

decentralised hypertension management in India, and they justify a larger randomised trial - with evaluation of cost-effectiveness and implementation - to establish efficacy and guide scale-up while accounting for baseline group differences.

Abbreviations

BP
blood pressure
SBP
systolic blood pressure
DBP
diastolic blood pressure
mHealth
mobile health
NCD
non-communicable disease
NP-NCD
National Programme for Prevention and Control of Non-Communicable Diseases
QoL
quality of life
WHOQOL-BREF
World Health Organization Quality of Life brief instrument
DASH
Dietary Approaches to Stop Hypertension
IQR
interquartile range
SD
standard deviation
IEC
Institutional Ethics Committee.

Declarations

Ethics approval and consent to participate The study was approved by the Institutional Ethics Committee, JSS Medical College, JSS Academy of Higher Education and Research (JSSAHER), Mysuru [JSS/MC/PG/IEC-85/2022-23], and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment.

Consent for publication Not applicable.

Availability of data and materials The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests The authors declare that they have no competing interests.

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Authors' contributions RA conceived the study, collected data, and drafted the manuscript. DSK, HPG, and AG contributed to the study design, methodology, supervision, and critical revision of the manuscript. VA developed the BP Fit mobile application, contributed to visualization and software validation, and assisted in manuscript revision. DY contributed to data interpretation and manuscript editing. RM assisted in participant recruitment and data collection. All authors read and approved the final manuscript.

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Figures

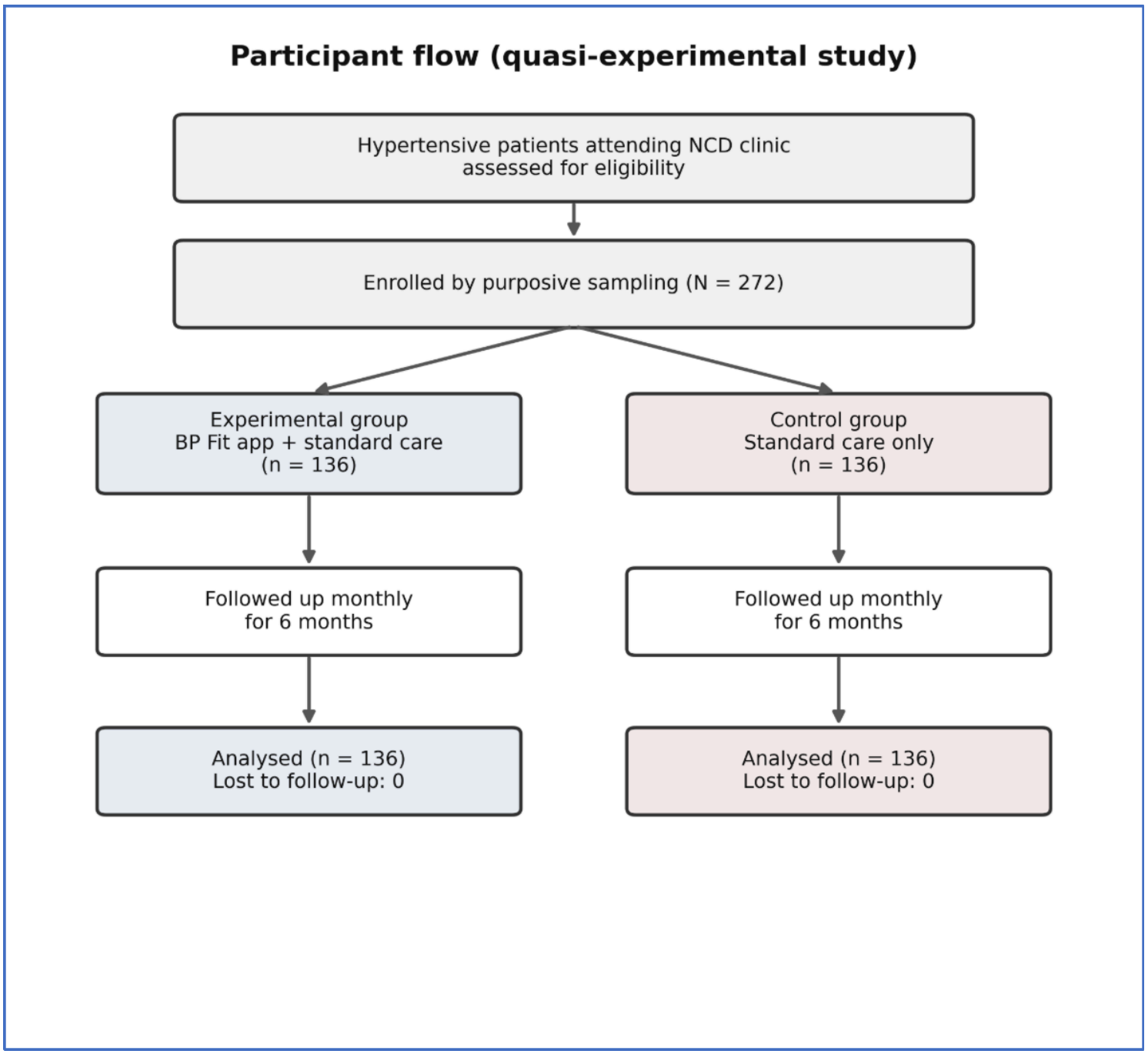
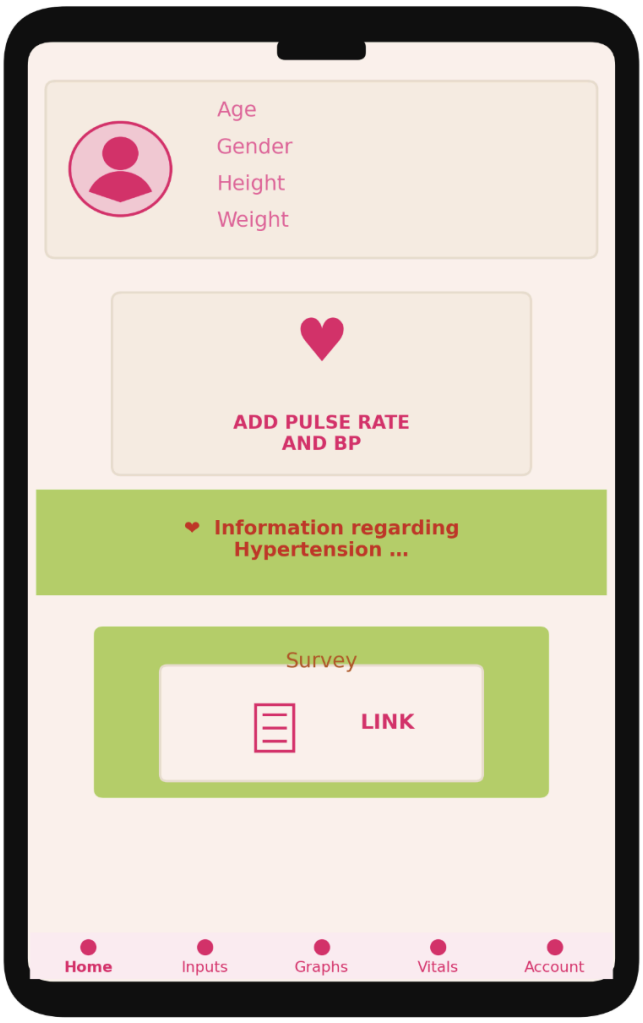
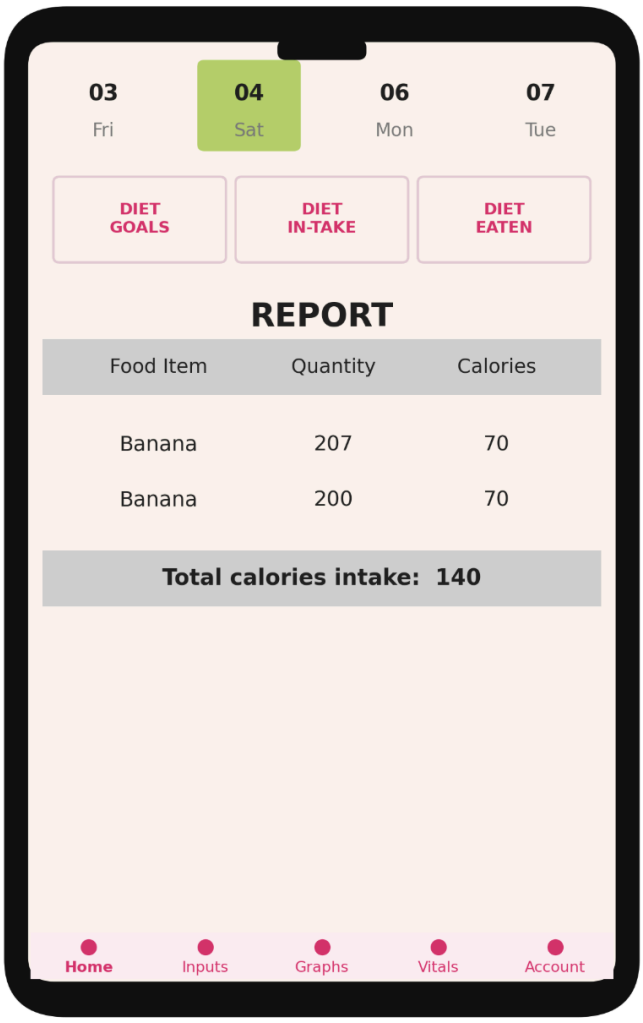


Figure 1

Flow of participants through the six-month quasi-experimental study.



(a) Home — profile, vitals entry, education, survey



(b) Daily diet report — intake and calories

Figure 2

Screenshots of the BP Fit application: (a) home screen with profile, vitals entry, hypertension education and survey; (b) daily diet report showing food intake and calories.

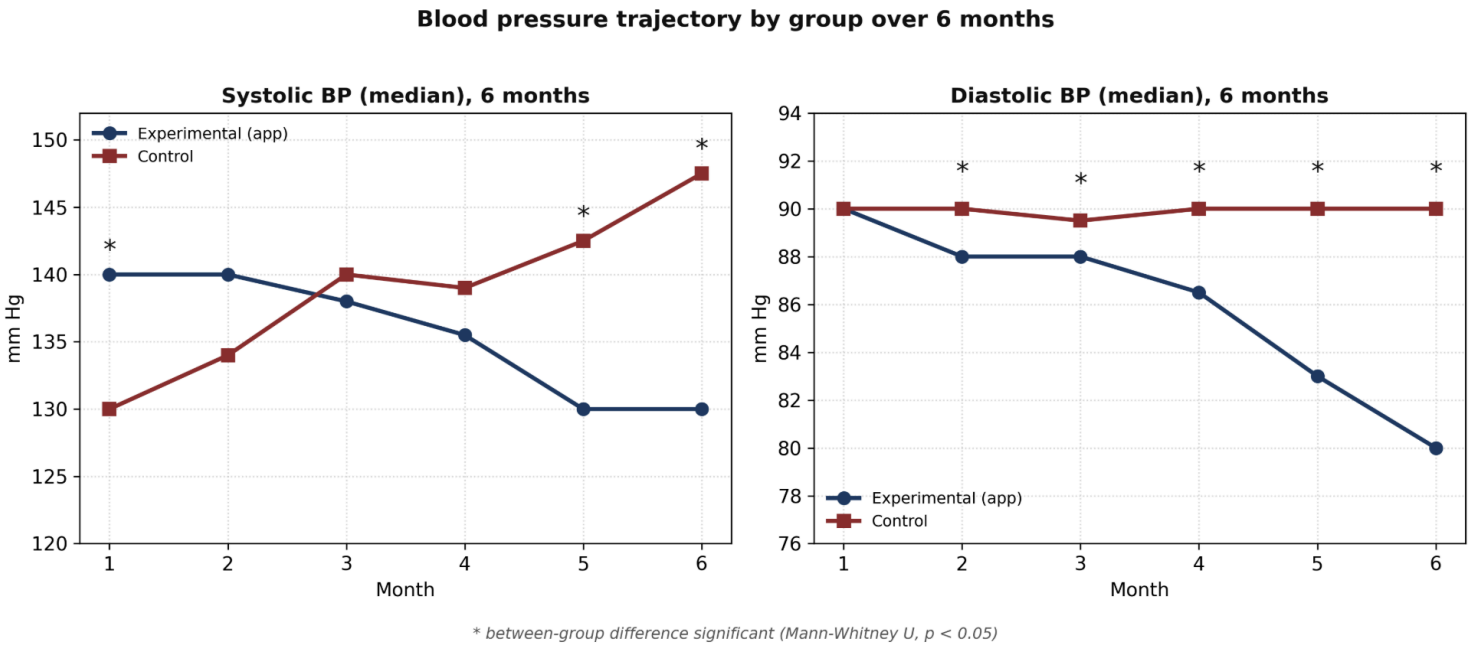


Figure 3

Median systolic and diastolic blood-pressure trajectories by group over six months; asterisks mark months with a significant between-group difference.

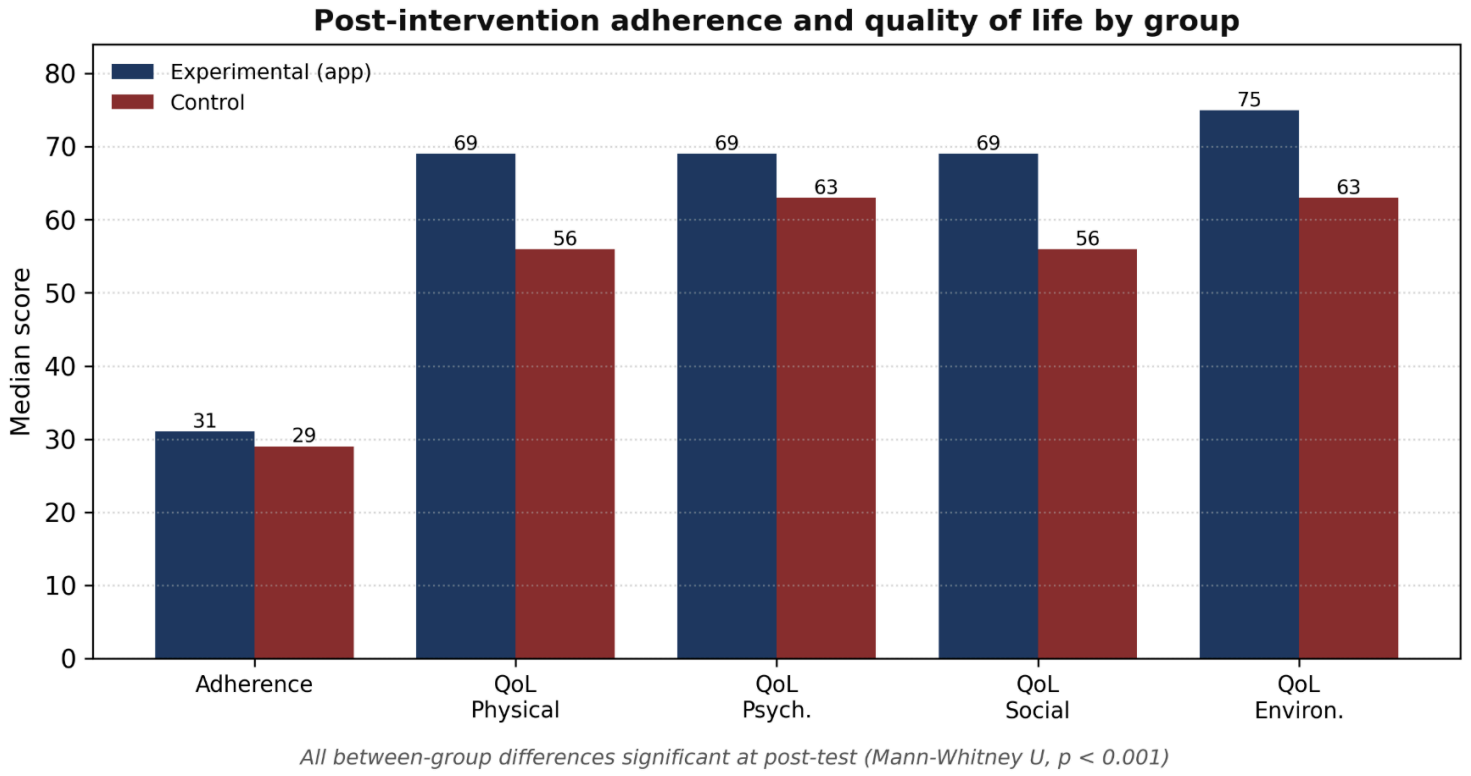


Figure 4

Post-intervention medication adherence and WHOQOL-BREF domain scores by group.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Additionalfile1StudyQuestionnaire.pdf