Title:

Beetroot supplementation lowers daily systolic blood pressure in older, overweight subjects

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Abstract

Although inorganic nitrate and beetroot juice supplementation are associated with decreased systolic blood pressure (BP), these results have primarily been obtained fromshort-term trials that focused on healthy young adults. Therefore, we hypothesized that oral supplementation of beetroot juice concentrate would decrease systolic BP in overweight older participants but that the decline in BP would not be sustained after a 1-week interruption of the beetroot juice supplementation. For 3 weeks, 24 participants were randomized to either the beetroot juice concentrate or blackcurrant juice group, with a 1-week postsupplementation phase (week 4). Changes in systolic and diastolic BP were assessed during the supplementation and postsupplementation phases. Blood pressure was measured using 3 different methods: (1) resting clinic BP, (2) 24-hour ambulatory BP monitoring, and (3) home monitoring of daily resting BP. The first 2 methods were applied at baseline and after weeks 3 and 4. Daily measurements were conducted throughout the study, with 21 subjects completing the study (beetroot/blackcurrant = 10/11; male/female = 12/9; age = 62.0 ± 1.4 years; body mass index =

30.1 ± 1.2 kg/m2). After 3 weeks, beetroot juice supplementation was not associated with significant changes in resting clinic BP or 24-hour ABPM. Conversely, beetroot juice concentrate reduced daily systolic BP after 3 weeks (−7.3 ± 5.9 mm Hg, P = .02); however, the effect was not maintained after the interruption of the supplementation (week 4, 2.8 ± 6.1mm Hg, P = .09). In overweight older subjects, beetroot juice concentrate supplementation was associated with beneficial effects on daily systolic BP, although the effects were not significant when measured by 24-hour ABPM or resting clinic BP.

Trial registration: ISRCTN85926713

Keywords: ageing, blood pressure, obesity,,beetroot juice concentrate, inorganic nitrate, cardiovascular risk, Human

1. Introduction

High blood pressure (BP) is responsible for nearly 5% of the global disease burden and an important risk factor for cardiovascular diseases [1–3]. The risk of hypertension is increased among elderly and overweight individuals [4,5]. Results from the 2009 Health Survey for England reported that 47% of women and 51% of men 55 and 64 years of age were classified as hypertensive [6].

Initiatives that target modifiable risk factors, such as diet, tobacco use, and physical activity levels, are important for the prevention and management of high BP [5]. Recent studies attribute the beneficial BP-lowering effects of dietary patterns, such as the Dietary Approach to Stop Hypertension (DASH) approach, to an increased intake of inorganic nitrate [7]. A recent meta-analysis of 16 trials showed that inorganic nitrate and beetroot juice supplementation were associated with a significant reduction in systolic BP (−4.4 mm Hg), whereas no significant effect was observed for diastolic BP [8]. The trials were generally characterized by a short duration (from 1 to 15 days) and predominantly focused on young subjects. The majority of these studies reported beneficial effects on resting clinic BP. However, no effects have been shown in studies on type 2 diabetic patients evaluating BP with 24-hour ambulatory BP monitoring (ABMP) [9].

In this study, we hypothesized that oral supplementation of beetroot juice concentrate would decrease systolic BP in overweight older participants and that the effect on BP would be independent of the BP measurement protocol (clinic, 24-hour ambulatory, daily). We also conjectured that the decline in BP would not be sustained after a 1-week interruption of the beetroot juice supplementation. To test our hypothesis, a 3-week supplementation periodwith beetroot juice concentrate was implemented among older, overweight participants. We investigated whether potential changes in BP were sustained after the disruption of beetroot supplementation. Three established methods were used for the measurement of BP (ie, resting clinic BP, 24-hour ABPM, and home daily BP monitoring) to minimize the confounding influence of the research environment on BP readings and to assess within-day (24-ABMP) and between-day (daily monitoring) changes in BP.

2. Methods and materials

2.1 Subjects: A total of 24 nonsmoking subjects (13men/11 women), between 55 and 70 years of age and with body mass indexes (BMIs) between 25 and 40 kg/m2, were recruited between March and December 2013. Participants were excluded if they had medical conditions (ie, diabetes, cancer, systemic inflammatory disorders) or were taking medications (ie, organic nitrates, corticosteroids, diuretics, hormonal therapies,weight lossmedications) that could interfere with the nutritional intervention and study outcomes. In addition, subjects were excluded if they were vegetarian, they reported alcohol intake greater than 21 U/wk for men and 14 U/wk for women, or their body weight had changed more than 3 kgwithin the lastmonth. Written informed consent was obtained from all participants prior to participation in the study. The study was approved by the Newcastle University Medical Ethics Committee.

2.2 The study was a 28-day, 2-arm, parallel, randomized clinical trial. Participants and researchers were not blind to the study interventions. A block randomization procedure was used to generate the randomization order of the interventions, with 6 participants for each block. RandList (DatInf GmbH, Tübingen, Germany) forWindows was used to perform the randomization. The study was divided into 3 phases: (1) screening, (2) intervention (weeks 1-3), and (3) postsupplementation (week 4).

2.3 Study Protocol: telephone screening interview was conducted to ensure eligibility of the participants. Participants, in fasting conditions, visited the NU-Food Research Facilities at

Newcastle University for a 2-hour assessment visit. Anthropometric measurements (weight, height, and waist circumference) were obtained following standard procedures, and BMI was calculated as weight in kilograms divided by the squared height in meters. Participants were then randomized to one of two interventions (beetroot or blackcurrant juice) and underwent baseline assessment of resting BP, collection of urine and saliva samples, measurement of body composition via leg-to-leg bioelectrical impedance analysis [10] (Tanita BC420 MA; Tanita Corporation, Tokyo, Japan), and calculation of physical activity using the International Physical Activity Questionnaire [11]. At the end of the visit, participants were fitted with a 24-hour AMBP monitor to continuously assess BP over the next 24-hour period. For 28 days, participants were also instructed to measure their daily resting BP at home. The intervention phase started immediately after the completion of the 24-hour BP monitoring period and lasted for 21 days. During this phase, each participant was expected to comply with the assigned nutritional intervention and low-nitrate dietary plan. On day 7, participants were instructed to collect urine samples for the assessment of nitrate concentration. At the end of the 3 weeks, participants returned to the research unit to repeat the set of measurements performed at baseline. At the end of the second visit, participants were fitted again with a 24-hour BP monitor and reminded that they were not required to drink either blackcurrant or beetroot juice over the following 7 days (post supplementation phase) but were still required to perform the daily resting BP measurements and follow the low-nitrate dietary plan.

On the last day of the study (28th day), participants were invited to attend the research facility for their final visit and assessment. At the end of the visit, participants were fitted with a 24-hour BP monitor. A summary of the study design is shown in Fig. S1 of the Online Supplementary Material.

2.4 Nutritional Supplementation: Participants randomized to the intervention group were asked to consume 70 mL of concentrated beetroot juice for 21 days (Beet-It Sport Shot;

James White Company Ltd, Ipswich, UK; 71 kcal). This dose provided approximately 300 to 400 mg of nitrate per bottle, according to the information reported on the label. A similar dose of inorganic nitrate was also used in another 2-week trial testing the effects of beetroot juice on BP and insulin sensitivity in older obese subjects [9]. However, after the study, we analyzed the contents of 3 remaining bottles and found a nitrate concentration of 165 ± 2 mgper bottle; these results need to be interpreted with caution in consideration of the small number of beetroot samples analyzed, and future studies are therefore required to confirm these findings.

Participants randomized to the control group were asked to consume 200 mL of blackcurrant juice (Capri-Sun Blackcurrant Juice, Rudolf Wild GmbH & Co. KG, Eppelheim, Germany,100 kcal), containing 2.7 ± 0.1 mg of nitrate per bottle. The choice of the blackcurrant juice as a neutral source of inorganic nitrate was confirmed by a previous study conducted by Vanhatalo et al [12]. Participants of both groups were instructed to consume the drinks in the morning and were required to follow a low-nitrate diet as a means to standardize nitrate intake during the study period. A low-nitrate diet limits the consumption of processed/ cured meats and patés, mature cheese, and green leafy vegetables (eg, rocket, spinach, cabbage, beetroot). The nitrate intake estimated by following this dietary scheme was approximately 50 to 100 mg/d, which is similar to the typical dietary nitrate intake of the British population [13]. During the study period, participants were also requested to not change their daily physical activity patterns, to avoid the use of mouthwash during the study, to limit alcohol and caffeine consumption, and to avoid consuming different sources/types of water.

2.5 Resting Blood Pressure Measurements: Resting BP was measured in triplicate using an automated BP monitor (Omron M2 Basic, Omron Healthcare, UK) with the patient seated comfortably for 15 min prior to measurement and the arm supported at the level of the heart.

The final value was calculated as the mean of the lowest two measurements. A large cuff was used for obese subjects.

2.6 24-hrABPM: A validated device approved by British Hypertension Society was used to monitor 24-hr systolic and diastolic BP (Mobil-O-Graph NG, I.E.M. GmbH). All participants were instructed on the use of the device. During monitoring BP was measured every 30 minutes between 8.00am and 22.00 pm, and every 60 minutes between 22.00 pm and 8.00 am. Patients were advised to continue their normal activity during the monitoring period. Over 70% of BP measurements were considered valid and were included in final analyses. All of the valid recordings were analyzed to obtain average 24-hour systolic and diastolic BP.

2.7 Daily Home Blood Pressure Monitoring: An automated BP monitor (Omron M2 Basic, Omron Healthcare, UK) was provided to each participant for the measurements of daily resting BP at home. Participants were asked to conduct duplicate measurements in seated position in the morning before drinking the juice and in the evening before going to bed. Participants were trained on the correct use of the monitor, with emphasis on the position of the cuff. In addition, written instructions on the measurement of BP were provided. A form was given to participants to record the BP readings (systolic, diastolic and HR) and time of each measurement. Agreement was verified against the BP recordings obtained from the 24-hr ABPM at baseline and end of intervention phase (Day 21). The average of the morning and evening daily measurements was calculated; the average of the values for each week (week 1, week 2, week 3, week 4) was calculated to evaluate differences in BP between the two interventions.

2.8 Nitrate Concentrations: A modified version of the method proposed by Tsikas et al [14] was used to determine nitrate concentrations in urine and saliva samples using gas chromatography–mass spectrometry (GC-MS). The validation and protocol of the modified GC-MS method are described elsewhere [15]. This method showed a good repeatability, as coefficients of variation for replicate analyses of samples were 7.8% and 8.6% in saliva and urine samples, respectively. The analyses were performed by a single operator who was blind to the treatment allocation.

2.9 Sample Size:A total sample size of 24 participants(i.e, 12 per group) was required to detect a significant difference of 5.0 mmHg (SD: 4.0mmHg) in systolic BP between the two groups with a power and significance levels set at 0.80 and 0.05, respectively.These calculations are based on a t-test for independent samples performed using G-Power 3 for Windows.

2.10 Statistical Analysis:All statistical analyses were completed using SPSS for Windows (SPSS, version 17.0; SPSS Inc, Chicago, Ill, USA). Summary data are presented as mean (SD or SEM). Data were checked for normality of distribution using Q-Q plots and appropriate transformations were applied to skewed distributions. T-test for independent samples was used to compare between-groups differences on baseline measurements and changes in salivary and urinary nitrate concentrations at each phase. A general linear model was used to test differences in resting clinic, 24-hr ABMP and home daily BP readings between the two nutritional interventions. Analyses testing differences between the two groups during the intervention phase were adjusted for baseline values of the selected outcome. Analyses testing differences between the two groups during the post-supplementation phase (Day 28) were adjusted for values measured at Day 21 for each selected outcome. P values<0.05 (2-tailed) were considered as statistically significant.

3. Results

3.1 Recruitment and Baseline: The flowchart describing the recruitment process is described in **Figure 1**. A total of 12 males and 9 females completed the study. **Table 1** shows the mean and range of baseline characteristics of the subjects. Mean age was 62.7±1.5 years in the beetroot group and 61.4±1.3years in the blackcurrant group. BMI was 30.5±1.3 and 29.4±4.4 kg/m^2in the beetroot group and blackcurrant group, respectively. There were no significant differences in BP readings between the two intervention groups. Only 24-hr ABPM HR was slightly higher in the blackcurrant group (p=0.03).

3.2 Safety and Compliance: Both interventions were well tolerated. The most commonly self-reported side effect with beetroot juice was red urine (beeturia); in addition, one subject experienced mild, temporary abdominal discomfort (beetroot juice concentrate group) and another one reported lower urinary tract symptoms (blackcurrant juice group). Both subjects completed the study. Urinary and salivary nitrate concentrations at baseline were similar between the two groups. However, the beetroot juice group was associated with a significant rise in urinary and salivary nitrate concentrations during the intervention phase (p<0.001), which returned to baseline levels at the end of the post-supplementation phase (**Figure 2A and 2B**). Body weight and physical activity level did not change during the study (**Figure S2 of the Online Supplementary Material**).

3.3 Resting Clinic BP: Resting clinic systolic BP showed a tendency to decline during the study but differences between the two groups were not significant at the end of the intervention (p=0.31) and post-supplementation (p=0.82) phases. Similarly, changes in resting clinic diastolic BP were not significant between the two groups at the end of both study phases (intervention, p=0.87; post-supplementation, p=0.64) (**Figure 3A and Table S1**

of the Online Supplementary Material).

3.4 24-hr ABPM: Beetroot juice supplementation was not associated with significant changes in systolic (p=0.87) and diastolic (p=0.91) compared to blackcurrant juice. After the interruption of the supplementation, 24-hr ABPM readings remained essentially unchanged for both systolic (p=0.64) and diastolic (p=0.74) BP (**Figure 3B and Table S1 of the Online Supplementary Material**).

3.5 Daily Home BP Monitoring: A progressive decrease in systolic BP during the intervention phase was observed in the beetroot juice group. Systolic BP was not significantly lower compared to blackcurrant juice during week 1 (-3.3±6.5mmHg, p=0.56) or week 2 (-4.9±5.9 mmHg, p=0.27), but was significant during the final week of the intervention (week 3, -7.3±5.9 mmHg, p=0.02). After the interruption of the intervention, there was a progressive increase in systolic BP in the beetroot juice group and values returned to baseline levels on the last day of the trial (p=0.09). No significant changes in daily diastolic BP readings were observed in either group throughout the study (**Figure 4**).

4. Discussion

This is the first study to use 3 different methods (clinic, daily, 24-hour ABPM) to assess changes in BP during beetroot supplementation in older overweight and obese subjects. Furthermore, for the first time, we also tested whether the BP-lowering effect of beetroot juice was sustained after the interruption of the supplementation. Our results support our hypothesis stating that a 3-week beetroot juice supplementation would lead to a progressive decline in daily systolic BP. In addition, the 1-week interruption of beetroot supplementation resulted in a progressive return of the daily systolic BP to baseline levels. We also found a nonsignificant effect of beetroot juice concentrate on clinic and 24-hourambulatory BP. Choosing the most accurate and precise method for measuring BP is a complicated matter in clinical and research settings for monitoring the effectiveness of specific dietary, lifestyle, and pharmacological treatments [16]. Although the use of clinic resting BP is the most commonly used method, its poor reliability is universally recognized due to measurement bias associated with white-coat syndrome, standardization of protocol, and operator bias [17]. Some of these issues are resolved by the recommended adoption of 24-hour ABPM and daily home monitoring for a more objective assessment of BP [18]. However, the 24-hour ABPM method may be prone to measurement bias (lack of precision), mostly related to the lack of standardization of the measurement conditions that include differences in posture (seated, standing), physical activity, and emotional status [19]. These factors may have contributed to the between-method differences. Home BP readings are shown to provide more reproducible results due to controlled conditions [20]. Furthermore, our findings of the significant BP-lowering effects observed with the home measurements but not with 24-hour ABPM might be related to transient effects of inorganic nitrate supplementation on resting BP that were not preserved during times of movement or activity. However, further research is needed to investigate this topic. Previous trials have shown that beetroot juice is associated with acute positive effects on seated clinic systolic BP in healthy, young volunteers [21–25]. Our study did not find an effect on clinic and 24-hour ABPM, but we demonstrated a significant drop in systolic daily BP. It is possible that a lack of effect on 24-hour ambulatory BP may relate to a lower nitrate dose as compared to studies reporting beneficial effects of beetroot juice on BP. However, a single bottle of beetroot juice was considered sufficient to increase nitrate intake over the 3-week period in view of the reported nitrate content of the bottle and similar amount of nitrate supplementation in another study [9]. The underlying mechanism is most likely due to an increase in nitric oxide (NO) bioavailability as a result of an increased nonenzymatic reduction of nitrate into nitrite and NO[26,27]. The association of inorganic nitrate with BP is shown by the rise of systolic BP within 24 hours after interrupting the supplementation and the return to baseline after 3 days. This seems to coincide with the pharmacokinetic effect of inorganic nitrate in humans (t1/2: ~8 hours; ~60% of ingested nitrate is excreted in the urine within 48 hours) [28]. These results suggest that continuous inorganic nitrate supplementation may be necessary to sustain beneficial cardiovascular effects. Although the results on clinic BP are not aligned to the current evidence, the lack of an effect on 24-hour ABPM was also reported by Gilchrist et al [9], who found a nonsignificant effect of 2-week beetroot juice supplementation on 24-ABMP in older obese diabetic patients. The only other study that recruited older subjects tested the effects of a 3-day beetroot supplementation on resting BP and observed a significant reduction in both systolic and diastolic BP [29]. No other study has tested the effects of either inorganic nitrate or beetroot juice supplementation on daily BP. The study is characterized by several limitations. First, the small sample size and the discontinuation of 3 participants may have reduced the power of the study to detect significant differences in BP. However, 24-hour ABMP and clinic BP were essentially unchanged; and therefore, it is unlikely that the lack of power influenced the lack of a significant effect of the beetroot intervention on these 2 outcomes. Second, our study was not a blinded trial; and measurements may have been unconsciously influenced by the allocation to the interventions. Third, participants were asked to manually record their daily BP readings, which may introduce a bias in the recording of BP measurements. We found a high level of compliance to the measurements and daily home monitoring, with the 24-hour BP readings taken at the same times and thus indicating reliable BP reporting. Similarly, participants were not asked to record their physical activity during the 24-hour ABPM recording period. However, participants received detailed instructions to avoid strenuous physical activities during this period. We only provided 1 bottle of beetroot juice, whereas previous studies commonly used higher doses. In addition, our estimation of nitrate concentrations in the beetroot juice consumed in this study showed a lower content than that reported by the manufacturer. However, the administration of the beetroot juice concentrate determined increases greater than 100% in both urinary and salivary nitrate concentrations. Therefore, careful interpretation of these results is recommended; and the results should be verified in future studies. In addition, the blackcurrant and beetroot juice interventions had different volumes (200 vs 70 mL). However, it is unlikely that this marginal volume difference influenced the results considering that we did not look at the acute effects on BP or control for the overall fluid intake during the study. Whether this may have been a factor in determining the nonsignificant decline in clinic and 24-hour- ABPM is currently not known, but the measurement of urinary and salivary nitrate indicates a marked increase in inorganic nitrate intake. Lastly, we did not obtain blood samples in this study to assess plasma nitrite levels or biomarkers of NO bioactivity, such as cyclic guanosine monophosphate, arginine, or methylated arginines.In older, overweight subjects, beetroot juice supplementation was associated with beneficial effects on daily systolic BP; but the effects were not significant when measured by 24-hour ABPM. The ability to detect an effect of beetroot juice concentrate supplementation in older, overweight subjects appeared to be influenced by the method that was used to measure BP. The daily monitoring of BP could represent a sensitive method to evaluate the efficacy of nutritional interventions on BP. Future research is needed to investigate the role of vascular aging in modulating the responsiveness of BP to nutritional interventions targeting the NO pathway.

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Figure Legends

Figure 1: Participant flow through the trial

Figure 2: Urinary (Fig 1A) and salivary (Fig 1B) nitrate concentrations stratified by type of intervention (beetroot juice; blackcurrant juice). Nitrate concentrations were measured by gas-chromatography mass spectrometry. T-test for independent samples was used to compare the two groups. Mean values are reported. Error bars are 1SE.

Figure 3: Effects of beetroot (n=10) and blackcurrant juice (n=11) on resting (Figure 3A) and 24-hr ambulatory (ABPM) (Fig 3B) systolic and diastolic blood pressure (BP). Changes in BP were not significant between groups using both methods.Mean values are reported. Error bars are 1SE.

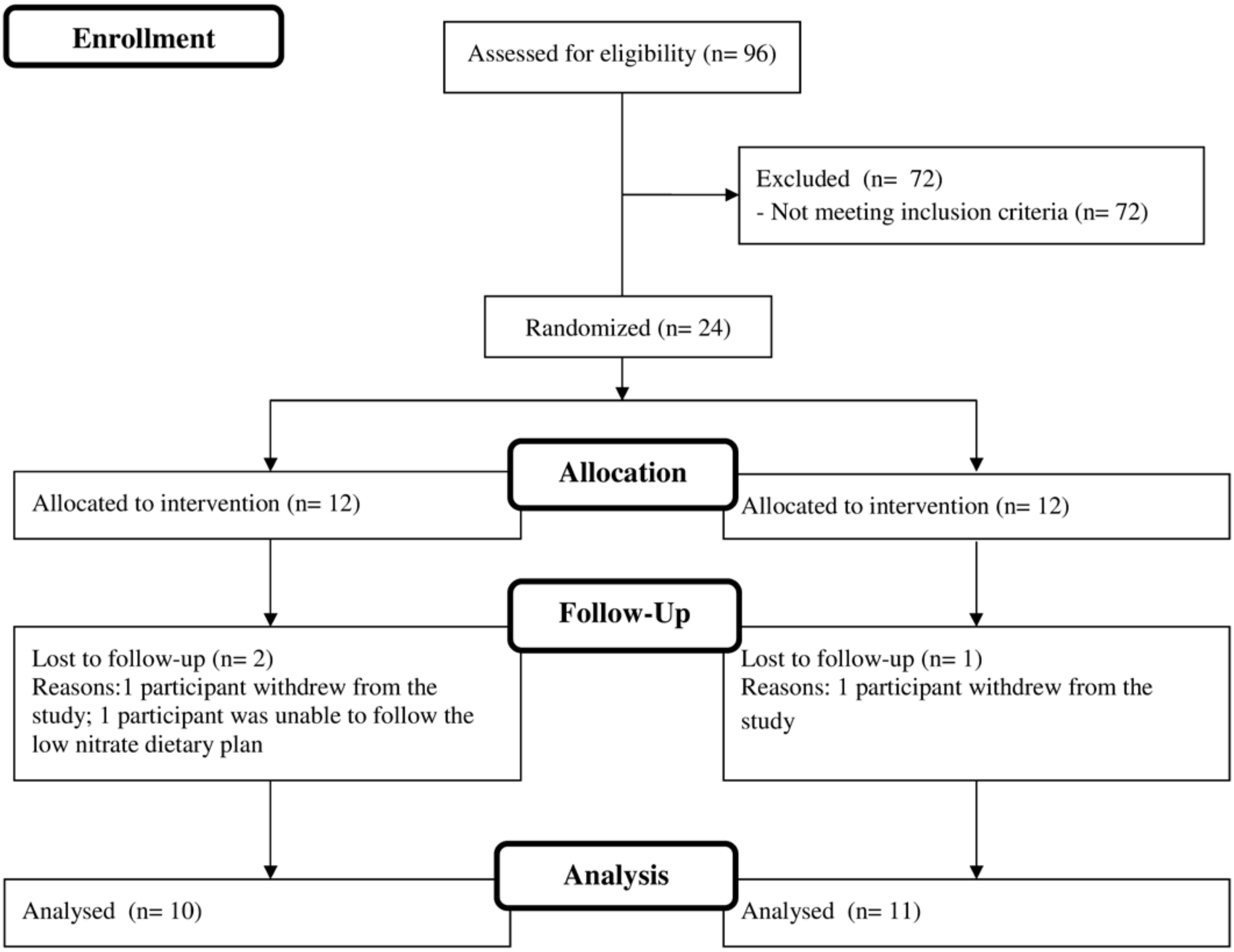
Figure 4: Effects of beetroot (n=10) and blackcurrant juice (n=11) on home daily monitored systolic and diastolic blood pressure (BP). BP values were averaged for each week and changes compared between groups at each week after adjustment for baseline values. At week 4, adjustment was performed for BP values measured on day 21. Weekly values in systolic and diastolic BP for the beetroot (BT) and blackcurrant (BC) interventions are: <u>Systolic BP</u> ($\overline{X} \pm SD$): Baseline BT = 129.8±19.1mmHg, Baseline BC = 131.5±14.6mmHg; Week 1 BT = 127.6±16.6mmHg, Week 1 BC = 131.0±13.4mmHg; Week 2 BT = 126.6±14.7mmHg, Week 2 BC = 131.6±12.3mmHg; Week 3 BT = 125.2±16.1mmHg, Week 3 BC = 132.5±10.6mmHg; Week 4 BT = 128.6±15.8mmHg, Week 4 BC =

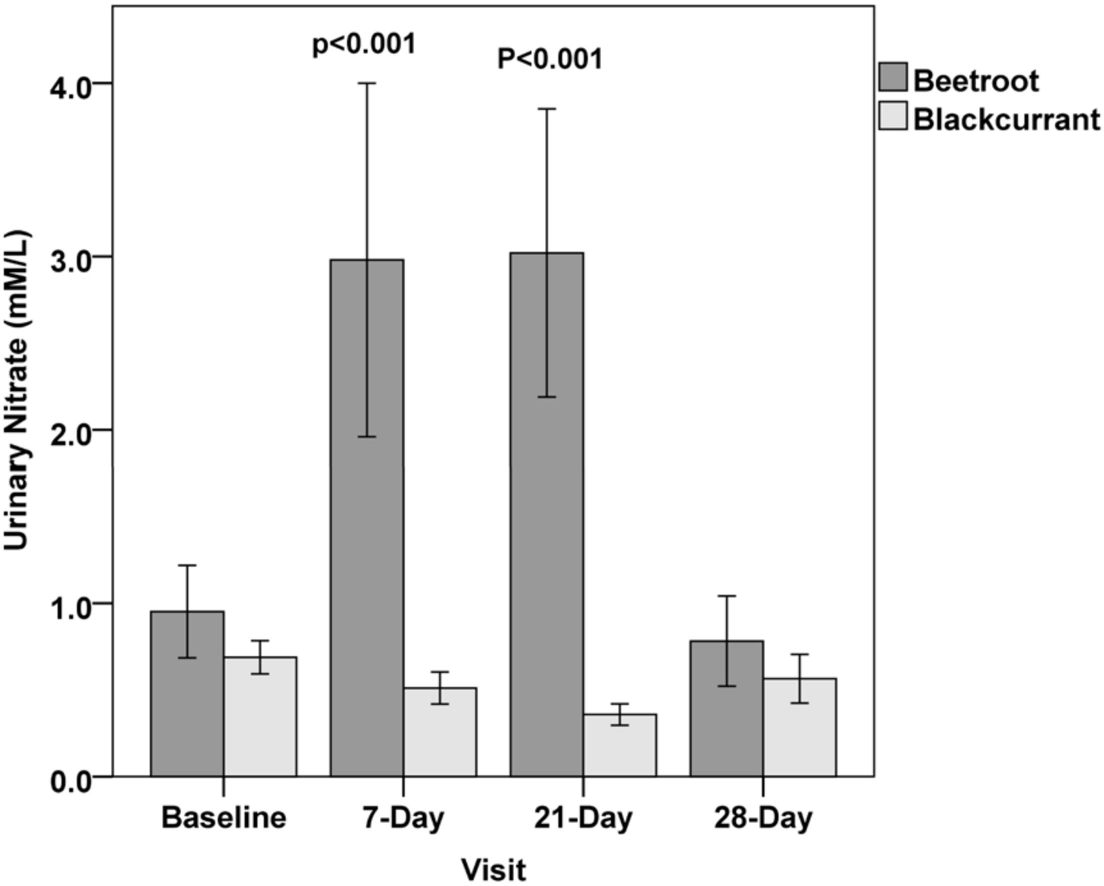
131.4±11.9mmHg. Diastolic BP ($\bar{X} \pm SD$): Baseline BT = 77.1±15.4mmHg, Baseline BC = 75.5±7.1mmHg; Week 1 BT = 76.0±12.4mmHg, Week 1 BC = 76.6±7.1mmHg; Week 2 BT = 75.5±10.7mmHg, Week 2 BC = 76.4±7.3mmHg; Week 3 BT = 74.5 ±10.9mmHg, Week 3 BC = 76.3±7.4mmHg; Week 4 BT = 75.9±11.2mmHg, Week 4 BC = 76.1±6.7mmHg.

Table 1: Baseline characteristics of participants randomised to the two nutritional interventions (beetroot concentrate; blackcurrant juice)

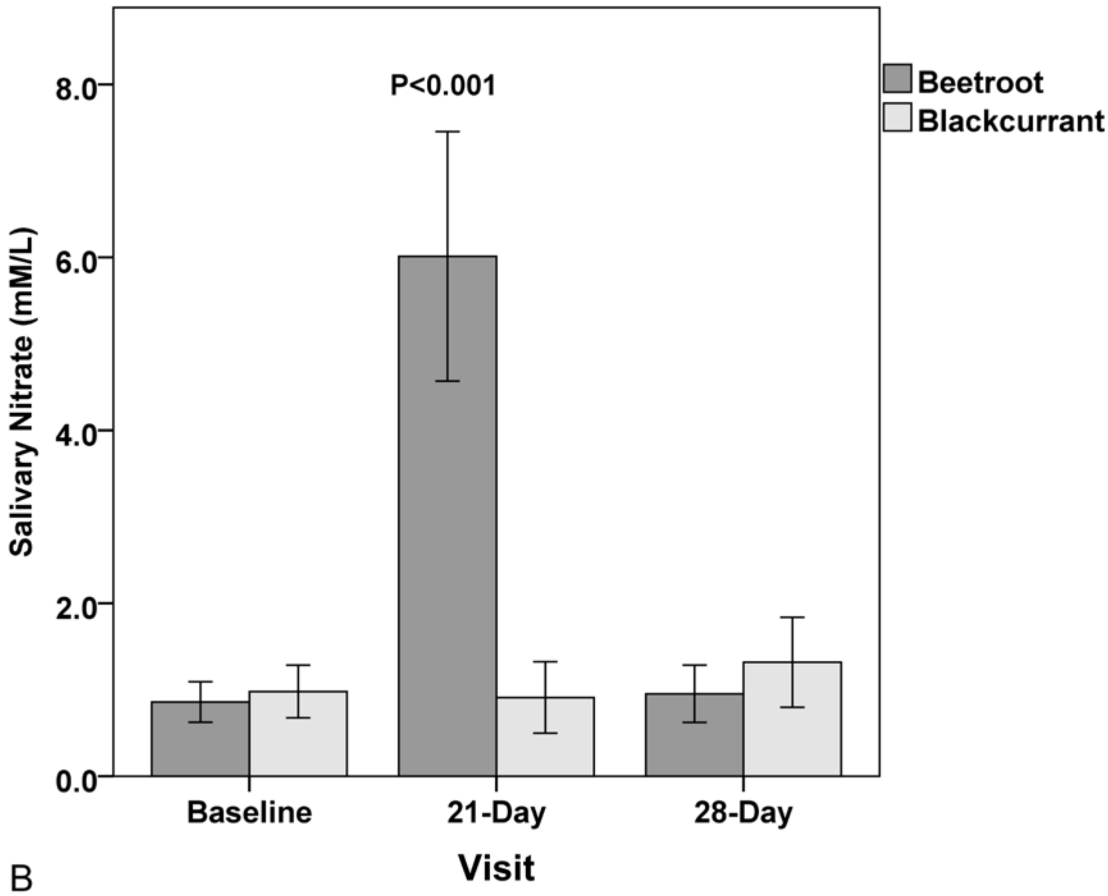
	Beetroot	Blackcurrant	p
N	10	11	
M/F	7/3	5/6	0.38
Age (years)	62.7±1.5	61.4±1.3	0.54
Height (m)	174.4±0.03	168.8±0.03	0.28
Weight (kg)	92.5±4.8	84.2±4.4	0.21
BMI (kg/m^2)	30.5±1.3	29.4±1.2	0.55
WC (cm)	103.8±4.0	100.7±3.0	0.55
FM (kg)	31.8±3.5	27.3±2.5	0.30
FFM (kg)	60.7±3.4	56.8±4.0	0.48
Clinic SBP (mmHg)	135.1±4.7	131.1±4.4	0.55
Clinic DBP (mmHg)	77.4±3.0	76.1±3.3	0.78
Clinic HR (bpm)	60.0±2.1	66.1±1.8	0.06
24-hour ABPM SBP (mmHg)	125.8±5.2	130.9±3.9	0.44
24-hour ABPM DBP (mmHg)	81.0±3.8	82.0±2.2	0.83
24-hour ABPM HR (bpm)	65.9±1.7	74.4±3.0	0.03
HM SBP (mmHg)	129.8±6.1	131.6±4.4	0.61
HM DBP (mmHg)	77.2±4.9	75.6±2.3	0.68
HM HR (bpm)	61.5±2.4	66±1.9	0.08
Urinary NO_3 (mmol/L)	0.95±0.2	0.68±0.09	0.34
Salivary NO_3 (mmol/L)	0.85±0.23	0.97±0.30	0.76

Data are presented as mean±SD; N= number of subjects; M/F=male/female; BMI=body mass index; WC= waist circumference; FM= fat mass; FFM= fat free mass; SBP= systolic blood pressure; DBP= diastolic blood pressure; HR= heart rate; ABPM= ambulatory blood pressure monitoring; HM= home monitoring; NO_3= nitrate. T test for independent samples was used to compare the two groups.


Enrollment
Assessed for eligibility (n= 96)
Excluded (n= 72)
- Not meeting inclusion criteria (n= 72)
Randomized (n= 24)
Allocation
Allocated to intervention (n= 12)
Allocated to intervention (n= 12)
Follow-Up
Lost to follow-up (n= 2)
Reasons:1 participant withdrew from the study; 1 participant was unable to follow the low nitrate dietary plan
Lost to follow-up (n= 1)
Reasons: 1 participant withdrew from the study
Analysis
Analysed (n= 10)
Analysed (n= 11)

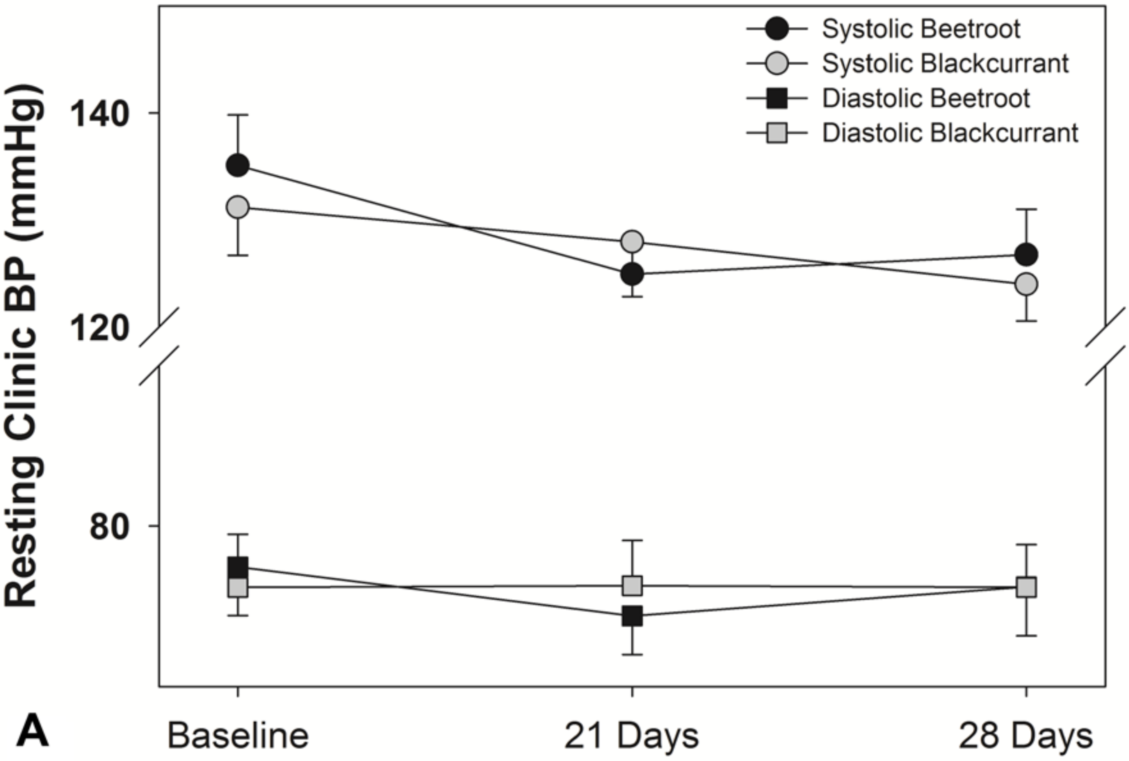

p<0.001
P<0.001
Beetroot
Blackcurrant
Urinary Nitrate (mM/L)
4.0
3.0
2.0
1.0
0.0
Baseline
7-Day
21-Day
28-Day
Visit

A

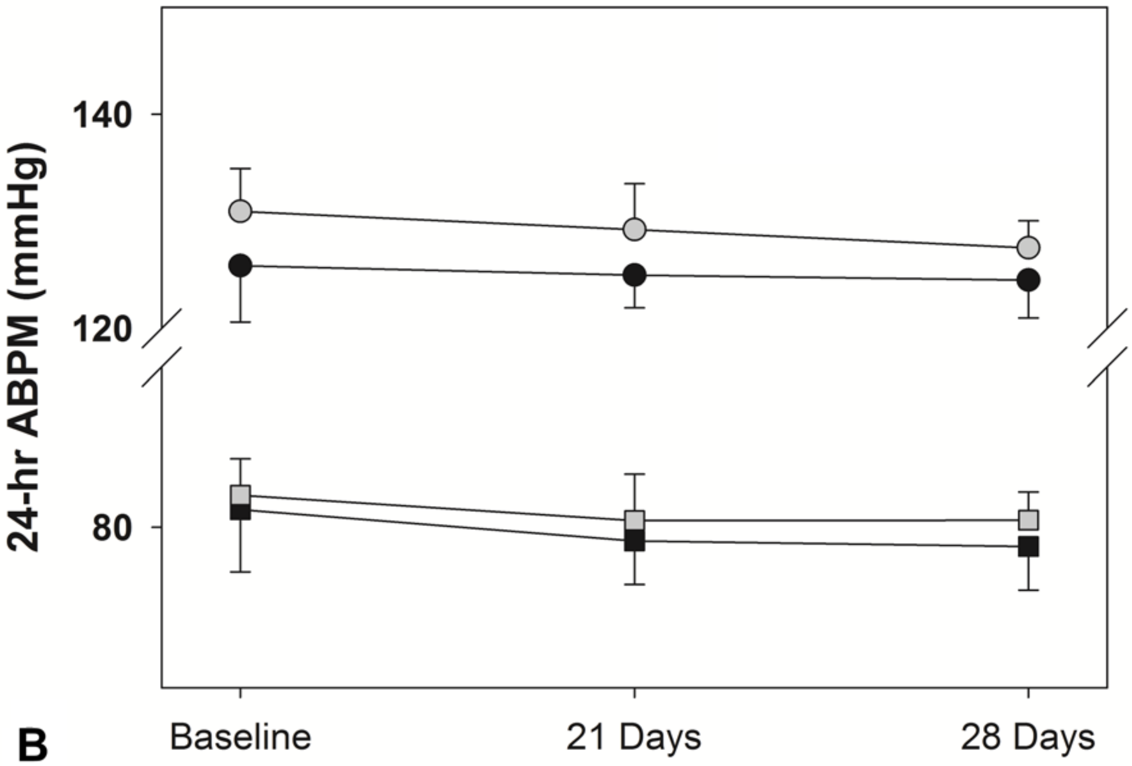


8.0
6.0
4.0
2.0
0.0
Salivary Nitrate (mM/L)
P<0.001
Beetroot
Blackcurrant
Baseline
21-Day
28-Day
Visit

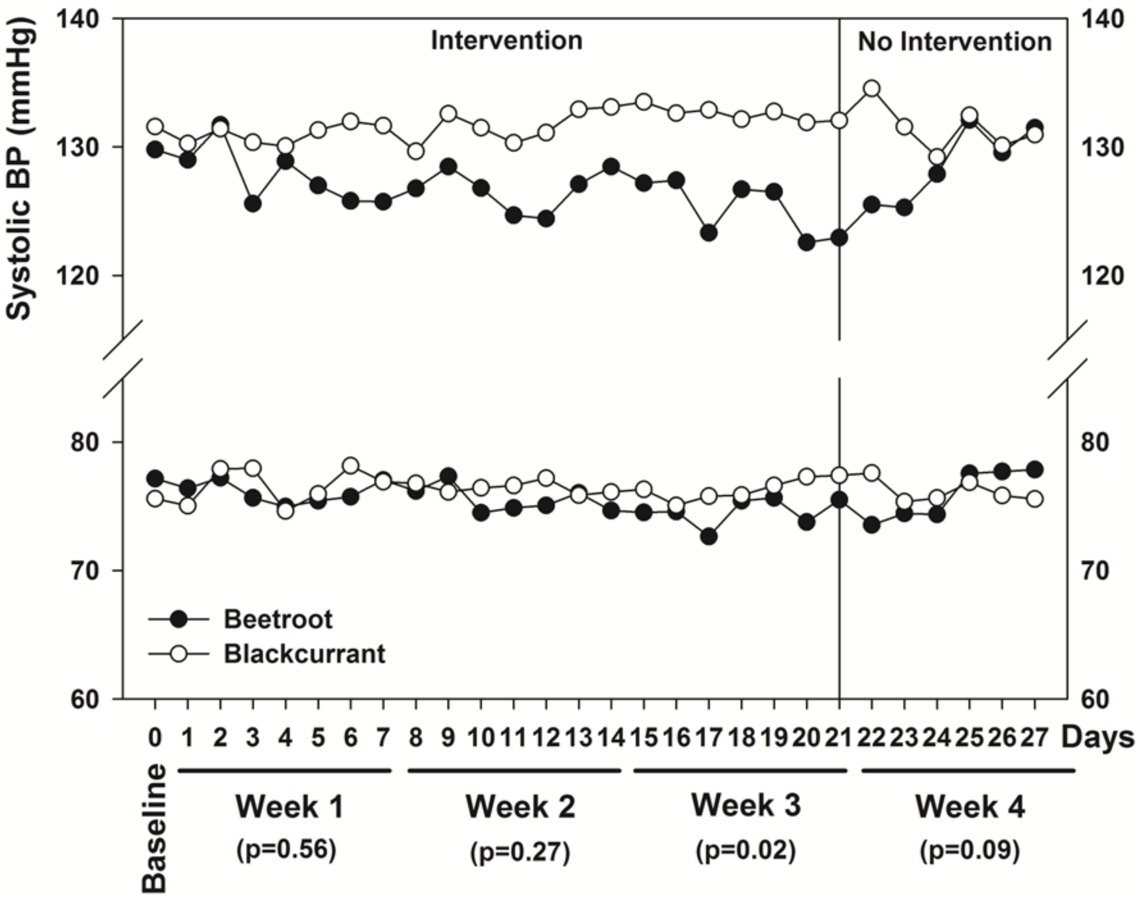
B

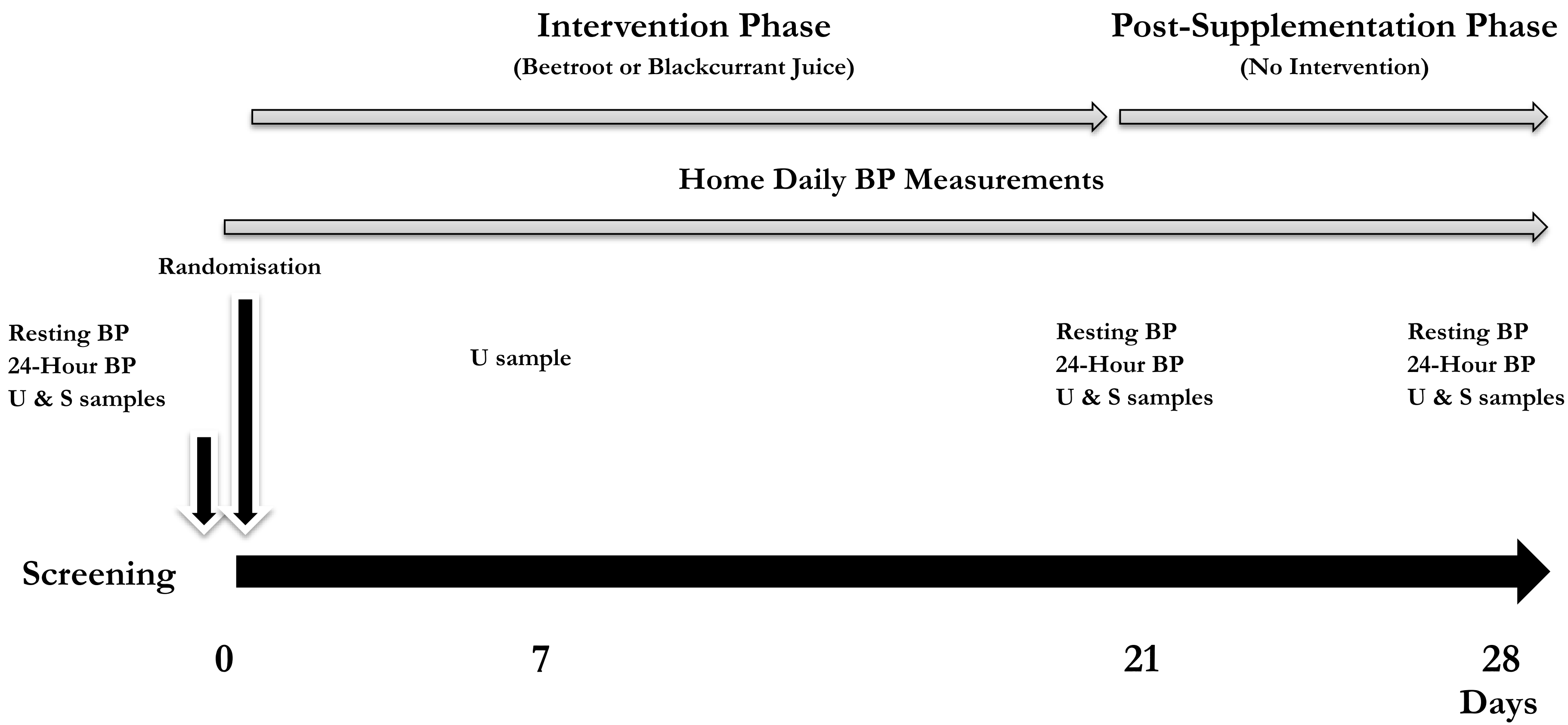

Systolic Beetroot
Systolic Blackcurrant
Diastolic Beetroot
Diastolic Blackcurrant
Resting Clinic BP (mmHg)
140
120
80
Baseline
21 Days
28 Days

A



B


Systolic BP (mmHg)
Diastolic BP (mmHg)
140
130
120
80
70
60
Intervention
No Intervention
Beetroot
Blackcurrant
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 Days
Baseline
Week 1
(p=0.56)
Week 2
(p=0.27)
Week 3
(p=0.02)
Week 4
(p=0.09)


Intervention Phase
(Beetroot or Blackcurrant Juice)
Post-Supplementation Phase
(No Intervention)
Home Daily BP Measurements
Randomisation
Resting BP
24-Hour BP
U & S samples
U sample
Resting BP
24-Hour BP
U & S samples
Resting BP
24-Hour BP
U & S samples
Screening
0
7
21
28
Days