Journal of the American College of Nutrition

ISSN: 0731-5724 (Print) 1541-1087 (Online) Journal homepage: http://www.tandfonline.com/loi/uacn20

Whole Red Grape Juice Reduces Blood Pressure at Rest and Increases Post-exercise Hypotension

Manoel Miranda Neto, Taís F. da Silva, Fabiano F. de Lima, Thibério M. Q. Siqueira, Lydiane T. Toscano, Stephanney K. M. S. F. de Moura & Alexandre S. Silva

JOURNAL OF THE AMERICAN COLLEGE OF NUTRITION
2017, VOL. 36, NO. 7, 533–540
https://doi.org/10.1080/07315724.2017.1331385

Taylor & Francis
Taylor & Francis Group

Whole Red Grape Juice Reduces Blood Pressure at Rest and Increases Post-exercise Hypotension

Manoel Miranda Neto, Taís F. da Silva, Fabiano F. de Lima, Thibério M. Q. Siqueira, Lydiane T. Toscano, Stephanney K. M. S. F. de Moura, and Alexandre S. Silva

Laboratory of Physical Training Studies Applied to Performance and Health, Federal University of Paraíba (Universidade Federal da Paraíba–UFPB), João Pessoa, Brazil

ABSTRACT

Objective: The objective of this study was to evaluate the effect of whole red grape juice (juice) on blood pressure (BP) at rest and on the magnitude of post-exercise hypotension (PEH).

Methods: This double-blind, randomized controlled study was performed with 26 individuals with hypertension (40 to 59 years old) who were divided into experimental ($n = 14$) and control ($n = 12$) groups. Subsequently, the experimental group was subdivided according to the initial BP values. The subjects performed 2 sessions of aerobic exercise on a treadmill (60 minutes, 60%–85% maximum heart rate), separated by a 28-day period of supplementation with a daily dose of juice (150 ml for men and 100 ml for women) or a control drink. BP was measured before, during, and immediately after each exercise session as well as every 10 minutes during the 60-minute post-exercise recovery period.

Results: The BP at rest did not change in the experimental group, but when this group was subdivided by initial BP, the subjects with controlled initial BP (EGCP) achieved a significant reduction (133.3 $\pm$ 5.6 to 114.6 $\pm$ 12.2 mmHg, $p = 0.02$); in contrast, the experimental group with borderline hypertensive BP values (EGBP) did not. Intervention with juice did not modify PEH in the experimental group, but when this group was divided as a function of the initial BP, PEH was potentiated at some times in EGCP.

Conclusions: We conclude that juice promotes a reduction in BP at rest and is also capable of improving PEH in individuals with hypertension, but these effects are dependent on the initial BP values.

ARTICLE HISTORY
Received 28 March 2017
Accepted 13 May 2017

KEYWORDS
Hypertension; blood pressure; post-exercise hypotension; grape; exercise

Introduction

In addition to its high global prevalence of more than 30%, systemic arterial hypertension is still considered a difficult-to-control disease [1]. Pharmacological monotherapy results in low rates of control of this disease, requiring the combination of 2 or more drugs for the treatment to be effective [2–6]. Pharmacological multi-therapy, which includes physical activity and nutritional adequacy, is recognized for significantly increasing hypertension control rates [7–10].

Physical exercise promotes a reduction in blood pressure (BP) at rest after a few weeks of training [2], and even a single exercise session alone results in a decrease in BP that lasts for several hours after the end of the exercise, a phenomenon called post-exercise hypotension (PEH) [11]. The postulated mechanisms for this BP reduction are a reduction in peripheral vascular resistance, reduction in cardiac output, release of vasodilatory substances [12–16], increase in histamine activity [17], reduction in sympathetic nerve activity [18], and possible improvement of the antioxidant system [19].

Similarly, dietary plans, such as the DASH (Dietary Approaches to Stop Hypertension) diet proposed by the National Heart, Lung, and Blood Institute of the United States, and several specific foods are known to promote BP reduction [20]. Among these foods, purple grapes and derivatives have shown a high capacity to reduce BP in animal models and in a human hypertension model [21–25]; this effect is attributed to their rich polyphenol composition, with the main component being flavonoids, which have vasodilator [26] and antioxidant [27] properties, allowing these foods to exert effects similar to those of moderate and regular physical exercise. One of the red grape species stands out due to the presence of 23 antioxidant substances distributed in phenolic compounds (totaling 1.82 g/L) and anthocyanins (52.8 mg/L), with antioxidant activity quantified in 1.16 μmol EAG/ml substances [28]. Despite this antioxidant capacity of the grape, few studies have shown the hypotensive capacity of this food in humans [23,24]. In addition, several studies have shown that various other foods like cocoa [29], green tea [30], chia [31], and watermelon [32,33] reduce BP.

Even in subjects previously practicing physical exercise, an intervention with red grape juice promotes BP reduction [28], which supports the hypothesis that grape juice and exercise can act synergistically to potentiate the hypotensive response. Despite this possibility, to date, no research group has reported that grape-derived products can influence PEH. The initial BP values before exercise and modality and intensity of training strongly influence the magnitude of PEH [34,35] and the chronic reduction caused by antihypertensive treatment [36]. The influence of extrinsic factors on the exercise protocol in BP reduction has rarely been explored in this line of research.

CONTACT Alexandre S. Silva alexandresergiosilva@yahoo.com.br Universidade Federal da Paraíba, Centro de Ciências da Saúde, Campus I, Cidade Universitária, CEP 58059-900, João Pessoa, PB, Brazil.

Therefore, the objective of this study was to evaluate whether a nutritional intervention with whole red grape juice intake is able to promote a reduction in BP at rest of individuals with hypertension previously practicing physical exercise and to increase the magnitude of the hypotension generated after an aerobic exercise session.

Materials and methods

Study subjects and ethical issues

The study was performed with 26 middle-aged individuals with hypertension (40 to 59 years old) of both sexes. The subjects were randomly divided into an experimental group (EG; $n = 14$, 9 females, 51.1 ± 4.3 years) and a control group (CG; $n = 12$, 8 females, 53.3 ± 4.0 years). For inclusion criteria, all individuals should be diagnosed with systemic arterial hypertension, be on drug therapy, have controlled BP (less than 140/90 mmHg), and regularly practice aerobic physical activity (e.g., walking, dancing) at least 3 times a week. Volunteers could not be diabetic, menopausal (women), a smoker or an alcoholic, or regular consumers of red grapes or their derivatives. For exclusion criteria, volunteers who did not perform all of the exercise sessions, did not consume the grape juice in the right amount and time, and/or modified their dietary patterns during the study period to begin consuming grapes were excluded from the study.

The project was approved by the human research ethics committee of the Lauro Wanderley University Hospital, Federal University of Paraíba (Universidade Federal da Paraíba–UFPB), under protocol number 625/10. The subjects freely signed an informed consent form according to resolution 466/12 of the National Health Council.

Study design

The study was an experimental, randomized controlled study. Individuals with hypertension performed 2 sessions of aerobic exercise separated by a period of 28 days of supplementation with a daily dose of whole red grape juice or control. BP measurements at rest were performed before and 48 hours after completion of the supplementation protocol. Other BP measurements were taken before and immediately after the exercise sessions and every 10 minutes during the 60-minute recovery period following the exercise sessions (Figure 1).

In addition to the analysis comparing the EG vs CG groups, the possibility that results could be influenced by previous BP values was tested by subdividing the EG into 2 subgroups: an EG with a BP above the ideal (120/80 mmHg) and below the borderline (140/90 mmHg) values (EGBP; $n = 8$) and an EG with controlled BP (EGCP; $n = 6$), composed of volunteers with an initial BP equal to or less than 120/80 mmHg. CG ($n = 12$) was the only group with controlled BP with values between 120 and 140 mmHg and between 80 and 90 mmHg for the systolic and diastolic components, respectively.

Nutritional intervention

EG subjects performed a 28-day supplementation protocol with whole red grape juice made from American burgundy and Isabella grapes (100 ml/day for women and 150 ml/day for men) at night. The CG had no nutritional intervention.

The juice was given to the volunteers on the first day of the study in the right amount for 28 days. A measured glass was also provided to facilitate ingestion of the correct volume of juice. To encourage consumer loyalty, the researchers made

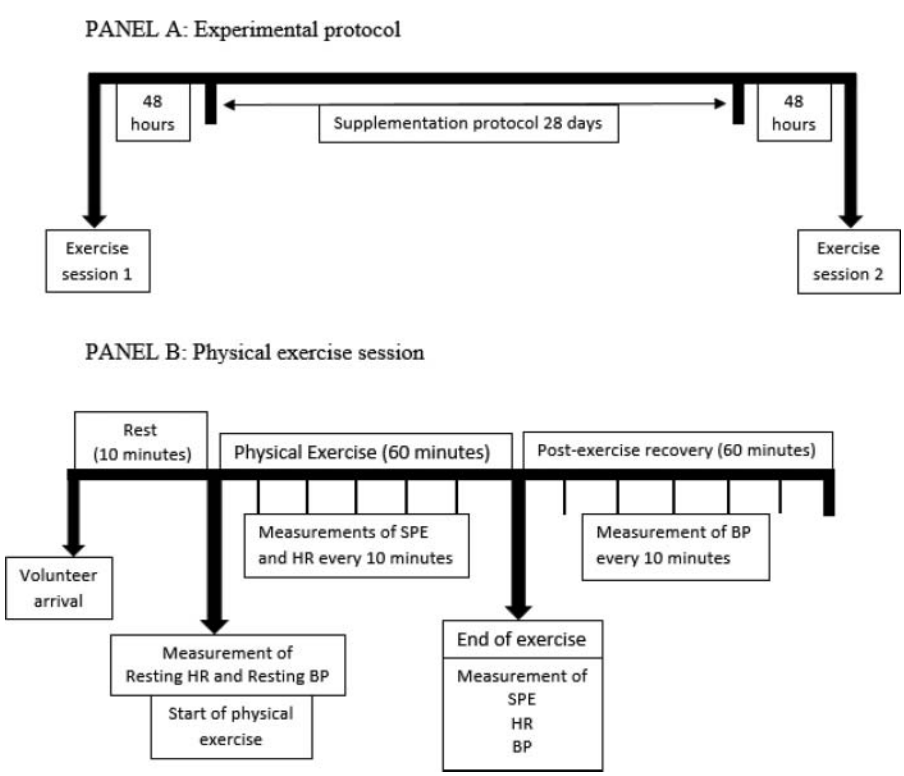

Figure 1. (A) Experimental protocol and (B) details of the physical exercise sessions of the study.

phone calls and sent SMS messages daily to the volunteers at an agreed-upon time. At the end, the volunteers returned the juice bottles so that the amount consumed and the amount left in the bottle were checked. Those who reported having shared the volume with other people or not consuming the full volume were excluded from the study.

The nutritional behavior of the volunteers was verified through a 24-hour dietary recall [37–39] before and at the end of the nutritional intervention period. This recall was performed 3 times for each individual, with 2 recalls to represent weekday food consumption and one recall representing weekend food consumption. For food adequacy analysis, the values obtained were compared with those recommended by the dietary reference intakes [40]. This instrument was applied and evaluated by a nutritionist using Avanutri Revolution software version 4.0 (Avanutri Informática Ltda, Rio de Janeiro, Brazil). After the first evaluation, all subjects were instructed not to modify their eating patterns, with an emphasis on not consuming grapes and their derivatives. In addition, the subjects received a list of caffeine-rich foods and were instructed not to consume them in the 48 hours preceding the experimental exercise sessions.

BP measurements

Before supplementation began, BPs at rest were recorded according to the protocol proposed in the Sixth Brazilian Guidelines for Hypertension [41] regarding prior preparation for BP measurements. The volunteers were instrumented with a Welch Allyn aneroid apparatus (New York) after 10 minutes of rest. Three BP measurements were performed and the 2 most similar values were considered.

After this procedure, the volunteers performed the experimental sessions of physical exercise. Immediately at the end of the session, the subjects remained in a seated position, and BP measurements were repeated every 10 minutes during the 60-minute post-exercise recovery period.

Exercise protocol

Prior to the experimental exercise sessions, the volunteers performed one or 2 sessions of exercise adaptation on an exercise treadmill to ensure that the exercise could be performed for 60 minutes without discomfort, which was understood as subjective perception of effort (SPE) greater than 14 on the scale proposed by Borg and Noble [42]. Two experimental sessions of aerobic exercise were performed on a treadmill; one was 48 hours before the protocol of the nutritional intervention and the other was 48 hours after the end. The CG, who did not receive the nutritional intervention, also participated in these exercise sessions.

The sessions had a 60-minute duration and moderate intensity (60% to 85% of the maximal heart rate), as proposed by Karvonen et al. [43], with recordings using a heart rate meter (Polar RS800CX, Polar Electro Oy, Kempele, Finland). The volunteers were instructed to report their SPE every 10 minutes during the exercise. In the period between these 2 sessions, the subjects continued to perform their physical exercise routine, but no changes could be made to their exercise routines. However, for the 2 sessions of this protocol, the volunteers maintained a 48-hour interval without performing physical exercise.

Statistical analysis

The data are presented as means and the standard errors of the mean. The data were initially tested for normality and homogeneity using Shapiro-Wilk and Levine tests, respectively. The baseline data from the 2 groups were compared using *t* test for independent samples, and the effect of the intervention on the 2 groups was verified by analysis of variance for repeated measurements with Tukey's post hoc test. When not parametric, the data were converted to the log unit. InStat 3.0 software (GraphPad InStat, San Diego, CA, USA) was used.

Results

The baseline characteristics of the groups were similar, as shown in Table 1. The volunteers were middle-aged, hypertensive, between normal weight and overweight, and normolipidemic. All individuals underwent drug therapy and had controlled BP at the time of the study (140/90 mmHg or less), but the EGBP group had significantly higher systolic and diastolic BP (SBP and DBP, respectively) values than those of the EGCP group. The CG consisted only of individuals with hypertension with BP equal to or greater than 120/80 mmHg. The CG was similar to the EGBP in DBP and had significantly higher SBP and DBP than the EGCP (Table 1). The volunteers in the EG and CG groups had similar dietary patterns at the beginning of the study and did not change their nutritional patterns during the intervention period.

Table 1. Anthropometric, biochemical, and hemodynamic nutritional characteristics at the preintervention measurement[a].

	EG ($n = 14$)	EGBP ($n = 8$)	EGCP ($n = 6$)	CG ($n = 12$)	p
Age (years)	50.5 ± 1.0	49.7 ± 1.6	51.6 ± 1.2	53.3 ± 1.0	0.17
BMI (kg/m^2)	25.5 ± 0.5	25.4 ± 0.3	25.5 ± 0.1	26.5 ± 0.6	0.59
TC (mg/dl)	182.7 ± 20.4	184.7 ± 27.4	164.4 ± 13.5	170.3 ± 15.4	0.81
HDL (mg/dl)	40.5 ± 3.7	32.5 ± 2.6	43.3 ± 4.4	34.1 ± 1.7	0.45
LDL (mg/dl)	84.1 ± 8.1	84.2 ± 14.5	79.9 ± 13.4	90.2 ± 7.4	0.12
SBP (mmHg)	123.7 ± 3.4	133.5 ± 2.0	110.6 ± 2.9$^{*\beta}$	125.3 ± 2.3	0.01
DBP (mmHg)	78.0 ± 3.0	83.7 ± 4.5	70.3 ± 1.7$^{\#}$	85.0 ± 1.7	0.001
MDA (μl)	7.0 ± 0.6	8.3 ± 0.6	5.7 ± 0.4	6.6 ± 0.4	0.14
Nitrite (μl)	57.3 ± 8.8	69.6 ± 7.2	56.5 ± 14.3	59.1 ± 13.3	0.76
CBO (g)	279.0 ± 13.0	286.0 ± 9.1	280.0 ± 10.8	287.0 ± 10.9	0.23
PTN (g)	96.0 ± 4.0	88.0 ± 2.2	95.0 ± 2.6	92.0 ± 2.1	0.48
LIP (g)	68.0 ± 8.0	60.4 ± 2.1	69.1 ± 2.9	62 ± 1.9	0.56
Vitamin E (mg)	29.4 ± 5.9	28.4 ± 5.7	29.3 ± 5.8	31.1 ± 6.1	0.86
Vitamin C (mg)	119 ± 22.3	102 ± 20.5	110 ± 19.0	129.2 ± 19.8	0.34
Zinc (mg)	23.5 ± 3.6	29.4 ± 3.8	30.2 ± 2.9	27.2 ± 3.2	0.41
Copper (mcg)	18.9 ± 4.3	18.8 ± 4.2	17.7 ± 4.5	16.2 ± 4.1	0.82
Selenium (mcg)	260.4 ± 44.3	291.7 ± 40.1	278.1 ± 42.1	269.2 ± 39.9	0.18

EG = experimental group, EGBP = experimental group with hypertensive blood pressure values, EGCP = experimental group with controlled blood pressure, CG = control group, BMI = body mass index, TC = total cholesterol, HDL = high-density lipoprotein, LDL = low-density lipoprotein, SBP = systolic blood pressure, DBP = diastolic blood pressure, MDA = malondialdehyde, CBO = carbohydrate, PTN = protein, LIP = lipids.

[a]Data are presented as the mean and standard error of the mean.

*Significant difference between EG and EGCP ($p < 0.05$, SBP).

$^{\beta}$Significant difference between EGCP and other groups ($p < 0.001$).

#Significant difference between EGCP and 2 other groups (EGCP and CG; $p < 0.001$).

Although instructed to perform moderate-intensity exercise sessions, volunteers achieved an intensity of only 47.4% ± 5.7% of the maximal heart rate (HR) during the preintervention session and 45.4 ± 1.3% of the maximal postintervention HR. However, no differences in intensity were noted between these 2 sessions. For this HR behavior, the volunteers reported SPE compatible with exercise of moderate intensity; the reported values for the subjects had a mean of 11.4 ± 0.4 for the preintervention session and 11.7 ± 0.4 after the intervention, with no differences between these 2 sessions ($p > 0.05$).

Treatment with grape juice promoted a descriptive reduction in SBP at rest of −4.4 ± 5.0 mmHg ($p = 0.12$), whereas the CG presented a reduction of −1.8 ± 3.3 mmHg ($p = 0.63$; Figure 2). For the diastolic component at rest, treatment with grape juice promoted a descriptive reduction only (−1.4 ± 3.9 mmHg; $p = 0.74$), and CG also showed a small BP reduction, also with no significant difference (−3.6 ± 2.1 mmHg, $p = 0.14$).

When the EG volunteers were separated into EGBP and EGCP, the group that started the study with higher BP at rest, EGBP, had a significant reduction in SBP (−13.7 ± 6.6 mmHg, $p = 0.02$), whereas DBP showed a clinical reduction only, with no significant difference (−7.7 ± 5.9 mmHg, $p = 0.23$). In addition, EGCP presented a nonsignificant increase in SBP after intervention with grape juice (+8.0 ± 4.0 mmHg, $p = 0.10$) and a significant increase in DBP (+7.0 ± 1.9 mmHg, $p = 0.01$). In the CG, no significant differences were observed for both SBP ($p = 0.59$) and DBP ($p = 0.11$; Figure 2).

BP responses to the physical exercise procedure are presented in Table 2. The intervention with whole red grape juice was not able to potentiate PEH in any of the moments in which BP was measured in the post-exercise recovery period.

When the EG individuals with hypertension were divided according to the initial BP values at rest, EGBP presented visibly greater post-exercise BP reductions for the SBP after treatment with grape juice in relation to the post-exercise BP response before treatment, as observed in Figure 3. In addition, the post-exercise SBP reduction values were significantly lower than those of the other groups for the pre- and postintervention procedures. Regarding the DBP, no significant differences were found for the pre- and postintervention procedures in the 2 EGs (EGBP and EGCP).

Discussion

The data from this study showed that a 28-day grape juice supplementation protocol promotes a reduction in the BP at rest and improves PEH but only in individuals with hypertension with an SBP between 120 and 140 mmHg and a DBP between 80 and 90 mmHg (EGBP). Individuals with better controlled hypertension with a pressure lower than 120/80 mmHg (EGCP) were not responsive to grape juice in terms of BP at rest. In turn, individuals with hypertension with BP below 120/80 mmHg did not show PEH prior to nutritional intervention and began to present a post-exercise BP reduction after 28 days of supplementation with whole red grape juice.

The high capacity of whole red wine in decreasing BP levels is well supported, as shown in a review study by Opie and Lecour [44]. For grape juice, the data are less robust and still somewhat controversial; whereas Dohadwala et al. [45] did not find a significant reduction in BP at rest after ingestion of this juice by hypertensive men, Park et al. [23,24] showed that grape juice intake has a beneficial effect on the improvement of BP levels in hypertensive men.

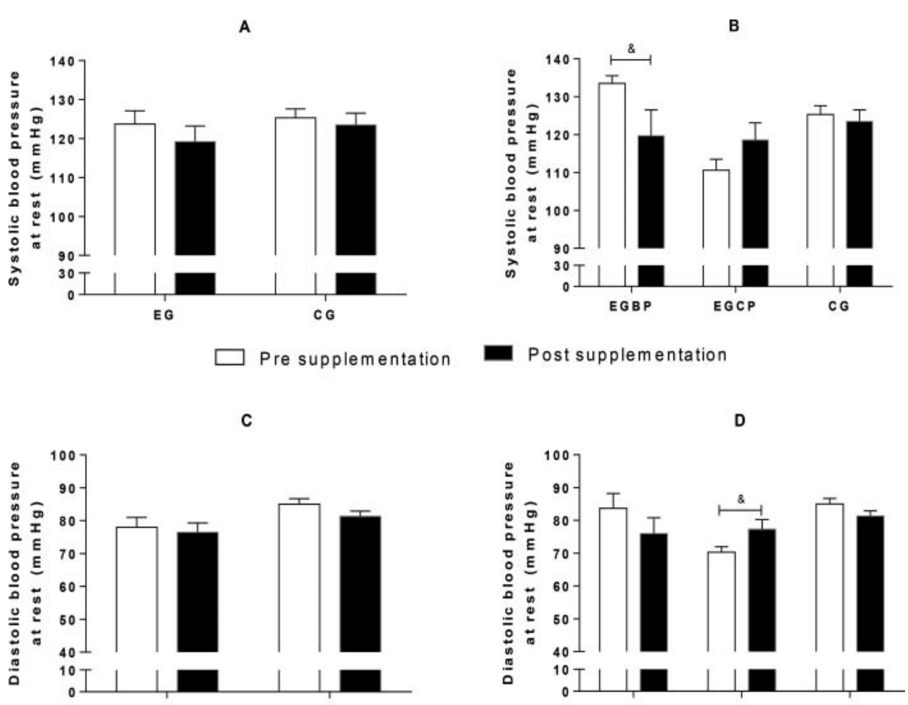

Figure 2. Systolic and diastolic BP at rest for the 2 experimental groups together and for EG divided into EGBP and EGCP. Data are presented as the mean and standard error of the mean. &Statistical difference found in SBP before and after intervention with grape juice in EGBP and significant difference found in DBP before and after intervention with grape juice in EGCP ($p < 0.05$).

Table 2. Differences between Blood Pressure Measured after Exercise and at Rest between EG and CG without Stratification by Initial Blood Pressure Values[a].

	Delta of blood pressure post-exercise × rest (mmHg)					
	10 minutes	20 minutes	30 minutes	40 minutes	50 minutes	60 minutes
SBP						
Pre, EG	0.0 ± 2.4	−4.9 ± 4.0	−8.6 ± 3.4	−11.1 ± 2.1	−9.7 ± 3.2	−9.6 ± 3.6
Post, EG	−3.0 ± 2.7	−9.3 ± 2.6	−7.1 ± 3.2	−6.3 ± 2.9	−7.3 ± 3.0	−6.4 ± 3.0
Pre, CG	2.2 ± 2.8	0.2 ± 4.9	−3.5 ± 1.9	−1.6 ± 1.9	−3.5 ± 2.1	0.9 ± 2.3
Post, CG	−0.5 ± 2.4	−5.6 ± 2.4	−8.7 ± 2.0	−6.2 ± 1.5	−5.5 ± 1.6	−10.9 ± 3.6
DBP						
Pre, EG	0.2 ± 2.0	−2.5 ± 2.1	−3.1 ± 2.5	−2.7 ± 2.5	−4.0 ± 2.5	−2.7 ± 3.2
Post, EG	−1.0 ± 1.4	−1.6 ± 1.9	−3.0 ± 2.3	3.4 ± 2.2	−0.1 ± 2.0	1.3 ± 1.9
Pre, CG	0.5 ± 1.5	0.7 ± 1.0	−2.4 ± 1.4	−1.1 ± 1.6	−0.4 ± 1.3	−0.7 ± 1.4
Post, CG	4.5 ± 0.9	0.0 ± 1.2	−1.6 ± 0.8	−1.6 ± 1.2	−2.2 ± 0.8	−3.3 ± 1.9

SBP = systolic blood pressure, EG = experimental group, CG = control group, DBP = diastolic blood pressure.
[a]Data are presented as means and standard errors of the mean. No significant intra- or intergroup differences were observed ($p > 0.05$).

Toscano et al. [28] demonstrated that recreational athletes obtained a significant BP reduction despite being physically active and even without hypertension. These data are relevant because it is known that in the face of lower BP values, some interventions need to have greater impact power to promote more BP reduction [34,35].

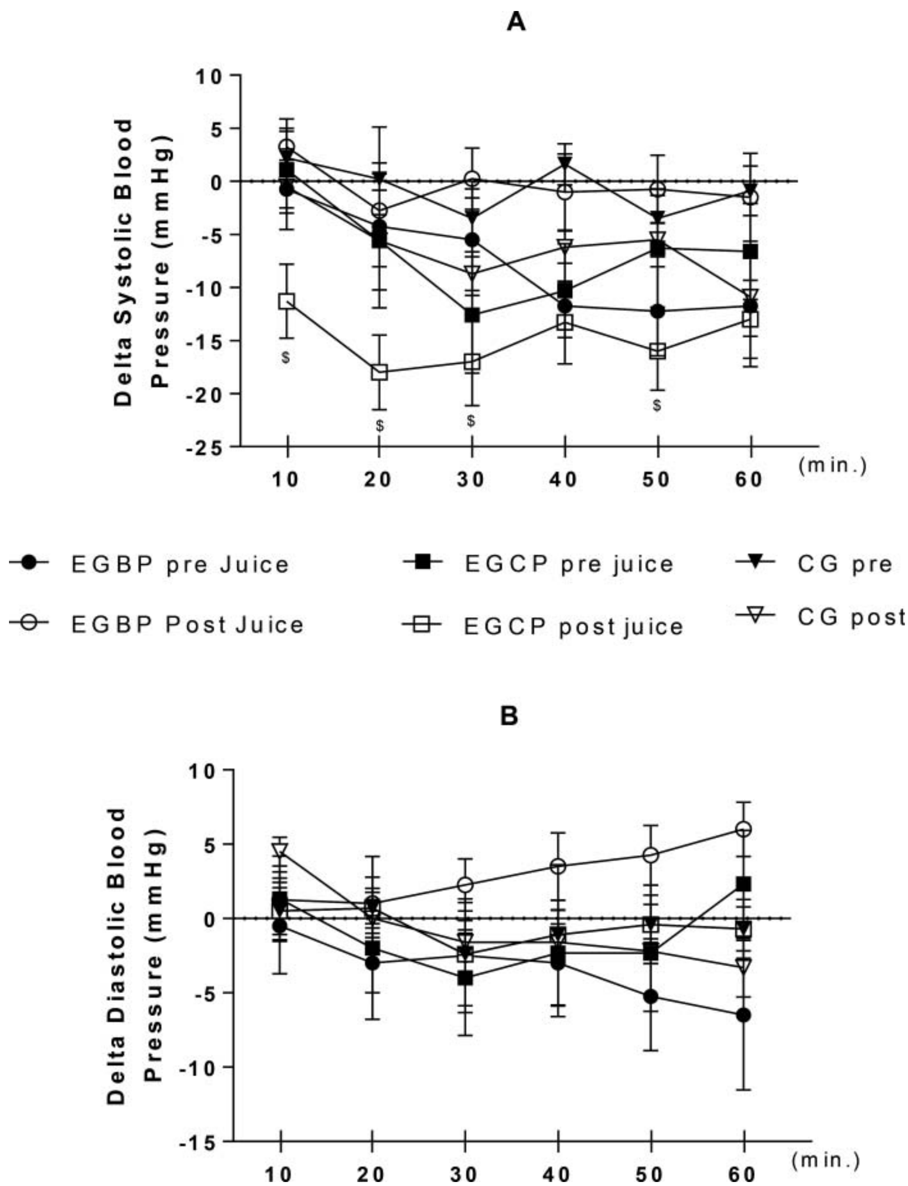

Figure 3. Variation in systolic and diastolic BP after exercise in the 3 groups. Data are presented as means and standard errors of the mean. $Statistical difference found between the postintervention values of EGCP and EGBP and the measurements at 10, 20, 30, and 50 minutes ($p < 0.05$).

Therefore, our data corroborate those of Park et al. [23,24] and Toscano et al. [28], who showed a reduction in BP at rest in response to nutritional interventions based on a daily intake of grape juice. In addition to this corroboration, the present study provides a novel finding by using a lower dosage than previous studies. Although Park et al. [23,24] adopted a dosage of 5.5 ml/kg/day, we used only 100 or 150 ml/day; when corrected for the body weight of the volunteers of our study, this dosage results in 1.5 and 2.0 ml/kg/day for the women and men, respectively, in our study. In addition, only 28 days of supplementation was required to promote a BP reduction in individuals with hypertension with a previous BP at rest between 120 and 140 mmHg for the SBP and between 80 and 90 mmHg for the DBP. In previous studies that showed a BP reduction with grape juice intake, 8 weeks of intervention was required for the effect to appear [23,24], which was much longer than the intervention of the present study.

The ability of physical training programs to promote a reduction in BP at rest after a few weeks is well established, as shown in a review by Sabbahi et al. [46]. One of the most determining factors in the magnitude of pressure reduction is the initial BP value, and in studies in which individuals had higher initial BP values, the hypotensive effect was more evident [34,35]. The data from this study show that the phenomenon previously observed for physical training programs was also demonstrated for nutritional interventions. This finding may explain previous controversies in the literature regarding the hypotensive power of grape juice. In fact, although the hypertensive subjects from the study by Dohadwala et al. [45], who had initial BP values of 138/82 mmHg, did not present a BP reduction at rest after grape juice ingestion, Park et al. [23] observed that individuals with an initial BP of 150/95 mmHg showed significant BP reductions after ingesting grape juice.

Considering the information already available in the literature, the most innovative finding of this study was that grape juice, in addition to promoting BP reduction at rest, influences PEH in individuals with hypertension with optimally controlled BP (below 120/80 mmHg). To date, no other studies have tested the hypothesis that a nutrient may improve the post-exercise BP response. Previous data showed opposite effects; that is, the consumption of coffee or caffeine alone, before or after exercise, abolished the effect of PEH [47–50]. Therefore, to the best of our knowledge, this study is the first to show that the interaction of some nutrients (in this case, whole red grape juice) beneficially influences PEH in individuals with hypertension.

However, one should consider that similar to BP at rest, this effect of grape juice on PEH was also dependent on the initial BP values. Additionally, unlike the case of BP at rest, the beneficial effect occurred for subjects with lower BP at rest. In previous studies, exercise did not promote PEH in individuals with hypertension who started exercise with a BP very close to normal values [51–53], confirming a consensus in this area of investigation that the PEH magnitude is directly proportional to the pre-exercise BP value, as shown by Anunciação and Polito [54] in their review of the literature. Therefore, our study showed that the ingestion of whole red grape juice promotes post-exercise hypotensive capacity in individuals with hypertension who begin their training sessions with controlled BP levels.

These findings should be weighted due to a limitation of this study: when the EG was subdivided, one subgroup had individuals with hypertension with well-controlled BP and the other subgroup had individuals with hypertension with higher BP values that were still within the ideal limits (approximately 140/90 MmHg). The findings need to be confirmed in future studies comparing individuals with hypertension with values lower and higher than 140/90 mmHg, which is the threshold of the BP values that are considered controlled. Another limitation is that we considered data from the previous literature that indicated the possibility that the initial BP value influences the intervention responses; however, our consideration involved a small initial sample (only 15 subjects), so that the sample size subdivision was limited. Therefore, we suggest new studies focused exclusively on this dependence of the BP with better sample sizes per subgroup.

An important practical implication of this study is the fact that although review studies indicate the good ability of aerobic exercise to promote PEH [55–57], some studies did not find a significant effect; genetic factors [58], the intensity and duration of exercise [59], and the initial levels of BP at rest [51–53] are factors that might explain the absence of PEH. Therefore, this study introduces the nutritional intervention with whole red grape juice as a variable capable of influencing PEH, particularly in individuals with hypertension who are not obtaining this benefit from physical exercise. Considering that there are individuals with hypertension resistant to the pressure reduction promoted by exercise [53–58], even when the subjects begin sessions with high BP, this study suggests that the possibility that grape juice or other nutritional agents can restore the post-exercise hypotensive capacity of these people should be investigated.

Another important practical implication is that interventions aimed at promoting BP reduction need to be considered in a multifactorial way. It is well known that the mechanisms involved in hypertension are pleiotropic, so treatment should be multifactorial [7–10]. Despite the importance of influencing variables in experimental studies, the present study draws attention to the possibility of encouraging nutritional associations with physical exercise to establish better treatment modalities for the population. Therefore, this study suggests that food may collaborate with physical exercise to increase the hypotensive response; that is, the synergy of these 2 interventions may improve the hypotensive results. We also suggest that other foods be investigated regarding the power of association with exercise programs or sessions to reduce BP.

Conclusion

The data from this study corroborate previously published data demonstrating the ability of whole grape juice to improve BP at rest, but this effect is dependent on initial BP values. The present study provided an unprecedented finding: whole red grape juice is also capable of improving the acute hypotensive response after an exercise session performed by individuals with hypertension who were previously not responsive to this beneficial phenomenon generated by physical exercise sessions.

ORCID

Manoel Miranda Neto http://orcid.org/0000-0002-5262-980X
Taís F. da Silva http://orcid.org/0000-0001-8096-857X

Fabiano F. de Lima http://orcid.org/0000-0003-1841-5098
Thibério M. Q. Siqueira http://orcid.org/0000-0001-7560-8107
Lydiane T. Toscano http://orcid.org/0000-0003-0020-6220
Stephanney K. M. S. F. de Moura http://orcid.org/0000-0002-1508-8696
Alexandre S. Silva http://orcid.org/0000-0003-3576-9023

References

1. Pereira M, Lunet N, Azevedo A, Barros H: Differences in prevalence, awareness, treatment and control of hypertension between developing and developed countries. J Hypertension 27:963–975, 2009.
2. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL Jr, Jones DW, Materson BJ, Oparil S, Wright JT Jr, Roccella EJ: Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension 42:1206–1252, 2003.
3. Mancia G, Parati G, Borghi C, Ghironzi G, Andriani E, Marinelli L, Valentini M, Tessari F, Ambrosioni E: Hypertension prevalence, awareness, control and association with metabolic abnormalities in the San Marino population: the SMOOTH study. J Hypertens 24:837–843, 2006.
4. Perez-Fernandez R, Mariño AF, Cadarso-Suarez C, Botana MA, Tome MA, Solache I, Rego-Iraeta A, Mato AJ: Prevalence, awareness, treatment and control of hypertension in Galicia (Spain) and association with related diseases. J Hum Hypertens 21:366–373, 2007.
5. Gus I, Harzheim E, Zaslavsky C, Medina C, Gus M: Prevalence, awareness, and control of systemic arterial hypertension in the state of Rio Grande do Sul. Arq Bras Cardiol 83:429–433, 2004.
6. Pereira MR, Coutinho MS, Freitas PF, D'Orsi E, Bernardi A, Hass R: Prevalence, awareness, treatment, and control of hypertension in the adult urban population of Tubarão, Santa Catarina, Brazil, 2003. Cad Saude Publica 23:2363–2374, 2007.
7. Pescatello LS, Franklin BA, Fagard R, Farquhar WB, Kelley GA, Ray CA: American College of Sports Medicine position stand. Exercise and hypertension. Med Sci Sports Exerc 36:533–553, 2004.
8. Cornelissen VA, Fagard RH: Effects of endurance training on blood pressure, blood pressure–regulating mechanisms, and cardiovascular risk factors. Hypertension 46:66775, 2005.
9. Dickinson HO, Mason JM, Nicolson DJ, Campbell F, Beyer FR, Cook JV, Williams B, Ford GA: Lifestyle interventions to reduce raised blood pressure: a systematic review of randomized controlled trials. J Hypertens 24:215–233, 2006.
10. Adrogue HJ, Madias NE: Sodium and potassium in the pathogenesis of hypertension. N Engl J Med 356:1966–1978, 2007.
11. Laterza MC, Rondon MUPB, Negrão CE: The anti-hypertensive effect of exercise. Rev Bras Hipertens 14:104–111, 2007.
12. Anunciação PG, Polito MD: A review on post-exercise hypotension in hypertensive individuals. Arq Bras Cardiol 96:e100–e109, 2011.
13. Halliwill JR: Mechanisms and clinical implications of post-exercise hypotension in humans. Exerc Sport Sci Rev 29:65–70, 2001.
14. Rao SP, Collins HL, Dicarlo SE: Postexercise alpha-adrenergic receptor hyporesponsiveness in hypertensive rats is due to nitric oxide. Am J Physiol Regul Integr Comp Physiol 282:R960–R968, 2002.
15. Boushel R, Langberg H, Gemmer C, Olesen J, Crameri R, Scheede C, Sander M, Kjaer M: Combined inhibition of nitric oxide and prostaglandins reduces human skeletal muscle blood flow during exercise. J Physiol 543(Pt 2):691–698, 2002.
16. Mortensen SP, Nyberg M, Thaning P, Saltin B, Hellsten Y: Adenosine contributes to blood flow regulation in the exercising human leg by increasing prostaglandin and nitric oxide formation. Hypertension 53:993–999, 2009.
17. Zafeiridis A: Mechanisms and exercise characteristics influencing postexercise hypotension. Br J Med Med Res 4:5699–5714, 2014.
18. Chen C-Y, Bonham AC: Postexercise hypotension: central mechanisms. Exerc Sport Sci Rev 38:122–127, 2010.
19. Powers SK, Ji LL, Leeuwenburgh C: Exercise training–induced alterations in skeletal muscle antioxidant capacity: a brief review. Med Sci Sports Exerc 31:987–997, 1999.
20. Brito AF, Oliveira CVC, Toscano LT, Silva AS: Supplements and foods with potential reduction of blood pressure in prehypertensive and hypertensive subjects: a systematic review. ISRN Hypertension 2013: 1–15, 2013.
21. Leibowitz A, Faltin Z, Perl A, Eshdat Y, Hagay Y, Peleg E, Grossman E: Red grape berry–cultured cells reduce blood pressure in rats with metabolic-like syndrome. Eur J Nutr 53:973–980, 2014.
22. Patki G, Allam FH, Atrooz F, Dao AT, Solanki N, Chugh G, Asghar M, Jafri F, Bohat R, Alkadhi KA, Salim S: Grape powder intake prevents ovariectomy-induced anxiety-like behavior, memory impairment and high blood pressure in female Wistar rats. PLoS One 8:e74522, 2013.
23. Park YK, Kim JS, Kang MH: Concord grape juice supplementation reduces blood pressure in Korean hypertensive men: double-blind, placebo controlled intervention trial. Biofactors 22:145–147, 2004.
24. Park YK, Lee SH, Park E, Kim JS, Kang MH: Changes in antioxidant status, blood pressure, and lymphocyte DNA damage from grape juice supplementation. Ann N Y Acad Sci 1171:385–390, 2009.
25. Belcaro G, Ledda A, Hu S, Cesarone MR, Feragalli B, Dugall M: Grape seed procyanidins in pre- and mild hypertension: a registry study. Evid Based Complement Alternat Med 2013:1–15, 2013.
26. Dohadwala MM, Vita JA: Grapes and cardiovascular disease. J Nutr 139:1788S–93S, 2009.
27. Noguer MA, Cerezo AB, Navarro ED, Garcia-Parrilla MC: Intake of alcohol-free red wine modulates antioxidant enzyme activities in a human intervention study. Pharmacol Res 65:609–614, 2012.
28. Toscano LT, Silva AS, Toscano LT, Tavares RL, Biasoto ACT, Camargo AC, Silva CSO, Goncalves MCR, Shahidi F: Phenolics from purple grape juice increase serum antioxidant status and improve lipid profile and blood pressure in healthy adults under intense physical training. J Funct Foods 33:419–424, 2017.
29. Ried K, Fakler P, Stocks NP: Effect of cocoa on blood pressure. Cochrane Database Syst Rev 4:CD008893, 2017.
30. Nogueira LP, Nogueira Neto JF, Klein MR, Sanjuliani AF: Short-term effects of green tea on blood pressure, endothelial function, and metabolic profile in obese prehypertensive women: a crossover randomized clinical trial. J Am Coll Nutr 36:108–115, 2017.
31. Toscano LT, Silva CS, Toscano LT, Almeida AE, Santos AC, Silva AS: Chia flour supplementation reduces blood pressure in hypertensive subjects. Plant Foods Hum Nutr 69:392–398, 2014.
32. Figueroa A, Sanchez-Gonzalez MA, Wong A, Arjmandi BH: Watermelon extract supplementation reduces ankle blood pressure and carotid augmentation index in obese adults with prehypertension or hypertension. Am J Hypertens 25:640–643, 2012.
33. Massa NM, Silva AS, Toscano LT, Silva JD, Persuhn DC, Gonçalves MCR: Watermelon extract reduces blood pressure but does not change sympathovagal balance in prehypertensive and hypertensive subjects. Blood Press 25:244–248, 2016.
34. Kenney MJ, Seals DR: Postexercise hypotension. Key features, mechanisms, and clinical significance. Hypertension 22:653–664, 1993.
35. Pescatello LS, Miller B, Danias PG, Werner M, Hess M, Baker C, Jane De Souza M: Dynamic exercise normalizes resting blood pressure in mildly hypertensive premenopausal women. Am Heart J 138:916–921, 1999.
36. Toscano LT, da Silva CS, Toscano LT, de Almeida AE, Santos Ada C, Silva AS: Chia flour supplementation reduces blood pressure in hypertensive subjects. Plant Foods Hum Nutr 69:392–398, 2014.
37. Fisberg RM: "Inquéritos Alimentares: Métodos e Bases Científicos." São Paulo, Brazil: Manole, 2005.
38. Lima FEL: Validade de um questionário de frequência alimentar desenvolvido para população feminina no nordeste do Brasil. Rev Bras Epidemiol 10:483–490, 2007.
39. Gibson RS. Validity in dietary assessment methods. In "Principles of Nutritional Assessement." New York: Oxford University Press, chapter 7, 149–196, second edition, 2005.
40. Otten JJ, Hellwig JP, Meyers LD: "Dietary Reference Intake: The Essential Guide to Nutrient Requirements." Washington, DC: The National Academies Press, 2006.
41. Sociedade Brasileira de Cardiologia, Sociedade Brasileira de Hipertensão, Sociedade Brasileira de Nefrologia: Revista de Hipertensão, VI Diretrizes Brasileiras de Hipertensão. 13, 2010.

42. Borg GAV, Noble BJ: Perceived exertion. In Wilmore JH (ed): "Exercise and Sport Sciences Reviews," Vol. 2. New York: Academic Press, pp 131–153, 1974.
43. Karvonen JJ, Kentala E, Mustala O: The effects of training on heart rate: a "longitudinal" study. Ann Med Exp Biol Fenn 35:307–315, 1957.
44. Opie LH, Lecour S: The red wine hypothesis: from concepts to protective signalling molecules. Eur Heart J 28:1683–1693, 2007.
45. Dohadwala MM, Hamburg NM, Holbrook M, Kim BH, Duess MA, Levit A, Titas M, Chung WB, Vincent FB, Caiano TL, Frame AA, Keaney JF Jr, Vita JÁ: Effects of Concord grape juice on ambulatory blood pressure in prehypertension and stage 1 hypertension. Am J Clin Nutr 1–3:1052–1059, 2010.
46. Sabbahi A, Arena R, Elokda A, Phillips SA: Exercise and hypertension: uncovering the mechanisms of vascular control. Prog Cardiovasc Dis 59(3):226–234, 2016.
47. Notarius CF, Morris BL, Floras JS: Caffeine attenuates early post-exercise hypotension in middle-aged subjects. Am J Hypertens 19:184–188, 2006.
48. Cazé RF, Franco GAM, Porpino SKP, Souza AA, Padilhas OP, Silva AS: Caffeine influence on blood pressure response to aerobic exercise in hypertensive subjects. Rev Bras Med Esporte 16:324–328, 2010.
49. Nóbrega TKS, Moura Junior JS, Alves NFB, Santos AC, Silva AS: A ingestão de café abole a hipotensão induzida por exercício aeróbio: um estudo piloto. Revista da Educação Física/UEM Maringá 22:601–612, 2011.
50. Souza AA, Silva RS, Silva TF, Tavares RL, Silva AS: Influence of different doses of coffee on post-exercise blood pressure response. Am J Cardiovasc Dis 6:146–152, 2016.
51. Forjaz CL, Tinucci T, Ortega KC, Santaella DF, Mion D Jr: Negrão CE: Factors affecting post-exercise hypotension in normotensive and hypertensive humans. Blood Press Monit 5:255–262, 2000.
52. Syme AN, Blanchard BE, Guidry MA, Taylor AW, Vanheest JL, Hasson S, Thompson PD, Pesvcatello LS: Peak systolic blood pressure on a graded maximal exercise test and the blood pressure response to an acute bout of submaximal exercise. Am J Cardiol 98:938–943, 2006.
53. Guidry MA, Blanchard BE, Thompson PD, Maresh CM, Seip RL, Taylor AL, Pescatello LS: The influence of short and long duration on the blood pressure response to an acute bout of dynamic exercise. Am Heart J 151:1322.e5–1312, 2006.
54. Anunciação PG, Polito MD: A review on post-exercise hypotension in hypertensive individuals. Arq Bras Cardiol 96:e100–e109, 2011.
55. Monteiro MF, Sobral Filho DC: Physical exercise and blood pressure control. Rev Bras Med Esporte 10:513–516, 2004.
56. Casonatto J, Polito MD: Post-exercise hypotension: a systematic review. Rev Bras Med Esporte 15:151–157, 2009.
57. Marques-Silvestre ACOM, Santos MSB, Oliveira AS, Silva FTM, Santos AC: Magnitude of hypotension after acute aerobic exercise: a systematic review of randomized trials. Motricidade 10:99–111, 2014.
58. Pardono E, Almeida MB, Bastos AA, Simões HG: Post-exercise hypotension: possible relationship with ethnic and genetic factors. Rev Bras Cineantropom Desempenho Hum 14(3):353–361, 2012.
59. Acerbi KKCS, Gonçalves A, Sobreira V: Furlanetto Júnior R: Hypotension post-exercise: considerations on intensity, duration and type of aerobic exercise. Bras Med 49(1), 2012.