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ABSTRACT

Background: The acute effects of high-intensity interval training (HIIT) on blood pressure (BP) may depend on the exercise protocol performed. **Purpose:** To compare the acute effect of high and low-volume HIIT on post-exercise and ambulatory BP in untrained older females diagnosed with both type 2 diabetes (T2D) and hypertension (HTN). **Methods:** Fifteen females (69 [65 ─ 74] years) completed a crossover study with three experimental conditions: 1) REST (35 min in sitting position); 2) HIIT10 (10 × 1 min at 90% heart rate max [HRmax]), and 3) HIIT4 (4 × 4 min at 90% HRmax). After each experimental condition, BP was measured under controlled (4 hours) and in subsequent free-living conditions (20 hours). **Results:** In the controlled post-condition 4-hour period, no significant interaction (time × condition) was observed for all BP parameters ($p \geq 0.082$). Similarly, during the subsequent 20-hour free-living ambulatory monitoring (diurnal and nocturnal), no differences between conditions were detected ($p \geq 0.094$). A significant reduction in nighttime pulse pressure was observed in both HIIT4 and HIIT10 compared to REST (46 [44 ─ 50], 45 [42 ─ 53] vs. 50 [45 ─ 57] mmHg, respectively; $p \leq 0.018$) with no differences between HIIT conditions ($p = 0.316$). Changes in nocturnal systolic BP approached but did not reach statistical significance ($p = 0.068$). **Conclusions:** This study suggests that in untrained older females living with T2D and HTN, the HIIT10 and HIIT4 protocols have very limited to no acute effect on post-exercise and ambulatory BP. The fact that the vast majority of participants had well-controlled office and ambulatory BP values as well as low cardiorespiratory fitness could explain these findings.

Key Words: AGING, HIIT, INTERVAL EXERCISE, POST-EXERCISE HYPOTENSION, VASCULAR HEALTH

INTRODUCTION

Females living with type 2 diabetes (T2D) are at a higher risk of developing vascular complications compared to males, and they are twice as likely to die from cardiovascular diseases (CVD) (1-3). T2D can contribute to atherosclerosis, impaired vasodilation, and increased arterial stiffness (4). Consequently, the risk of vascular complications, including hypertension (HTN), is significantly elevated (4, 5). HTN stands as the primary risk factor for CVD in the context of T2D and constitutes a significant contributor to premature mortality (6, 7). Hypertension Canada and the American Heart Association now recommends the use of out-of-office blood pressure measurement with ambulatory blood pressure (ABP) monitoring as it appears to be a better predictor of cardiovascular complications and mortality associated with HTN (8-13).

Regular exercise is universally recommended to improve blood pressure (7, 12, 13). High-intensity interval training (HIIT) has garnered particular interest for its positive effects on cardiorespiratory fitness (*i.e.*, $\dot{V}O_2$ max) and cardiometabolic health (*i.e.*, arterial stiffness and blood glucose) despite requiring a shorter exercise duration than traditional continuous exercise (14-17). Recent evidence has highlighted the cardiometabolic benefits of low-volume HIIT (≤ 10 min of vigorous intensity) (17, 18). Nevertheless, we have previously reported that low-volume HIIT (6 × 1 min at 90% of maximum heart rate [HRmax]) was insufficient to reduce ABP in older females living with T2D (19). It is worth noting that reductions in systolic ABP have been observed by others using different HIIT protocols. Notably, Ramirez-Jimenez et al. (2017) found a decrease in ABP in middle-aged individuals with metabolic syndrome and HTN using a HIIT protocol of higher volume intervals (4 × 4 min at 90% HRmax) (20). On the other hand, Dantas

et al. (2017) observed acute reductions in ABP over 20 hours in normotensive young males following a low-volume HIIT protocol of 10 × 1 min at 100% of maximal treadmill speed required to reach $\dot{V}O_2$ max (21).

Thus, there appears to be a minimal effective dose of HIIT required to positively influence blood pressure management. Since a higher HIIT volume (*i.e.*, time at vigorous intensity) can lead to greater dropout rates in sedentary or inactive individuals, it is crucial to determine if low-volume HIIT can achieve similar benefits in clinical populations regarding blood pressure control (22). However, no study has directly compared the effects of the popular 4 × 4 min protocol to the low-volume 10 × 1 min protocol on ABP in a population at risk of CVD. Therefore, the main objective of this study was to compare the acute effects of these two HIIT modalities on post-exercise blood pressure and ABP in untrained older females diagnosed with T2D and HTN. Due to the strong association between arterial stiffness and the risk of cardiovascular events in older individuals with HTN, estimated indicators of arterial stiffness and wave reflection were also examined (23). It was hypothesized that a higher volume at high-intensity (4 × 4 min at 90% HRmax) would reduce post-exercise blood pressure and ABP more significantly than a protocol with lower-volume (10 × 1 min at 90% HRmax).

METHODS

Study protocol

A counterbalanced crossover study was conducted at the Research Centre on Aging of the CIUSSS de l'Estrie-CHUS from October 2021 to May 2023, with three experimental conditions: REST (35 min in sitting position); 2) HIIT10 (10 × 1 min at 90% HRmax), and 3)

HIIT4 (4 × 4 min at 90% HRmax). After the confirmation of eligibility and providing written informed consent, each participant completed 8 to 9 visits at the research centre. First, participants completed a preliminary visit which included the following assessments: 1) resting blood pressure and heart rate (HR); 2) fasting metabolic profile (glucose, insulin, A1c, lipid profile); 3) anthropometry and body composition; 4) medical history and physical activity habits (Physical Activity Scale for the Elderly) (24). Additionally, participants completed a brief familiarization period on the treadmill, followed by a maximal cardiopulmonary exercise test to determine HRmax, peak oxygen uptake ($\dot{V}O_2$ peak) and to obtain medical clearance for vigorous exercise. In the two-week period after the preliminary visit, participants underwent 4 to 5 familiarization exercise sessions aimed to: 1) assess the participant's ability to complete both HIIT protocols (4 × 4 min and 10 × 1 min); 2) to confirm the appropriate treadmill settings (speed and incline) required to achieve the prescribed intensity (90% HRmax); 3) and to acquaint participants with the process of blood pressure measurement. However, intervals of 1 minute are not long enough to reach 90% HRmax. Therefore, the first two intervals of the HIIT4 familiarization session were used to determine the treadmill settings needed to reach 90% of HRmax, eliminating the confounding effect of cardiac drift later during the session. The same speed and slope were then used for the 10 × 1 minute session to replicate the same mechanical intensity. After completion of all familiarization sessions, and at least 72 hours after the last one, participants began the experimental period with the control condition (REST). Subsequently, they performed the HIIT10 and HIIT4 conditions over 10 days, with the order randomized by the principal investigator using variable block sizes (2 or 4). Each experiment was performed with at least 48 hours between them. Visual representation of the study protocol is also available in a previous publication and in Supplemental Figure 1 (Supplemental Digital Content) (25). The

study was conducted following the Canadian Tri-Council Policy Statement and registered under ClinicalTrials.gov: NCT04986345 with changes in blood pressure as the primary outcome measure. Ethical approval from the Research Ethics Committee of CIUSSS de l'Estrie-CHUS was obtained before participant recruitment and the study was conducted following ethical guidelines.

Participants

Participants were recruited through a recruitment platform of the Research Centre on Aging (Nabû), advertisements, and word-of-mouth referrals. To be eligible for inclusion, participants had to be: 1) female (self-declaration of biological sex at enrollment); 2) aged between 60 and 80 years old; 3) diagnosed with both T2D and HTN; 4) considered physically inactive (≤ 150 min of moderate to vigorous aerobic activity per week), but engaged in at least 60 minutes of structured physical activity per week for the preceding 3 months (26); 5) non-smokers (cigarette, e-cigarette, tobacco pipe, marijuana); 6) and consuming fewer than 7 alcoholic beverages per week. Research volunteers were excluded from the study if they met any of the following exclusion criteria: 1) individuals undergoing insulin therapy; 2) recent medication changes within the past 6 months; 3) had a stroke within the last 6 months or any other condition that significantly limited exercise capacity at high-intensity; 4) diagnoses of coronary artery disease or peripheral artery disease without revascularization; 5) presence of microvascular complications associated with T2D, such as neuropathy, retinopathy, or nephropathy; 6) orthopedic limitations; 7) and individuals with planned surgery during the study period.

Cardiorespiratory fitness

Cardiorespiratory fitness ($\dot{V}O_2$ peak) was assessed according to a previously published protocol (25). Briefly, $\dot{V}O_2$ peak was determined using a mixing chamber metabolic gas analysis system (PARVO Medics, TrueOne 2400, Sandy, USA) during an incremental maximal treadmill test. The test involved customizing the speed for each participant based on their age-predicted HR, and then gradually increasing the treadmill incline while keeping the speed constant (27). Whether participants reached $\dot{V}O_2$ max was assessed based on the following criteria: 1) respiratory exchange ratio ≥ 1.15; 2) HR ≥ predicted HRmax (220 – age); 3) oxygen consumption plateau (< 150 mL or < 2.1 mL/kg/min) despite an increase in workload; 4) perceived exertion ≥ 9 out of 10 on the modified Borg scale (28). Since most participants did not meet all these criteria, $\dot{V}O_2$ peak was used instead (28). Continuous HR monitoring was conducted using a 12-lead electrocardiogram (Quinton Q-stress, Quinton Inc, Bothell, USA), and all tests were supervised by an exercise physiologist and a cardiologist.

Experimental Conditions

For each experimental condition, participants arrived at the Research Centre for Aging in the morning in a fasted state (≥ 12 hours). They were first equipped with a triaxial accelerometer (wGT3X-BT, Actigraph, Pensacola, USA). Participants were then provided with a standardized breakfast consisting of a protein shake (Boost, Nestle, Vevey, Switzerland; 245 kcal: 33% protein, 49% carbohydrate, 18% fat) and instructed to take their medications as per their regular schedule. One hour after breakfast, participants completed the control condition (REST), which involved sitting still in a chair for 35 minutes. Following the REST condition, participants underwent a 4-hour controlled period of passive sitting, with a standardized meal provided after

the first 2 hours (546 kcal: 18% protein, 61% carbohydrate, 21% fat). They were allowed to perform passive tasks that they might normally do in their daily lives (e.g., reading), but they were required to remain seated in silence and not allowed to take a nap. Afterward, participants returned home and were scheduled for the two HIIT experimental conditions. Both HIIT protocols were performed on a treadmill (Life Fitness, Illinois, USA) at the same time of day for each condition, supervised by an exercise physiologist. HR was continuously monitored using a HR monitor (Polar H10, Polar, Finland) and the Polar Flow application. Capillary blood glucose levels (Accu-Chek inform II, Basel, Switzerland) were measured before and after each exercise session for safety purposes. More details on each exercise prescription are available elsewhere (25). In brief, the HIIT4 condition consisted of 4 intervals of 4 minutes at 90% HRmax (determined during the incremental maximal treadmill test), separated by 3 minutes of active recovery periods at 70% HRmax, totaling 35 minutes of exercise time. The HIIT10 session involved 10 intervals of 1 minute at 90% HRmax, with 1 minute of active recovery at 70% HRmax, totaling 38 minutes of exercise time. The warm-up and cool-down durations were designed to match the estimated external workload (time × % HRmax) between the two protocols. HIIT4 began with a 4-minute warm-up at 60% HRmax and 1 minute at 70% HRmax and ended with a 2-minute cool-down at 60% HRmax. HIIT10 began with an 8-minute warm-up at 60% HRmax and 2 minutes at 70% HRmax and ended with an 8-minute cool-down at 60% HRmax.

Post-Condition Blood Pressure, Ambulatory Blood Pressure and Arterial Stiffness

Blood pressure was measured using a manual sphygmomanometer (ADC Diagnostix 703, American Diagnostic Corporation, New-York, USA) before, directly after, and 5 minutes after each experimental condition. This approach was chosen because most automatic oscillometric devices are only validated for use at rest. For each measurement, except immediately after exercise, participants were instructed to maintain a relaxed posture, sitting with their feet flat on the floor and their back supported. Room temperature was maintained between 22 and 24°C for consistency. Participants' arm was supported at heart level, and the appropriate cuff size was ensured. Participants were encouraged to use the bathroom before the 4-hour controlled period to avoid the potential increase in blood pressure (20-25 mmHg) due to a distended bladder (29). As they were not allowed to shower during the monitoring period, participants were provided with a wet towel to avoid the potential effects of water temperature on blood pressure (30). The ABP monitor (Mobil-O-Graph PWA, IEM, Stolberg, Germany) was installed on the non-dominant arm of the participant within 10 minutes following the exercise intervention. The monitor was worn for the next 24 hours, including the 4-hour post-condition period (Figure 1). Before installing the ABP monitor, arm circumference was measured to ensure the proper fit. The monitor was placed halfway between the tip of the shoulder and the elbow, with a marker line drawn at the location of the brachial artery. Participants received standardized instructions on proper cuff repositioning and were instructed: 1) not to talk or move during measurements; 2) to support their arm at heart level whenever possible during measurement; 3) how to reattach the tubing to the device if it becomes displaced, 4) and how to turn off the monitor the next day. A logbook was provided for participants to document medication intake, bedtime, and other

activities influencing blood pressure. They were instructed to replicate these activities during the other experimental conditions as much as possible.

Systolic (SBP) and diastolic (DBP) blood pressure, HR, and blood pressure variability (standard deviation [SD] of blood pressure values) were monitored using the Mobil-O-Graph device for the subsequent 4-hour controlled period and 20-hour free-living conditions. The Mobil-O-Graph is regularly used in clinical settings and has excellent validity for blood pressure measurements (31). It also has acceptable validity and excellent reliability for non-invasive arterial stiffness monitoring (32, 33). Mean arterial pressure (MAP) values were calculated according to the most common used formula (MAP = DBP + 0.33 × PP) (34). Estimated indicators of arterial stiffness and wave reflection, including pulse wave velocity (PWV), augmentation index normalized to a HR of 75 bpm (AIx@75), and pulse pressure (PP), were collected. PP is defined by the difference between SBP and DBP; PWV by the time between estimated forward and reflected waves, and AIx@75 by the ratio of augmentation pressure to the PP standardized at 75 bpm (35). Dipping status (≥ 10% reduction in nocturnal SBP) and pre-waking morning surge (mean blood pressure 2 hours after awakening – mean blood pressure 2 hours before awakening) were both examined considering their clinical relevance (36, 37). Measurements were collected every 20 minutes during the day and every 30 minutes during the night (38). Valid ABP monitoring required 24 hours of recording and 70% of total valid measures, with at least 20 daytime and 7 nighttime measurements (39). On only two occasions, ABP monitoring did not have 70% of valid measurements, but they were still considered as they had at least 20 daytime and 7 nighttime measurements. The diurnal and nocturnal periods were

established according to participants' usual waking and sleeping times. Data analysis was performed using the HMS CS Analysis Tool (IEM, Stolberg, Germany).

Anthropometric and Body Composition

To calculate body mass index, body weight was measured with an electronic scale (SECA707, Hamburg, Germany; ± 0.2 kg) and height was obtained using a wall stadiometer (Takei, Tokyo, Japan; ± 0.1 cm). The waist circumference (± 0.1 cm) was measured at the midpoint between the inferior costal border and the iliac crest (40). Assessment of lean body mass (coefficient of variation in our laboratory [CV] of 1.2 %) and fat mass (CV of 1.9 %) was performed using Dual-energy X-ray absorptiometry (iDXA, GE Healthcare, Chicago, USA) and analyzed with EnCORE Version 16 software.

Macronutrient Intakes and Physical Activity Levels

A dietary journal was used to record the food intake, both 12 hours before and 24 hours after the REST condition. Participants received clear instructions on how to complete the dietary journal and were asked to replicate their exact meals for the two other conditions to prevent influencing blood pressure measurements (also recorded with the dietary journal). They were also instructed to refrain from consuming caffeine and alcohol for the same time frame. Total energyintake, macronutrient composition, and sodium intake were then determined using Nutrific software (Laval University, Sainte-Foy, Canada). Physical activity levels were assessed by accelerometer (wGT3X-BT, ActiGraph, Pensacola, USA) throughout the study duration. The triaxial accelerometer was worn at the waist level of the non-dominant side, specifically at the anterior auxiliary line and participants had to replicate the same physical activities around each

condition. Data were collected in 60-second epochs at a frequency of 30 Hz and physical activity behaviors (sedentary: SED, light physical activity: LPA, and moderate to vigorous physical activity: MVPA) were classified using validated cut-off points (41). Participants were instructed to keep wearing the accelerometer during sleep but sleeping time recorded in the participants' logbook was subtracted when calculating time spent in SED behaviors.

Statistical Analysis

Since there is no study comparing the intra-individual response to HIIT4 and HIIT10, a power analysis based on the study by Ramirez-Jimenez et al. (2017) indicated that 9 individuals would be sufficient to detect a difference (alpha of 0.05, beta of 0.80, effect size f = 0.95) between a HIIT modality and a moderate-intensity training modality in 24-hour ABP (20). However, basing a sample size calculation on the data from another study is increasingly criticized, as it can lead to variable power calculations or even reproduce potential biases, such as type I errors (42). Thus, a sample size of 15 participants was deemed sufficient to detect a large effect size (f = 0.4) based on the in changes in SBP after exercise (post-exercise hypotension) as the main outcome, according to G*Power software (alpha of 0.05, beta of 0.80), using a crossover study design, and repeated measures (43). A large effect size was considered reasonable based on previously published meta-analyses (44, 45). Data normality was assessed using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots. Since normality tests may be less suitable for sample sizes under 30, the normality of the data was primarily determined by visual examination of quartile histograms and Q-Q plots (46). HR and Borg scale ratings at the end of each interval and during all exercise sessions were compared using paired t-tests.

Comparisons between experimental conditions for SBP, MAP, and DBP during the post-condition 4-h controlled period were performed using linear mixed-effects models (LMM) to account for missing and repeated data (47). The fixed effect of the condition, time, and their interaction was examined with parameter estimation using restricted maximum likelihood (REML) considering pre-condition values as a covariate. Random effects were added at the participant level (ID) to account for repeated measures of each participant using an unstructured repeated covariance type. Accordingly, comparisons between experimental conditions for ABP, HR, indicators of arterial stiffness and wave reflection, physical activity levels, macronutrient and sodium intake during the free-living ambulatory monitoring period were analyzed using the same approach. However, only the fixed effect of the condition was considered with no covariates included. In case of a statistically significant difference in the overall model, post-hoc analyses were adjusted for multiple comparisons with the False Discovery Rate (FDR) using the Benjamini – Yekutieli procedure (48). The assumptions of the LMM, including residual normality of data, homoscedasticity, and independence, were examined. Nonetheless, the model was still employed in cases of small deviations given its robust properties (49). Statistical analyses were performed using IBM SPSS Statistics version 26.0 (Armonk, New York, United States) and the procedures were carried out in collaboration with a qualified biostatistician to ensure methodological accuracy. Data are presented as median [interquartile range] (IQR) unless otherwise stated and the alpha was set to ≤ 0.05.

RESULTS

Participant characteristics

A total of 70 older females living with both T2D and HTN were initially contacted to participate in the study. A total of 28 refused to participate and 24 were excluded based on inclusion/exclusion criteria, resulting in 18 individuals who signed the information and consent form. Three participants were later excluded after the initial visit or after the REST condition (1 = severe dizziness not related to exercise; 1 = non-compliance with study protocol; and 1 = detection of cardiac abnormality not related to the study procedures). Therefore, 15 participants completed all experimental conditions and were included in the final analyses (Figure 2).

Baseline characteristics are summarized in Table 1. Alcohol consumption ranged from never (n = 2), to occasionally (n = 9), and 1 – 2 times a week (n = 4). Most participants had a high school diploma (n = 14/15) and one had a post-secondary degree (n = 1/15). Results of Table 1 are also presented as mean ± SD in the Supplemental Table 1 (Supplementary Digital Content).

Experimental conditions

All participants completed study procedures with no adverse events reported. HR during intervals was 134 [120 – 146] bpm for HIIT4 and 120 [116 – 132] bpm for HIIT10 ($p = 0.001$; Figure 3), and was significantly higher in HIIT4 than HIIT10 (120 [112 – 129] bpm vs. 111 [106 – 119] bpm, $p = 0.049$) for the entire training. The speed during intervals was 3.5 [3.0 – 4.0] km/h, and the slope used was 7.0 [6.0 – 8.5] % with a similar rate of perceived exertion,

measured by Borg Scale CR-10, between both HIIT condition (HIIT4: 3.3 [2.5 – 4] vs. HIIT10: 3.0 [2 – 4.2], p = 0.127).

Experimental 4-h controlled period

When assessing SBP in the post-condition controlled period, LMM revealed a significant time effect (p = 0.001) and condition effect (p = 0.001), but no interaction was detected (p = 0.387; Figure 4). For MAP, a similar pattern was observed with a significant effect of time (p = 0.001) and condition (p = 0.001), while no interaction effect was detected (p = 0.314). Finally, for DBP, significant effects of time (p = 0.0001) and condition (p = 0.007) were noted, with an interaction that approached but did not reach statistical significance (p = 0.082). Results from Figure 4 are also presented as numerical mean ± SD in Supplemental Tables 2 and 4 (Supplemental Digital Content), with estimated marginals means ± standard error and 95% confidence interval.

Free-living blood pressure monitoring

All 20-hour ambulatory hemodynamics parameters (SBP, MAP, DBP, HR, and blood pressure variability) were not different between conditions (p ≥ 0.278; Table 2). Similarly, no condition effect was detected for arterial stiffness and wave reflection indicators (p ≥ 0.284). For diurnal measures, all parameters remained unchanged after each experimental condition (p ≥ 0.123). When considering nocturnal measures, an effect of condition was noted for changes in PP (p = 0.002). Post-hoc analysis showed a statistically significant difference between HIIT4 and REST, 46 [44 – 50] mmHg vs. 50 [45 ─ 57] mmHg (adjusted p = 0.003), and between HIIT10 and REST, 45 [42 – 53] mmHg vs. 50 [45 ─ 57] mmHg (adjusted p = 0.018), with no difference between HIIT conditions (adjusted p = 0.316). Changes in nighttime SBP and PWV approached

but did not reach statistical significance ($p = 0.068$ and $p = 0.057$, respectively). All other parameters were not significantly different between conditions in the nocturnal period ($p \geq 0.094$). Results from Table 2 are also presented as numerical mean ± SD in Supplemental Tables 3 and 5 (Supplemental Digital Content) material, with estimated marginals means ± standard error and 95% confidence interval.

Macronutrient Intakes and Physical Activity Levels

No condition effect was observed in total energy intake in calories and macronutrient composition (proteins, carbohydrates, lipids) 24 hours after the experimental conditions ($p \geq 0.232$; Table 3) and in the 12 hours preceding them ($p \geq 0.066$). Accordingly, sodium intake was not different between conditions for each of these periods ($p \geq 0.682$). No significant differences were also observed in SED, MVPA, and sleep time ($p \geq 0.061$; Table 4) after each experimental condition. Results from Table 3 and Table 4 are also presented as mean ± SD in Supplemental Tables 6 and 7 (Supplemental Digital Content).

DISCUSSION

The objective of this study was to assess the acute effects of high and low-volume HIIT protocols on post-exercise blood pressure, ABP, indicators of arterial stiffness, and wave reflection in untrained older females diagnosed with both HTN and T2D. Overall, our results suggest that performing a high volume HIIT (*i.e.*, 4 × 4-min at 90% HRmax) or a low-volume HIIT *(i.e.*, 10 × 1-min at 90% HRmax) could acutely decrease nighttime PP, while no difference was observed after the REST condition. However, no other parameters, either in post-condition or during ambulatory monitoring, were influenced by the HIIT protocols.

When considering the post-condition 4-h controlled period, our study does not support a clear effect of the HIIT4 and HIIT10 on blood pressure parameters in untrained aging females with T2D and HTN. Despite the fact that both HIIT conditions visually appear to consistently reduce SBP, MAP, and DBP for at least up to 60 minutes after exercise (Figure 4), these reductions were not sufficient to show a significant difference compared to the control condition. This observation contradicts some evidence suggesting that acute post-exercise hypotension induced by HIIT can persist for a few hours in individuals with HTN (20, 50). During exercise, cardiac output increases, and peripheral vascular resistance decreases to meet the heightened metabolic demands. At the end of exercise, cardiac output returns to resting values more quickly than peripheral vascular resistance, causing a decrease in blood pressure and characterizing post-exercise hypotension (51). The endothelial dysfunction commonly observed in T2D may limit the production of vasodilatory factors during and after exercise, potentially explaining the limited hypotensive response observed in our study (52). This hypothesis needs further investigation in future studies.

Examining 20-hour ABP parameters, our study did not observe significant differences between conditions, and no significant impact on blood pressure variability was noted. The absence of a clear effect of HITT on ABP of older females living with T2D and HTN was surprising. Previous studies and meta-analyses have reported significant reductions in ABP after both moderate-intensity continuous training and HIIT in adults, regardless of HTN status (53, 54). Similar findings have been observed in older individuals living with and without T2D (55, 56). However, it is possible that the training status, baseline blood pressure values of our participants, and the acute setting of our protocol played a role in the observed outcomes.

Iellamo et al. (2021) demonstrated that, at baseline, only moderate-intensity continuous training and combined training resulted in acute reductions in 24-hour SBP in elderly patients living with HTN, whereas HIIT did not (53). By the end of a 12-week training period, the trend reversed, showing acute reductions in ABP only after HIIT (53). Thus, the hypotensive effect of HIIT in individuals diagnosed with HTN may depend on training status, specifically a higher $\dot{V}O_2$ max, which facilitates a greater absolute intensity during exercise. This is consistent with the fact that participants in our study had low aerobic fitness according to both the Fitness Registry and the Importance of Exercise National Database (FRIEND) and the American College of Sport Medicine (ACSM) reference values for females (25^{th} and 15^{th} percentile, respectively) (57, 58). Furthermore, considering the median speed (3.5 km/h) and incline (7%) used in the exercise conditions, the absolute intensity attained during the intervals was roughly 4.75 Metabolic Equivalent of Task (METs) by the Kokkinos, Kaminsky (59) formula validated with the FRIEND registry. Despite being the treadmill intensity required to elicit ~ 90% HRmax (as confirmed during the familiarization sessions in our study), this is below the vigorous intensity threshold in the last World Health Organization 2020 guidelines on physical activity and sedentary behaviors, as well as the ACSM guidelines. (58, 60). Additionally, the majority of participants already maintained well-controlled office and ABP values (128 [119 – 145] / 79 [72 – 82] mmHg; 116 [108 ─ 126] / 65 [63 ─ 72] mmHg, respectively) per the latest guidelines of Hypertension Canada for individuals living with T2D (≤ 130/80 mmHg) (12). This may have introduced a floor effect, limiting the potential magnitude of reduction in response to the HIIT conditions, a phenomenon known as Wilder's principle (61). A recent network meta-analysis comparing the hypotensive effects of various exercise modalities illustrates this principle, indicating that while all modalities could reduce blood pressure, the effects were notably more

pronounced in individuals with higher baseline values (62). Another explanation could be that in our study design, the post-condition period (4 hours) was in controlled laboratory setting and analyzed separately from the ambulatory period (20 hours). However, similar results were observed when the 24-hour period after the conditions was analyzed as a single block (*data not shown*). The analysis of both diurnal and nocturnal ABP revealed consistent results, with all variables remaining unchanged across conditions. The HIIT sessions also did not result in statistically significant changes in nocturnal dipping or pre-waking morning surge. Although most participants were initially classified as non-dippers following the REST condition (n = 10/15), three additional participants surpassed the threshold of ≥ 10% only after the HIIT4 condition, being categorized as dippers (63).

Indicators of arterial stiffness and wave reflection were generally consistent across periods. AIx@75 and PWV were not influenced by the exercise sessions. However, participants already had relatively normal AIx@75 values considering their sex (female) and cardiovascular status (risk factor of CVD), questioning the possibility of a notable reduction (35). Moreover, a recent meta-analysis showed a limited effect of exercise on PWV in individuals living with T2D (64). During the nocturnal period, both HIIT conditions resulted in lower PP, suggesting improved arterial compliance (65). While statistically significant, the clinical implications of these changes appear limited. Because our participants initially had normal PP values (~50 mmHg) for their age, it becomes challenging to draw conclusions about the potential impact of a reduction of 4 –5 mmHg in this situation. Nevertheless, it is reasonable to hypothesize that engaging in long-term HIIT could help alleviate the age-related increase in PP.

These findings should be considered in light of the study's strengths and limitations. While the total workload was equivalent between the two exercise sessions, HIIT4 involved a higher volume at 90% of HRmax (16 min vs. 10 min). However, our primary goal was to compare these two common HIIT protocols, given their frequent use in the scientific literature, particularly with clinical populations (66). Additionally, post-exercise blood pressure was examined over an extended period in controlled settings (4 hours), offering a precise depiction of its evolution after the two HIIT conditions. Meticulous control measures were also implemented to address other potential confounders, including factors such as room temperature, diet, and physical activity levels. Moreover, it is essential to acknowledge that this study exclusively examined the acute effects of various HIIT protocols on ABP. The observed outcomes might differ following a chronic intervention. Lastly, the study focused solely on elderly females, a demographic that historically received limited attention or exclusion in exercise science. This choice helps address potential sex-specific nuances in exercise-related outcomes and health implications.

CONCLUSIONS

This study shows that a single session of HIIT with either low-volume (10 × 1 min at 90% HRmax) or high-volume (4 × 4 min at 90% HRmax) intervals led to acute reductions in nighttime PP. However, the clinical significance of these changes remains uncertain. The lack of a profound difference between the two exercise interventions and the control condition suggests that acute HIIT may not substantially impact post-exercise blood pressure and ABP management in untrained older females living with T2D and HTN. The fact that most participants already had well-controlled office and ABP values, along with low cardiorespiratory fitness, could explain

these limited effects. It is essential to consider that the impact of HIIT may be more pronounced in those with less optimized ABP control or untreated HTN. Future research should explore the long-term effects of these different HIIT modalities, particularly in older females diagnosed with T2D and HTN, or in individuals with less optimal ABP values.

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FIGURE LEGENDS

Figure 1. Overview of blood pressure monitoring periods

ABP: ambulatory blood pressure; BP: blood pressure.

Figure 2. Flow chart diagram

Figure 3. Heart rate during each experimental condition

Data are presented as median [interquartile range].

HIIT4: 4 × 4 min; HIIT10: 10 × 1 min; dash (HIIT4) and dot (HIIT10) lines = separate the warm-up/cool-down from the interval training period.

Figure 4. Blood pressure measurements during the post-condition 4-h controlled period

Data are presented as median [interquartile range].

Cond: condition; HIIT4: 4 × 4 min; HIIT10: 10 × 1 min; T1: pre-condition; T2: post-condition; T3: 5 min post; T4: 20 min post; T5: 40 min post; T6: 60 min post; T7: 80 min post; T8: 100 min; T9: 120 min; T10: 140 min; T11: 160 min post; T12: 180 min; T13: 200 min; T14: 220 min; T15: 240min; Dash line represents the end of the condition; A: systolic blood pressure; B: diastolic blood pressure; C: mean arterial pressure.

SUPPLEMENTARY DIGITAL CONTENT

SDC 1: DT2A_MAPA_SUPP_Revised.docx

Figure 1

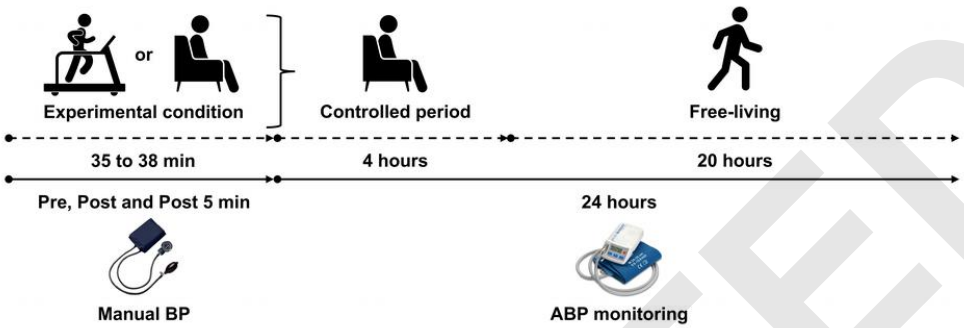


Figure 2

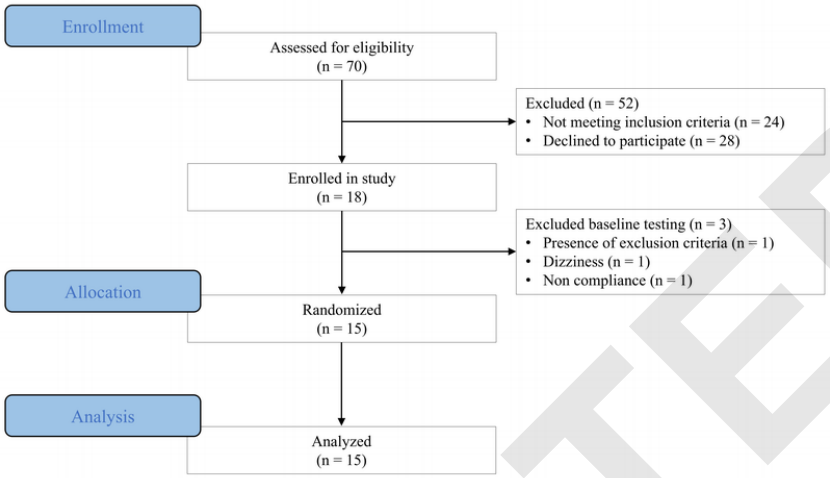


Figure 3

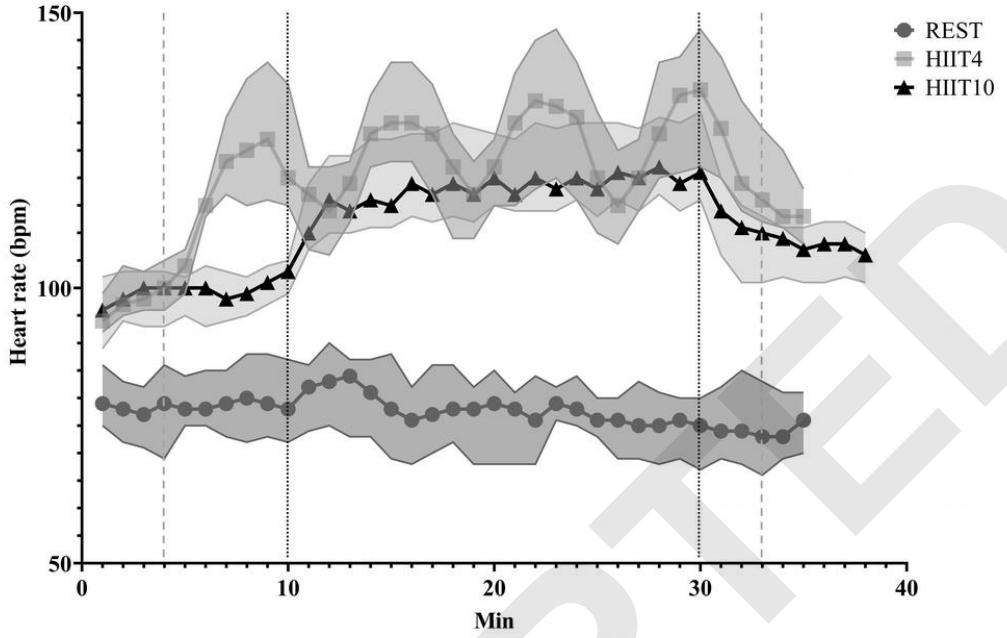
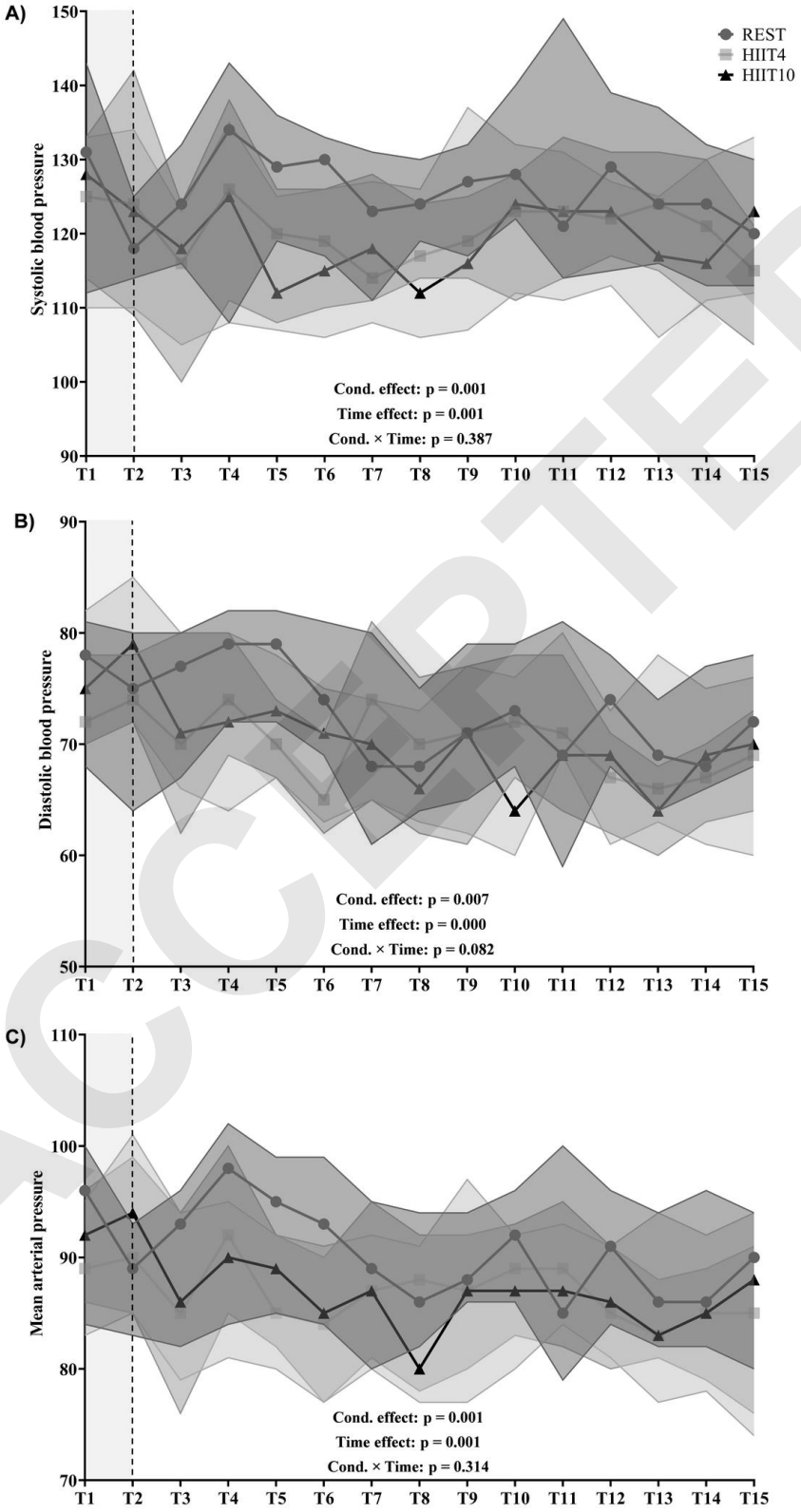
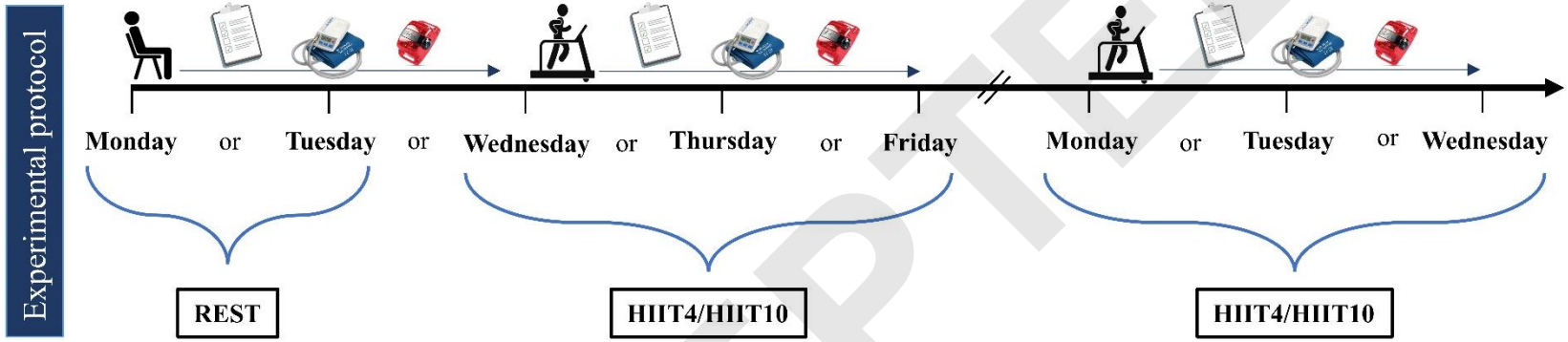


Figure 4



SUPPLEMENTARY DIGITAL CONTENT 1

Figure S1. Chronology of experimental sessions



: REST condition, : dietary journal, : ambulatory blood pressure monitoring, : accelerometry; HIIT4: 4 × 4 min; HIIT10: 10 × 1 min.

Table S1. Participants baseline characteristics

Variables	**Total** (n = 15)
Age (years)	69.6 ± 4.3
Duration of T2D (years)	10.9 ± 6.7
PASE score	127 ± 63
Body composition and anthropometry	
Weight (kg)	81.8 ± 14.3
BMI (kg/m^2)	32.9 ± 5.6
Waist circumference (cm)	107.8 ± 12.1
Total fat mass (kg)	36.4 ± 8.3
Total LBM (kg)	42.2 ± 6.2
Fasting blood profile	
A1c (%)	6.6 ± 1.0
Fasting glucose (mmol/L)	7.1 ± 0.9
Fasting insulin (mmol/L)	137.8 ± 115.6
Triglycerides (mmol/L)	1.4 ± 0.6
Total cholesterol (mmol/L)	3.6 ± 0.8
LDL-C (mmol/L)	1.7 ± 0.6
HDL-C (mmol/L)	1.4 ± 0.4
Resting/Maximal cardiorespiratory parameters	
Resting systolic BP (mmHg)	128 ± 16
Resting diastolic BP (mmHg)	77 ± 8
VO_2 peak (mL/kg/min)	17.1 ± 3.2

Maximal HR (bpm)	149 ± 18
Glucose lowering medication [n (%)]	
SGLT2 inhibitors	5 (33)
Biguanides	11 (73)
GLP-1 agonists	4 (27)
Sulfonylureas	1 (6)
Hypotensive medication [n (%)]	
Diuretics	3 (20)
ACE inhibitors	3 (20)
ARBs	9 (60)
Calcium-channel blockers	3 (20)
Lipid-lowering medication [n (%)]	
Statins	12 (80)
Cholesterol absorption inhibitors	2 (13)

Data are presented as mean ± SD and n (%) for the medication; A1c: glycated hemoglobin; ACE: angiotensin-converting enzyme; ARB: angiotensin receptor blockers; BMI: body mass index; BP: blood pressure; GLP-1: glucagon-like peptide-1 receptor; HDL: high-density lipoprotein; HR: heart rate; LBM: lean body mass; LDL: low-density lipoprotein; PASE: physical activity scale for the elderly; SGLT2: sodium-glucose cotransporter 2; T2D: type 2 diabetes; glucose: n = 14; insulin: n = 12; fasting profile: n = 14.

Table S2. Blood pressure measurements during the post-condition 4-h controlled period

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
							Systolic BP (mmHg)								
REST	128 ± 17	119 ± 19	123 ± 14	130 ± 17	126 ± 14	126 ± 11	121 ± 14	124 ± 9	125 ± 10	128 ± 14	129 ± 19	127 ± 12	126 ± 12	123 ± 11	117 ± 20
HIIT4	122 ± 16	126 ± 15	113 ± 11	125 ± 18	119 ± 11	119 ± 13	119 ± 12	117 ± 10	118 ± 10	119 ± 10	123 ± 17	123 ± 10	123 ± 11	120 ± 10	114 ± 11
HIIT10	124 ± 14	120 ± 18	118 ± 15	123 ± 16	115 ± 12	116 ± 12	120 ± 15	114 ± 14	120 ± 19	124 ± 14	122 ± 12	126 ± 18	118 ± 14	121 ± 15	122 ± 14
							Mean arterial BP (mmHg)								
REST	93 ± 11	88 ± 14	91 ± 9	95 ± 11	93 ± 9	91 ± 9	87 ± 9	88 ± 7	89 ± 8	91 ± 9	90 ± 12	91 ± 9	89 ± 9	88 ± 8	87 ± 11
HIIT4	89 ± 8	92 ± 8	84 ± 9	91 ± 9	86 ± 6	84 ± 8	88 ± 8	85 ± 9	85 ± 9	88 ± 9	89 ± 15	85 ± 7	84 ± 7	84 ± 7	84 ± 10
HIIT10	92 ± 8	92 ± 12	88 ± 12	89 ± 10	86 ± 9	85 ± 8	85 ± 8	83 ± 8	87 ± 12	85 ± 9	88 ± 7	87 ± 8	85 ± 9	86 ± 10	85 ± 11

Diastolic BP (mmHg)

REST	73 ± 9	72 ± 13	74 ± 8	77 ± 9	76 ± 8	74 ± 9	69 ± 11	70 ± 8	71 ± 9	72 ± 10	71 ± 12	73 ± 10	70 ± 9	71 ± 7	72 ± 8
HIIT4	73 ± 6	75 ± 7	70 ± 9	74 ± 7	70 ± 6	67 ± 9	73 ± 9	69 ± 9	69 ± 10	72 ± 10	73 ± 16	67 ± 9	65 ± 9	66 ± 8	70 ± 10
HIIT10	76 ± 6	78 ± 10	73 ± 11	71 ± 10	72 ± 8	70 ± 8	68 ± 8	67 ± 7	70 ± 10	66 ± 11	72 ± 7	68 ± 7	69 ± 8	68 ± 8	67 ± 10

Mean arterial BP (mmHg)

REST	93 ± 11	88 ± 14	91 ± 9	95 ± 11	93 ± 9	91 ± 9	87 ± 9	88 ± 7	89 ± 8	91 ± 9	90 ± 12	91 ± 9	89 ± 9	88 ± 8	87 ± 11
HIIT4	89 ± 8	92 ± 8	84 ± 9	91 ± 9	86 ± 6	84 ± 8	88 ± 8	85 ± 9	85 ± 9	88 ± 9	89 ± 15	85 ± 7	84 ± 7	84 ± 7	84 ± 10
HIIT10	92 ± 8	92 ± 12	88 ± 12	89 ± 10	86 ± 9	85 ± 8	85 ± 8	83 ± 8	87 ± 12	85 ± 9	88 ± 7	87 ± 8	85 ± 9	86 ± 10	85 ± 11

Data are presented as mean ± SD; BP: blood pressure; HIIT4: 4 × 4 min; HIIT10: 10 × 1 min; SD: standard deviation; T1: pre-condition; T2: post-condition; T3: 5 min post; T4: 20 min post; T5: 40 min post; T6: 60 min post; T7: 80 min post; T8: 100 min; T9: 120 min; T10: 140 min; T11: 160 min post; T12: 180 min; T13: 200 min; T14: 220 min; T15: 240min.

Table S3. Free-living ambulatory blood pressure measurements after each experimental condition

	REST	HIIT4	HIIT10	P value
		ABP 20h		
SBP (mmHg)	117 ± 11	116 ± 12	116 ± 11	0.451
DBP (mmHg)	66 ± 7	66 ± 8	65 ± 7	0.278
MAP (mmHg)	83 ± 11	81 ± 7	83 ± 6	0.826
HR (bpm)	72 ± 9	73 ± 9	73 ± 10	0.602
PP (mmHg)	51 ± 9	50 ± 7	51 ± 8	0.831
AIx@75 (%)	29 ± 5	29 ± 6	28 ± 5	0.409
PWV (m/s)	9.8 ± 0.9	9.7 ± 0.9	9.7 ± 0.9	0.284
		ABP Variability 20h		
SBP (mmHg)	13 ± 3	14 ± 4	13 ± 3	0.518
DBP (mmHg)	9 ± 2	9 ± 2	9 ± 1	0.722
		Diurnal ABP		
SBP (mmHg)	120 ± 11	120 ± 12	119 ± 11	0.644
DBP (mmHg)	70 ± 7	68 ± 9	67 ± 8	0.123
MAP (mmHg)	85 ± 12	84 ± 6	86 ± 6	0.795
HR (bpm)	76 ± 9	77 ± 9	76 ± 10	0.659
PP (mmHg)	51 ± 8	52 ± 8	52 ± 9	0.611
AIx@75 (%)	29 ± 5	29 ± 6	28 ± 5	0.715
PWV (m/s)	9.9 ± 0.9	9.8 ± 0.9	9.8 ± 0.9	0.573
		Diurnal ABP Variability		

SBP (mmHg)	12 ± 3	13 ± 5	13 ± 4	0.790
DBP (mmHg)	7 ± 2	8 ± 2	8 ± 2	0.222
		Nocturnal ABP		
SBP (mmHg)	112 ± 15	108 ± 14	108 ± 12	0.068
DBP (mmHg)	60 ± 8	60 ± 10	60 ± 8	0.823
MAP (mmHg)	78 ± 10	75 ± 11	76 ± 8	0.392
HR (bpm)	67 ± 9	68 ± 10	67 ± 12	0.985
PP (mmHg)	**52 ± 9**	**47 ± 6**	**48 ± 8**	**0.002**
AIx@75 (%)	30 ± 9	29 ± 7	28 ± 8	0.400
PWV (m/s)	9.6 ± 0.9	9.5 ± 0.8	9.5 ± 0.8	0.057
DPG (%)	7.6 ± 8.4	10.3 ± 6.6	9.8 ± 7.2	0.148
PWMS (mmHg)	9 ± 8	15 ± 13	10 ± 8	0.094
		Nocturnal ABP Variability		
SBP (mmHg)	11 ± 4	9 ± 3	10 ± 2	0.343
DBP (mmHg)	7 ± 2	7 ± 2	7 ± 2	0.823

Data are presented as mean ± SD; ABP: ambulatory blood pressure; AIx@75: augmentation index standardized at 75 beats per minute; DBP: diastolic blood pressure; DPG: systolic blood pressure nocturnal dipping; HIIT4: 4 × 4 min; HIIT10: 10 × 1 min; HR: heart rate; MAP: mean arterial pressure; PP: pulse pressure; PWMS: systolic blood pressure pre-waking morning surge; PWV: oulse wave velocity; SBP: systolic blood pressure; SD: standard deviation; bold: significantly different ($p \leq 0.05$).

Table S4. Estimates of marginal means for blood pressure measurements during the post-condition 4-h controlled period

	REST			HIIT4			HIIT10		
	Estimate	**Std.E**	**95%CI**	**Estimate**	**Std.E**	**95%CI**	**Estimate**	**Std.E**	**95%CI**
				Systolic BP (mmHg)					
T1	127	3.2	[121 ; 133]	122	3.3	[116 ; 129]	124	3.2	[118 ; 131]
T2	118	3.2	[111 ; 124]	127	3.3	[121 ; 134]	121	3.2	[114 ; 127]
T3	122	3.3	[115 ; 128]	114	3.4	[107 ; 120]	117	3.3	[111 ; 124]
T4	129	3.6	[122 ; 136]	122	3.9	[114 ; 129]	124	3.3	[117 ; 130]
T5	124	3.4	[117 ; 131]	116	3.5	[109 ; 123]	116	3.2	[110 ; 122]
T6	124	3.4	[116 ; 131]	118	3.4	[111 ; 125]	115	3.2	[109 ; 122]
T7	121	3.4	[114 ; 127]	117	3.5	[110 ; 124]	121	3.3	[114 ; 127]
T8	123	3.4	[117 ; 130]	116	3.5	[110 ; 123]	115	3.3	[108 ; 121]
T9	125	3.3	[118 ; 131]	118	3.6	[111 ; 125]	121	3.2	[115 ; 127]
T10	127	3.3	[121 ; 134]	119	3.5	[112 ; 126]	124	3.4	[117 ; 131]
T11	127	3.4	[120 ; 134]	123	3.4	[116 ; 130]	123	3.6	[116 ; 131]
T12	126	3.3	[120 ; 133]	123	3.4	[116 ; 129]	127	3.2	[120 ; 133]

T13	124	3.3	[117 ; 130]	123	3.4	[116 ; 130]	118	3.4	[111 ; 125]
T14	123	3.3	[116 ; 129]	120	3.5	[113 ; 127]	121	3.3	[115 ; 128]
T15	116	3.4	[109 ; 122]	113	3.4	[107 ; 120]	122	3.5	[115 ; 129]
				Diastolic BP (mmHg)					
T1	76	2.3	[71 ; 80]	73	2.3	[68 ; 78]	75	2.3	[71 ; 80]
T2	72	2.3	[67 ; 76]	76	2.3	[71 ; 81]	78	2.3	[73 ; 82]
T3	74	2.3	[69 ; 78]	71	2.4	[66 ; 75]	72	2.3	[67 ; 77]
T4	76	2.5	[72 ; 81]	72	2.7	[67 ; 78]	71	2.3	[67 ; 76]
T5	75	2.4	[70 ; 80]	69	2.4	[64 ; 74]	72	2.3	[67 ; 76]
T6	73	2.4	[68 ; 77]	68	2.4	[63 ; 72]	69	2.3	[64 ; 73]
T7	70	2.4	[65 ; 74]	72	2.4	[67 ; 77]	68	2.3	[64 ; 73]
T8	70	2.4	[65 ; 74]	70	2.4	[65 ; 74]	67	2.3	[62 ; 72]
T9	71	2.3	[67 ; 76]	70	2.5	[65 ; 75]	70	2.3	[66 ; 75]
T10	72	2.3	[68 ; 77]	73	2.4	[68 ; 78]	66	2.4	[62 ; 71]
T11	69	2.4	[65 ; 74]	73	2.4	[69 ; 78]	71	2.5	[66 ; 76]
T12	73	2.3	[68 ; 77]	67	2.4	[63 ; 72]	68	2.3	[63 ; 72]

T13	69	2.3	[64 ; 73]	65	2.4	[61 ; 70]	68	2.4	[63 ; 72]
T14	70	2.3	[66 ; 75]	66	2.4	[61 ; 70]	68	2.3	[64 ; 73]
T15	71	2.4	[66 ; 76]	70	2.4	[65 ; 75]	68	2.4	[63 ; 72]
				Mean arterial BP (mmHg)					
T1	93	2.1	[88 ; 97]	90	2.2	[85 ; 94]	92	2.1	[87 ; 96]
T2	87	2.1	[83 ; 91]	93	2.2	[89 ; 98]	92	2.1	[88 ; 96]
T3	89	2.2	[85 ; 94]	85	2.2	[81 ; 90]	87	2.2	[83 ; 91]
T4	94	2.4	[89 ; 99]	89	2.6	[84 ; 94]	89	2.2	[84 ; 93]
T5	91	2.2	[87 ; 96]	85	2.3	[80 ; 90]	86	2.1	[82 ; 91]
T6	90	2.2	[85 ; 94]	85	2.2	[80 ; 89]	84	2.2	[80 ; 88]
T7	86	2.2	[82 ; 91]	87	2.3	[83 ; 92]	86	2.2	[82 ; 90]
T8	87	2.2	[83 ; 92]	85	2.3	[81 ; 90]	83	2.1	[79 ; 87]
T9	89	2.2	[85 ; 93]	86	2.4	[81 ; 91]	87	2.1	[83 ; 91]
T10	90	2.2	[86 ; 95]	88	2.3	[84 ; 93]	85	2.2	[81 ; 90]
T11	88	2.2	[84 ; 93]	90	2.2	[86 ; 95]	88	2.4	[84 ; 93]
T12	91	2.2	[86 ; 95]	86	2.2	[82 ; 90]	87	2.1	[83 ; 92]

T13	87	2.2	[83 ; 91]	85	2.2	[80 ; 89]	84	2.2	[80 ; 89]
T14	88	2.2	[83 ; 92]	84	2.3	[79 ; 89]	86	2.2	[81 ; 90]
T15	86	2.2	[81 ; 90]	85	2.2	[80 ; 89]	86	2.3	[81 ; 90]

Data are presented as mean ± Std.E and [95%CI]; BP: blood pressure; CI: confidence interval; HIIT4: 4 × 4 min; HIIT10: 10 × 1 min; Std.E: standard error; T1: pre-condition; T2: post-condition; T3: 5 min post; T4: 20 min post; T5: 40 min post; T6: 60 min post; T7: 80 min post; T8: 100 min; T9: 120 min; T10: 140 min; T11: 160 min post; T12: 180 min; T13: 200 min; T14: 220 min; T15: 240min

Table S5. Estimates of marginal means for free-living ambulatory blood pressure measurements after each experimental condition

	REST			HIIT4			HIIT10		
	Estimate	**Std.E**	**95%CI**	**Estimate**	**Std.E**	**95%CI**	**Estimate**	**Std.E**	**95%CI**
				ABP 20h					
SBP (mmHg)	117	3.0	[111 ; 124]	116	3.0	[109 ; 122]	116	3.0	[109 ; 122]
DBP (mmHg)	66	1.9	[62 ; 70]	66	1.9	[62 ; 70]	65	1.9	[61 ; 69]
MAP (mmHg)	83	2.1	[78 ; 87]	81	2.1	[77 ; 85]	83	2.1	[79 ; 87]
HR (bpm)	72	2.3	[67 ; 77]	73	2.3	[68 ; 78]	73	2.3	[68 ; 78]
PP (mmHg)	51	2.1	[46 ; 55]	50	2.1	[46 ; 55]	51	2.1	[46 ; 55]
AIx@75 (%)	29	1.4	[26 ; 32]	29	1.4	[26 ; 32]	28	1.4	[25 ; 31]
PWV (m/s)	9.8	0.2	[9.3 ; 10.3]	9.7	0.2	[9.2 ; 10.2]	9.7	0.2	[9.3 ; 10.2]
				ABP Variability 20h					
SBP (mmHg)	13	0.9	[11 ; 15]	14	0.9	[12 ; 16]	13	0.9	[11 ; 15]
DBP (mmHg)	9	0.5	[7 ; 10]	9	0.5	[8 ; 10]	9	0.5	[8 ; 10]
				Dirunal ABP					

SBP (mmHg)	120	3.0	[114 ; 127]	120	3.0	[113 ; 126]	119	3.0	[113 ; 125]
DBP (mmHg)	70	2.0	[65 ; 74]	68	2.0	[64 ; 72]	67	2.0	[63 ; 72]
MAP (mmHg)	85	2.1	[81 ; 89]	84	2.1	[80 ; 89]	86	2.1	[82 ; 91]
HR (bpm)	76	2.4	[71 ; 81]	77	2.4	[72 ; 82]	76	2.4	[71 ; 81]
PP (mmHg)	51	2.1	[46 ; 55]	52	2.1	[47 ; 56]	52	2.1	[47 ; 56]
AIx@75 (%)	29	1.4	[26 ; 32]	29	1.4	[26 ; 31]	28	1.4	[26 ; 31]
PWV (m/s)	9.9	0.2	[9.4 ; 10.4]	9.8	0.2	[9.3 ; 10.3]	9.8	0.2	[9.3 ; 10.3]
Diurnal ABP Variability									
SBP (mmHg)	12	1.0	[10 ; 14]	13	1.0	[11 ; 15]	13	1.0	[11 ; 15]
DBP (mmHg)	7	0.5	[6 ; 8]	8	0.5	[7 ; 9]	8	0.5	[7 ; 9]
Nocturnal ABP									
SBP (mmHg)	108	3.5	[104 ; 119]	108	3.5	[100 ; 115]	108	3.5	[100 ; 115]
DBP (mmHg)	60	2.2	[55 ; 65]	60	2.2	[56 ; 65]	60	2.2	[55 ; 64]
MAP (mmHg)	84	2.7	[78 ; 89]	82	2.7	[76 ; 88]	82	2.7	[76 ; 88]
HR (bpm)	67	2.7	[62 ; 73]	68	2.7	[62 ; 73]	67	2.7	[62 ; 73]
PP (mmHg)	52	2.0	[48 ; 56]	47	2.0	[43 ; 51]	48	2.0	[44 ; 52]

AIx@75 (%)	30	2.1	[26 ; 34]	29	2.1	[24 ; 33]	28	2.1	[23 ; 32]
PWV (m/s)	9.6	0.2	[9.2 ; 10.1]	9.5	0.2	[9.0 ; 10.0]	9.5	0.2	[9.0 ; 10.0]
DPG (%)	7.6	1.9	[3.6 ; 11.6]	10.3	1.9	[6.3 ; 14.3]	9.8	1.9	[5.8 ; 13.8]
PWMS (mmHg)	8	2.7	[3 ; 14]	15	2.6	[9 ; 20]	10	2.7	[4 ; 16]
Nocturnal ABP Variability									
SBP (mmHg)	11	0.9	[9 ; 13]	9	0.9	[8 ; 11]	10	0.9	[8 ; 12]
DBP (mmHg)	7	0.6	[6 ; 8]	7	0.6	[6 ; 8]	7	0.6	[6 ; 8]

Data are presented as mean ± Std.E and [95%CI]; ABP: ambulatory blood pressure; AIx@75: augmentation index standardized at 75 beats per minute; CI: confidence interval; DBP: diastolic blood pressure; DPG: systolic blood pressure nocturnal dipping; HIIT4: 4 × 4 min; HIIT10: 10 × 1 min; HR: heart rate; MAP: mean arterial pressure; PP: pulse pressure; PWMS: systolic blood pressure pre-waking morning surge; PWV: pulse wave velocity; SBP: systolic blood pressure; Std.E: standard error.

Table S6. Macronutrient intakes before and after each condition.

	REST	HIIT4	HIIT10	P Value
		12h before CON		
Energy intake (Kcal)	684 ± 265	674 ± 261	711 ± 243	0.088
Protein (g)	35 ± 15	36 ± 16	38 ± 17	0.520
Carbohydrate (g)	77 ± 53	74 ± 56	78 ± 53	0.376
Lipid (g)	27 ± 15	26 ± 14	28 ± 14	0.066
Sodium (mg)	891 ± 427	925 ± 365	928 ± 403	0.870
		24h after CON		
Energy intake (Kcal)	1476 ± 336	1482 ± 325	1494 ± 311	0.263
Protein (g)	61 ± 17	62 ± 16	62 ± 15	0.281
Carbohydrate (g)	212 ± 57	212 ± 56	215 ± 55	0.319
Lipid (g)	45 ± 19	45 ± 18	45 ± 18	0.232
Sodium (mg)	1168 ± 559	1095 ± 502	1084 ± 550	0.682

Data presented as mean ± SD; COND: condition; HIIT4: 4 × 4 min; HIIT10: 10 × 1 min; SD: standard deviation.

Table S7. Physical activity levels after each condition.

	REST	HIIT4	HIIT10	P Value
		24h after CON		
SED (%)	76.5 ± 5.9	76 ± 6.4	73.8 ± 5.8	0.139
LPA (%)	21.8 ± 5.5	22.4 ± 6.2	24.9 ± 5.4	0.061
MVPA (%)	1.8 ± 2.2	1.6 ± 2.8	1.1 ± 1.8	0.539
SLEEP (min)	566 ± 89.8	540.5 ± 71.5	545.1 ± 72.3	0.281

Data presented as mean ± SD; COND: condition; HIIT4: 4 × 4 min; HIIT10: 10 × 1 min; LPA: light physical activity; MVPA: moderate to vigorous physical activity; SD: standard deviation; SED: sedentary.