The Association of Daytime and Nighttime Ambulatory Blood Pressure with Carotid IMT When Controlling for Daytime Physical Activity

by

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Associations Between Daytime and Nighttime Ambulatory Blood Pressure and Carotid Atherosclerosis: The Influence of Physical Activity

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The purpose of this study was to examine the associations between daytime and nighttime ambulatory blood pressure (ABP) on carotid IMT when controlling for daytime physical activity (PA) in a sample of 201 healthy older adults (mean age 66.9 yrs, 49.8% females) who were part of the 6 year follow-up of the Pittsburgh Healthy Heart Project (PHHP). Daytime ABP and nighttime ABP were assessed every 45 minutes over a period of 3 days and 2 nights. Physical activity was measured by a wrist accelerometer, a waist accelerometer, and a self-report measure of physical activity. Regression analysis was used to analyze the association of daytime and nighttime ABP with carotid IMT and to determine the type of PA measure (wrist, waist, or self-report), and the time interval (1, 5, 10, 15 minutes prior to ABP) that has the greatest influence on daytime ABP. Results showed that PA 1 minute (wrist) and 10 minutes (waist) prior to ABP assessment accounted for 9% of the variance in daytime ABP. When entered separately into a regression model, both daytime SBP ($F(1,194)=6.33$, $p=.01$) and nighttime SBP ($F(1,194)=6.46$, $p=.01$) significantly predicted IMT. When entered simultaneously into the model, both daytime SBP($F(1,193)=1.81$, $p=.18$) and nighttime SBP($F(1,193)=1.94$, $p=.17$) lost their significance. However, after adjusting for PA, daytime SBP ($F(1,193)=3.47$, $p=.06$) was a marginally stronger predictor of IMT than nighttime SBP. This finding supports the specific prognostic importance

of daytime ABP and, to that extent, may support work on a greater understanding of the daytime variables that uniquely influence daytime ABP as potential correlates of CVD risk.

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1.0 SPECIFIC AIMS

Numerous studies have shown that 24 hour ambulatory blood pressure (ABP) is a better predictor of cardiovascular morbidity and mortality than clinic blood pressure measured in the doctor's office. There is still debate, however, on the relative importance of daytime and nighttime ABP in the prediction of cardiovascular endpoints. When daytime and nighttime ABP are examined separately, each has been found to be significantly associated with cardiovascular disease. However, when the two predictors are examined together in the same statistical models, the majority of studies have found that nighttime ABP remains significant whereas daytime ABP does not. The explanation for the superior prognostic value of nighttime ABP is unclear, but a number of factors may play a role.

It is frequently noted that ABP measures collected during daytime hours may be affected by a number of confounding influences that are less prevalent at night, making the daytime measures less precise, and thereby, less predictive. One important factor that may affect daytime BP is daytime physical activity. Engaging in physical activity leads to an acute increase in systolic BP and the greater the intensity of the physical activity, the greater the increase in BP. However, these fluctuations due to acute physical activity are not harmful to physical health, unlike other sources that elevate BP. It is possible that the association between ABP and CVD is attenuated by the effects of physical activity, and this attenuation may be greatest when daytime

ABP is assessed. None of the existing studies examining the relative prognostic value of daytime and nighttime ABP have controlled for physical activity. This study will be the first to examine the predictive value of daytime versus nighttime BP when controlling for the effects of concurrent physical activity.

The sample involves a group of 296 older adults (ages 56-76) from the Pittsburgh Healthy Heart Project 6 year follow up, in whom ABP was monitored in conjunction with multiple assessments of physical activity. To measure physical activity concurrently with ambulatory blood pressure assessments, waist and wrist actigraphy was used, as well as a self-report physical activity diary. Carotid artery intima medial thickness (IMT), a marker of atherosclerosis, was measured to assess cardiovascular disease risk.

Specific Aim 1: To compare the association between nocturnal ABP and daytime ABP with carotid artery IMT.

As shown in previous studies, it is hypothesized that nocturnal BP will be more closely associated with IMT than daytime ABP when not controlling for physical activity.

Specific Aim 2: To examine the effect of concurrent physical activity on daytime ABP.

Previous studies have found that physical activity is one of the major determinants of daytime BP variation. Therefore, it is hypothesized that concurrent physical activity, as measured by actigraphy, will have a significant impact on daytime ABP.

Specific Aim 3: To examine the association between daytime ABP and carotid IMT when controlling for concurrent daytime physical activity.

It is hypothesized that controlling for concurrent physical activity may strengthen the association between daytime ABP and IMT. Controlling for physical activity may provide a more accurate marker of the relative pathogenic effects associated with daytime and nighttime ABP.

Specific Aim 4: To compare nocturnal ABP and daytime ABP with carotid IMT when controlling for concurrent daytime physical activity.

Daytime physical activity may weaken the association between daytime ABP and CVD, which may partially account for the superior prognostic value of nighttime ABP over daytime ABP. Therefore, it is hypothesized that the pattern of associations between daytime and nighttime ABP with carotid artery IMT outlined in Specific Aim 1 will be altered when controlling for concurrent daytime physical activity, with daytime ABP now accounting for a larger independent portion of the variance.

2.0 BACKGROUND AND SIGNIFICANCE

ABP is a Better Predictor of Cardiovascular Outcomes than CBP

There is a large literature examining the predictive value of ambulatory blood pressure (ABP) with respect to cardiovascular morbidity and mortality (1,2). The majority of the studies in this area have been prospective studies that examine both clinic blood pressure taken in the doctor's office (CBP) and 24 hour ABP, with average follow up periods that range from 5 to 20 years (1). These studies have found CBP and ABP to be only moderately correlated, and of the two, ABP measures have generally been shown to be more strongly associated with cardiovascular outcomes, such as myocardial infarction, stroke, chronic coronary heart disease, and heart failure (1-17). Tables 1 and 2 (pgs. 12-13) summarize the literature in this topic from the last 10 years, with the 9 most recent prospective studies from independent populations (8-17). Using multivariate Cox regression models, 7 out of the 9 studies found that ABP was a significant predictor of cardiovascular mortality and morbidity, while CBP lost its significance when both ABP and CBP were entered simultaneously into the same statistical model. These most recent studies are consistent with the literature as a whole (1).

In addition to the examination of cardiovascular morbidity and mortality, a growing body of literature has examined the relationship between 24 hour ABP and measures of subclinical cardiovascular disease such as carotid artery intima-medial thickness (IMT) (18-24). Carotid

IMT is a widely used index of cardiovascular risk, assessing the thickness of vascular lining, due to inflammation, vascular hypertrophy, and plaque, measured non-invasively by external ultrasound; carotid IMT has been shown to better predict the risk of myocardial infarctions and stroke than most other CVD risk factors (19). Examining carotid IMT allows us to assess a significant marker of atherosclerosis in a continuous manner within a community sample (19).

There have been 7 studies published since the year 2000, all cross-sectional, that have examined the association of carotid IMT with both ABP and CBP. Tables 3 and 4 (pgs. 13-14) describe these studies (18-24). Four out of the 7 studies used multivariate regression models that included both CBP and ABP in their analyses (18, 21-23) and 2 of the studies entered CBP and ABP into separate regression models (19, 24). Five of 7 studies found ABP to be significantly associated with carotid IMT, while CBP was not (18-19, 21, 23-24), and one study found that associations involving ABP ($p<.0001$) were non-significantly larger than those involving CBP ($p<.01$) (22). Nystrom et al. was the only study to find that carotid IMT was equally correlated with CBP and ABP, however, this study did not compare CBP with ABP in the same statistical model (20). In general, it appears that ABP outperforms CBP as a correlate of subclinical disease as well as clinical outcomes.

The majority of the research using ABP assessments has focused on average measurements taken over a 24 hour period. There has been increasing interest, however, in the circadian variation in ABP, and there is emerging evidence that daytime and nighttime ABP may differ in prognostic significance for cardiovascular mortality and morbidity (25).

Nighttime ABP is better than Daytime ABP as a Predictor of Cardiovascular Disease.

Fourteen prospective studies from independent populations published since 2000 have compared daytime and nighttime blood pressure with cardiovascular risk. Detailed

descriptions of these studies are displayed in Tables 5 and 6 (pgs. 14-17) (8, 11-16, 25-29, 31, 32). Out of these 14 studies, 10 found that nighttime ABP was a better predictor of cardiovascular disease than daytime ABP. Eight of these 10 entered both daytime and nighttime ABP simultaneously into a multivariate Cox regression model, and found that nighttime ABP was a significant predictor of cardiovascular outcomes, while daytime ABP lost its significance (11, 12, 13, 15, 25, 27, 29, 31). Two of the remaining studies also examined daytime and nighttime ABP similarly (entered together into a multivariate model), and found that nighttime ABP was more strongly associated with cardiovascular events than daytime ABP. In these studies, daytime ABP still remained a significant predictor, though it had either a smaller hazard ratio (14) or was not predictive of as many cardiovascular outcomes as nighttime ABP (32).

The final 4 studies found that the independent prognostic value of daytime or nighttime ABP depended on the population (16) or cardiovascular outcome examined (28). Eguchi et al. found that nighttime ABP was a better predictor of cardiovascular disease in non-diabetic hypertensives, but daytime ABP was a better in hypertensives with type 2 diabetes (16). Metoki et al. found that both nighttime and daytime ABP were predictive, but for different cardiovascular outcomes (28).

Pickering et al. and Hansen et al. found daytime systolic ABP to be a better predictor of cardiovascular disease when both daytime and nighttime systolic ABP were entered together into the same regression model, however, nighttime ABP ($p<.0001$) appeared to be a stronger predictor of stroke than daytime ABP ($p=.0002$) (26), and nighttime diastolic ABP ($p=.021$) appeared to be a stronger predictor of cardiovascular mortality than daytime diastolic CBP ($p=.05$) (8).

In conclusion, the majority of the literature examining the prognostic value of daytime

and nighttime ABP supports the superiority of nighttime ABP over daytime ABP in predicting cardiovascular outcomes. Possible explanations for the differences in relative predictive value of nighttime and daytime ABP as a function of population (for example, the finding that daytime ABP may be a relatively strong predictor among diabetics) may be due to characteristics of the population (in the case of diabetics, a higher body mass index (BMI) and a more sedentary lifestyle) that may reduce variance in daytime physical activity and thereby enhance its predictive value (16).

The Apparent Superiority of Nighttime ABP Extends to Measures of Subclinical Disease

There have been 7 cross-sectional studies, to our knowledge, that have examined the association of nighttime ABP and carotid IMT: three of these compared daytime and nighttime ABP as predictors (33-34, 36), while the remaining 4 studies examined only the association of carotid IMT with nocturnal BP, or nocturnal BP dipping (35, 37-39). Nocturnal dipping refers to the extent of decline of BP during the nighttime hours. Studies have generally considered a nocturnal decline in BP of 10% or more to be normal (40). Individuals who show this pattern are categorized as "dippers". "Nondippers" are the individuals whose nighttime BP fall is attenuated or absent (40). Table 7 and 8 (pgs. 17-18) summarize the findings of these studies. The 3 studies that examined nighttime ABP found that it was more closely associated with carotid IMT than daytime ABP (33-34, 36), and the four studies that examined nocturnal BP dipping found that participants who lacked a dipping pattern had higher carotid IMT values (35, 37-39).

One of the most recent studies in this group, Shintani et al.(33), examined the association of carotid IMT with daytime and nighttime BP in 775 participants from the Japanese general population with a mean age of 66 years. This study found that a nocturnal decline in BP was

significantly and negatively correlated with mean IMT, such that those showing larger nocturnal declines had smaller IMT. When both daytime and nighttime systolic BP were entered together into a multiple regression model, only nighttime BP was significantly associated with mean IMT (33). The investigators suggest that nighttime ABP is more closely associated with target organ damage and prognosis than daytime ABP, though the reasons for this are still unclear.

According to the literature, there appears to be evidence that 24 hour ABP is superior to CBP in predicting cardiovascular endpoints, as well as measures of subclinical cardiovascular disease such as carotid IMT. In addition, nighttime ABP appears to carry additional predictive value over daytime ABP for measures of both clinical and subclinical CVD. The reasons for the superior prognostic value of nighttime ABP remain uncertain.

Reasons for Prognostic Value of Nocturnal ABP are Unknown

Several physiological mechanisms have been proposed that may be responsible for the superior prognostic value of nocturnal ABP (40-45). Mechanisms such as changes in the sympathetic nervous system modulation of blood pressure at night, circadian changes in natriuresis, or the presence of sleep apnea, have been proposed as plausible sources of individual differences in nocturnal blood pressure that may be independent of BP as assessed during the day (40-45). Studies have, in fact, found elevated nocturnal ABP to be associated with increased nighttime activity of the sympathetic nervous system, as assessed by day and nighttime levels of urinary catecholamines (42) or muscle sympathetic nerve activity (MSNA; 43). In addition, Lurbe et al. reported a relationship between insulin resistance, determined by the homeostatic model assessment technique and elevated nocturnal, but not daytime, ABP in overweight and obese adolescents (45).

In addition to these physiological mechanisms, it has also been suggested that

confounding variables may play a role in accounting for the apparent superior prognostic value of ABP in the studies that have shown such effects. It has been noted that daytime ABP is affected by a number of confounding influences that are not prevalent at night, which may make daytime ABP less precise as a marker of cardiovascular risk (29). For example, a few studies found that daytime ABP lost its prognostic significance when examined in participants who were taking anti-hypertensive medications (27, 30), although the results of other studies did not find evidence to support the effect of anti-hypertensive medication on the prognostic significance of daytime ABP. (8, 10). Because daytime BP is usually the target for treatment, antihypertensive drugs might be presumed to have a larger impact on daytime ABP than on nighttime ABP.

One possibly major confound noted by investigators is daytime physical activity (27, 29-31, 50). Several investigators suggest that nighttime BP is more stable than the daytime ABP because of variations in physical activity during the day, which may attenuate the association between daytime ABP and cardiovascular disease (27, 29-31). However, none of these reports were equipped to test this hypothesis.

Physical Activity is Associated With ABP

Several studies have examined the effect of physical activity on 24 hour ABP, but to our knowledge, only six have done so using accelerometry, which is, arguably, the most accurate widely used measure of physical activity in an ambulatory study (46-49). Many studies have compared the use of self-report measures of physical activity and accelerometers against doubly labeled water and indirect calorimetry, the current standard in physical activity measurement, and have found that accelerometers are more accurate in estimating energy expenditure (52-56). In addition, a few of these studies have found that waist accelerometers tend to be more accurate then wrist accelerometers due to the failure of wrist accelerometers to detect

trunk movements (55, 56). It has been suggested that the combination of both a wrist and waist accelerometer may provide a better overall estimate of physical activity (53, 56). In these 6 studies described below, physical activity was measured by a wrist actigraph (46, 49, 51), waist actigraph (47), an acceleration pickup sensor on the ABP instrument (50), and accelerometers mounted on the trunk and legs (48).

Several studies used within-subject correlations to identify the time interval over which physical activity most strongly influences within-person fluctuations in blood pressure measurements. Leary et al. and Jones et al. found that average activity in the 15 minutes preceding ABP was most strongly associated with ABP values while the remaining three studies found that shorter time intervals of 6 minutes (47), 5 minutes (51), and 3 minutes (49, 50) had the most influence over ABP. All six of these studies found that physical activity was associated with ABP ($p<.05$), although variance in ABP explained by physical activity differed among studies as well as within individuals (46-49). For example, Leary et al. found that the percentage variance in ABP explained by physical activity ranged from 7.1% to 10.7% between individuals and it ranged from 0% to 62% in within-subjects analyses (46). Hayashi et al. compared non-adjusted SBP levels with physical activity-adjusted SBP levels between subjects during three levels of physical activity in daily life: resting, walking, vigorous exercise. This study found that if an individual engages in walking-level physical activity, SBP may increase by about 10mmHG, and during vigorous exercise, SBP may increase by about 20mmHG (50). O'Shea and Murphy examined ABP variation within subjects on a more active day and a less active day (52 activity units vs. 35 activity units $p<.0001$), where they were asked to reduce their level of physical activity. The results showed that subjects had a significantly higher systolic ABP during their active day then on their less active day (136mm HG vs. 130mm HG, $p<.005$) (51).

These results provide support for the hypothesis that individuals who are physically active may show significantly higher daytime ABP than sedentary individuals

All these studies found that physical activity significantly affects ABP, though this effect appears to vary within and between individuals (46-51). However, none of these studies have examined how adjusting for physical activity may affect the relationship between daytime ABP and cardiovascular outcomes.

The Potential Role of Physical Activity in Confounding the Comparisons Between Daytime and Nighttime ABP Remains Unknown

In the literature that has compared the prognostic value of ABP versus CBP, nearly all of the studies have found ABP to be superior in predicting cardiovascular disease. When comparing daytime and nighttime ABP, the majority of the studies have found nighttime ABP to be a better independent predictor of cardiovascular mortality and morbidity, while daytime ABP lost its prognostic significance when nighttime ABP was added into the same statistical model.

The reasons for the superior prognostic value of nighttime ABP are uncertain. Measurement issues rather than physiological mechanisms may contribute insofar as daytime ABP is affected by several confounding influences, particularly daytime physical activity, that are not as apparent during the night. Indeed, several studies have found that physical activity, measured by actigraphy, is associated with fluctuations with daytime ABP, although it appears to vary between individuals. Without adjusting for physical activity, physically active individuals may show higher daytime ABP levels due to these exercise-induced fluctuations. This may

attenuate the relationship between daytime ABP and cardiovascular disease since exercise has been associated with a decreased risk of hypertension and cardiovascular disease.

There have been no studies to our knowledge that have examined the relationship between daytime ABP and cardiovascular disease, when adjusting for daytime physical activity. In addition, many of the studies that examined the association of physical activity and ABP only measured physical activity with a wrist actigraph, which by itself, is not the most accurate measure of physical activity. This will be the first study, to our knowledge, to examine the relative association of daytime and nighttime ABP with measures of cardiovascular disease after taking into account the influence of daytime physical activity on daytime ABP. The sample used in the proposed study is from a general population which, as evidenced by the existing literature, has shown nighttime ABP to carry greater prognostic value over daytime ABP in predicting cardiovascular disease.

Study results will have implications for the relative emphasis placed on determinants of daytime and nighttime ABP in future research. If nighttime ABP is still a stronger correlate of carotid IMT, even after adjustment for daytime physical activity, then relatively greater emphasis is warranted on understanding the biological and behavioral mechanisms that may directly affect nighttime ABP, and increased efforts are justified to lower nighttime ABP, such as taking anti-hypertensive medication toward the evening hours rather than after waking. However, if daytime ABP is more closely associated with carotid IMT after adjusting for physical activity, then greater emphasis should be placed on understanding the daytime variables that uniquely influence daytime ABP such as daily psychosocial stress, as potential correlates of cardiovascular risk.

3.0 METHODS

The data for this project were derived from the 6-year follow-up from the Pittsburgh Healthy Heart Project (PHHP), which was designed to examine the role of biobehavioral factors in atherosclerotic progression in a healthy community sample. The protocol used for the 6 year follow up was ideal for answering the questions posed in this proposal because it implemented the use of a wrist and waist based accelerometer to measure physical activity, collected 3 days and 2 nights of 24 ABPM, and examined measures of carotid IMT.

Participants

The PHHP study included 464 participants at baseline; all subjects met the following inclusion criteria: 50-70 years of age, no chronic disease, including coronary heart disease or hypertension, no cardiac medication including antihypertensive or lipid-lowering medication, no alcoholism, greater than eighth grade reading skill, and not employed in a position involving heavy labor (with potential to disrupt the operation of ambulatory blood pressure monitoring). A total of 296 participants gave consent to participate in the 6 year follow-up of PHHP. Out of those 296 participants, 27 chose not to complete the ambulatory monitoring assessments, but were allowed to continue in the study (296 – 27). Out of these 269, 6 participants had data that was unusable due to problems with data retrieval (269 – 6). Out of these 263, 36 participants did not have complete activity data. To be included in this study, participants were required to have

at least 2 full days of both actical and actiwatch data. Out of these 36, 7 did not have any actical data, 16 did not have actiwatch data, and 13 participants had less than two full days of either actical or actiwatch data. After excluding participants with missing activity data (263 – 36), this left the sample at 227 participants.

The daytime period was determined by the participant's first and last interaction with the electronic diary (ED). The nighttime period was measured by examining the actiwatch data to determine when participants went to sleep and when they woke up. Twenty one participants had unusable actiwatch data, with no apparent drop in activity during the night. For these individuals, we implemented a conservative method to assess nighttime ABP by using fixed nighttime intervals from 1am – 5 am.

Participants were required to have at least five ABP measurements over the period of two nights. Twenty-six participants did not meet this criterion, leaving 201 participants with valid data for these analysis (227 – 26). Eight participants had only one full night of data, but otherwise met all the criteria described above; the rest of the sample had two nights of data.

Recruitment Procedures

The original PHHP study involved follow-up through 3 years only. Participants had to be re-contacted and re-consented in order to be included at the 6 year point. Contact with participants was maintained with participants via annual participant newsletters which assisted in keeping track of participant address changes as well as maintaining interest in the project among volunteer participants. Participants were sent postage paid response postcards on which they indicated their interest in the follow-up, and were also given the opportunity to opt out of further contact. If participants did not respond, they were sent repeated mailings (up to 3 separate

letters). Non-responding participants were then called using the phone numbers listed in the 3 year contact information. Out of the 361 participants who participated in the 3 year follow-up, 40 were non-responsive (i.e., lost to follow up), 6 were not interested the 6 year study, 8 did not respond to scheduling attempts after initial contact, and 1 was deceased, which left a total sample size of 296 participants for the 6 year follow-up.

Procedures

The 6 year follow up for PHHP involved 6 visits over a 3 month period.

First Visit: The first visit consisted of a medical history interview followed by several physiological assessments (CBP, blood glucose, insulin, C-reactive protein, etc.) Subjects also completed questionnaires about their health habits.

Second Visit: The second visit was scheduled for a week later, and it was at this visit that subjects participated in a training session on the use of the ABPM, wrist and waist actigraph, and the ED that assessed various ambulatory behavioral states, including physical activity. Typically, this visit was scheduled on a Monday. After this visit, participants were sent out for a practice monitoring day.

Third Visit: Participants returned the following day, (usually Tuesday), to address any problems they may have encountered using the equipment. After the third visit, the subjects were instructed to use the ABPM, ED, and both the wrist and waist actigraphs over the course of the next three days. They were also instructed to use the ABPM during the day and during two non-consecutive nights of sleep (Wednesday and Friday nights). Following each ABP reading, participants were asked to report their physical activity in the 10 minutes prior to the cuff inflation, using a four point activity scale (1=limited activity – 4= heavy activity) presented by the ED.

Fourth Visit: The fourth visit occurred a week after the second visit (typically Monday). Participants returned to the lab and received feedback on the use of the ABPM, ED, and both actigraphs.

Fifth Visit: The fifth visit occurred a week after the fourth visit and was scheduled at the Ultrasound Research Laboratory (URL). During this visit, carotid IMT and observable plaque was measured using ultrasound.

Sixth Visit: The final visit occurred a week after the fifth visit and involved the measurement of heart rate variability and baroreceptor functioning, during two brief relaxation tasks. (data not used here).

The figure below summarizes the sequence of visits for a typical participant:

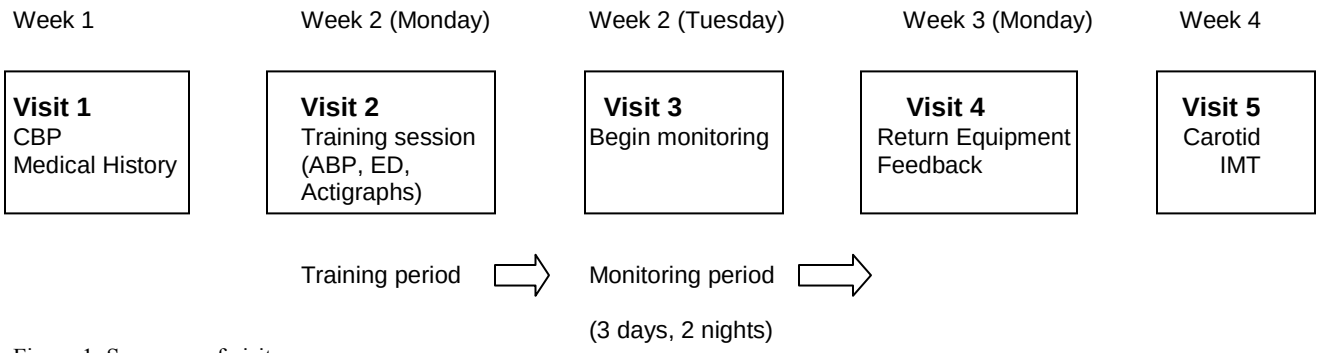

Figure 1: Sequence of visits

Due to participant availability, this typical schedule wasn't always followed, but as long as participants completed all of their 6 visits within the 3 month period (as stated in the Institutional Review Board protocol), they were allowed to continue in the study.

Measurements

Electronic Diary (ED)

The ED system was implemented on a personal digital assistant (PDA) device (Palm Pilot).

Diary items assessed ambulatory behavioral states (stressors, current mood, social interactions, physical activity) 10 minutes prior to cuff inflation. Participants powered down the ED when they went to sleep, and turned it back on when they awoke the following day. Immediately thereafter, the ED presented a set of questions about sleep timing and quality the previous night.

Ambulatory Blood Pressure Monitoring (ABPM)

ABP measures were assessed over a three day testing period using the Accutracker DX ambulatory monitor, an ausculatory monitor, which is relatively quiet and comfortable for extended wear, and has been shown to track blood pressure changes appropriately during physical exercise and mental stress (57). Participants had their BP measured at 45 minute intervals throughout the monitoring period. Daytime ABP was defined from the time of awakening on each day to bed-time the following night, defined by participants' first and last interaction with the ED. Nighttime ABP was defined from the time of sleep onset until the time of awakening, as assessed by the actiwatch (see below). We excluded ABP readings that were outside of estimated physiological ranges, using criteria established by Verdecchia et al. (58) (SBP > 260 or < 70 mm Hg and DBP readings of > 150 or < 40 mm Hg).

Physical Activity Measures

Self-report Physical Activity

Self-report physical activity was measured after each ABP assessment, using the following ED item (Movement: which refers to participants' level of PA in the 10 minutes prior to ABP assessment). Response options ranged from 1 – 4 where: 1=limited movement (write), 2=light movement (walk), 3=moderate movement (jog), 4=heavy movement (run).

Actical

Accelerometry is a well validated method for objective assessment of physical activity in

free living environments and has been shown to be moderately to highly correlated with concurrent objective measures of energy expenditure, such as doubly labled water and indirect calorimetry (59). The actical (Mini-mitter, Bend, Oregon) is an omnidirectional sensor which is worn at the waist on a belt; a pieza-electric sensor generates a voltage whenever there is a change in acceleration, signaling vertical movements of the torso. The device records the frequency of motor movements for each minute, from which estimates of energy expenditure can be derived. Haile et al. developed regression algorithms that optimize the conversion between raw activity counts (AC) and activity energy expenditure (AEE, $kcal \times kg^{-1} \times min^{-1}$) as measured by indirect calorimetry (59).

For lower counts (350 to 1200) that indicate sedentary activities such as sitting:

$AEE=0.0237 + (5.268E\text{-}5) \times AC$ ($R^2 = .75$, SEE = 0.013, $p<.001$)

For higher counts (≥ 1200) that indicate physical activity such as jogging:

$AEE=0.02663 + (1.107E\text{-}5) \times AC$($R^2 = .85$, SEE = 0.015, $p<.001$)

These parameters are calculated automatically by the actical unit.

Actiwatch

The actiwatch (Mini-mitter Inc., Bend, Oregon) is worn on the wrist and contains similar accelerometry sensors for detection of physical activity, though it is more sensitive to movement than the waist actigraph. Participants wore the actiwatch throughout the 3 days and 2 nights during the monitoring period. The actiwatch measures physical activity in 1 minute epochs, and gives an average count for each minute epoch. The higher the activity counts, the higher the activity or movement. It also can estimate when participants are sleeping.

Measures were collected across 3 days of ambulatory monitoring. Preliminary analyses have shown that all three physical activity measures (self-report, actiwatch, actical) may be

independent predictors of physical activity; they were used as additive measures of physical activity for this study; the effects of physical activity were operationalized as the total variance accounted for by all three measures.

In addition, the actiwatch was used to define sleep and wake times. The device detects sleep onset and awakening using a wake threshold value (≤ 40 counts for a period of at least 10 minutes).

Carotid IMT

A Toshiba SSA-270A ultrasound scanner was used to identify the borders of the intima and medial layers of the left and right carotid arteries. The distances between the intima-lumen interface and the media-adventitial interface were measured across the distal 1cm of the common carotid artery (near and far walls), the carotid bulb (far wall), and the first 1cm of the internal carotid (far wall). Both right and left carotids were assessed, yielding a total of eight sets of images for measurement. Mean carotid IMT was calculated for each subject using the mean interface distance from each of the eight segments and then averaging these measures across segments.

Data Analysis

Based on results from previous literature (33) we would expect a small to medium effect size of .35. Using a two-tailed test, an α level of .05, an effect size of .35, and a sample of 201 participants, the power to detect effects of this magnitude is estimated at .79 (GPower).

Specific Aims Testing

Specific Aim 1: To compare the association between nighttime ABP and daytime ABP with carotid artery IMT.

Partial correlation analysis was used to examine the association between both daytime

and nighttime ABP with carotid IMT, while adjusting for standard covariates (age, sex, race) as well as any other variables that may significantly predict IMT. Systolic and diastolic ABP were examined separately for both daytime and nighttime ABP. We tested for the difference between the daytime and nighttime correlation coefficients using the Test for Difference Between Dependent Correlations (60). Similar to previous studies, we also conducted a multiple regression model to examine the independent influence of daytime and nighttime systolic and diastolic ABP measures, after covariate adjustment.

Specific Aim 2: To examine the effect of concurrent physical activity on daytime ABP.

Multi-level modeling (Proc-Mixed) was used to examine within-person associations of daytime physical activity and ABP using all three measures of activity (wrist-based, waist-based actigraphs, and self-report physical activity). Age, sex, and race were adjusted for in the model. Different time intervals of time-averaged activity (1, 5, 10, 15 min) prior to ABP measurement were examined to determine the time course of activity that is most closely associated with ABP. All three measures of physical activity were added as independent predictors into the model. We also examined the optimal time intervals and PA measures for predicting ABP in between-subject analyses.

Specific Aim 3: To examine the association between daytime ABP and carotid IMT when controlling for concurrent daytime physical activity.

We took the mean daytime activity scores that were most strongly associated with daytime ABP for between-subject analyses and added them to a multiple regression analysis with mean SBP or DBP as the dependent variable. The residuals from these models were then entered into a multiple regression model (along with our standard covariates) with carotid IMT as a dependent variable.

Specific Aim 4: To compare nocturnal ABP and daytime ABP with carotid IMT when controlling for concurrent daytime physical activity.

The Test for Difference Between Dependent Correlations (59) was conducted to test the statistical significance of the difference of the following two correlations: a) the partial correlation coefficient of the association of activity-adjusted daytime ABP and IMT (with standard covariates) and b) the partial correlation coefficient of the association of nighttime ABP and IMT (with standard covariates). This was conducted separately for SBP and DBP. We also conducted a multiple regression model to examine the independent influence of activity-adjusted daytime ABP and nighttime ABP with standard covariates, once again, separately for SBP and DBP.

4.0 RESULTS

Sample Characteristics

Table 9 displays descriptive information regarding demographics and physical characteristics of the sample. Half of the participants were women, and almost 88% of the sample was White. Mean age was 66.95 years and mean BMI was 27.6. Almost 29% of the sample reported currently taking anti-hypertensive medication. We compared demographic variables between individuals who were currently taking hypertensive medication or clinically hypertensive (n=66) and those who were not, by t-test and chi-square analyses. Hypertensive participants were significantly older (p=.04) and had a larger waist circumference (p=.03) than normotensive participants. (Table 10).

A number of participants were excluded from this sample at the 6-year point on the basis of missing data, as noted above. We examined whether these participants differed from those who were not excluded (see Table 11). Participants who were excluded had significantly lower education status than those who were not (p=.005). Only 30% of excluded participants had at least a bachelor's degree while nearly 58% of included participants had a bachelor's degree or higher. Participants who were excluded from the sample did not differ on any of the other demographic characteristics from those who were included in this sample.

Table 12 reports the insulin, glucose, cholesterol, and triglyceride levels for the sample. The right column of the table shows the desirable or healthy ranges for these risk factors. As shown in this table, the means for this sample all fell within the desirable range, with the exception of HDL levels falling slightly below the healthy value.

Clinic and Ambulatory Blood Pressure

Clinic blood pressure was assessed at two different time points for the 6 year follow-up (visit 1 and visit 6). We took the average of the final two readings (out of three) at both time points and then averaged the clinic BPs from these two timepoints. Daytime ambulatory blood pressure was averaged over all available data across the three days of ambulatory monitoring, and nighttime ambulatory blood pressure was averaged over all available data across the two monitoring nights. Tables 13 and 14 display the correlation matrices for the relationship among clinic, daytime, and nighttime BP for both systolic and diastolic BP. Variables adjusted for in the regression analyses examining daytime and nighttime ABP are shown in tables 15 and 16. Table 17 displays the mean and standard deviations for CBP and ABP. Tables 18 – 20 compare the blood pressure values by gender, race, and hypertensive status. Males (n=101) had significantly higher nighttime DBP (64.37 vs 61.91 mmHg, p=.04) than females (n=100). There were no significant differences in clinic or ambulatory BP by race or medication status.

Carotid IMT

Covariates adjusted for in the analyses are displayed in Table 21. Table 22 displays the means and standard deviations for carotid IMT values for the entire sample, as well as the results from the t-tests comparing the means among gender, race, age, and hypertensive status. One-way ANOVA was used to examine carotid IMT values by education status. Males (n=101) had

significantly higher IMT values (0.94 mm vs. 0.82 mm, p=.0001) than females (n=100). Hypertensive participants (n=66) had significantly higher IMT levels (0.93 mm vs. 0.85 mm, p=.01) than normotensive participants (n=135). Older participants had significantly higher IMT levels (0.94 mm vs. 0.82 mm, p<.001) than younger participants. There were no significant differences in carotid IMT values by race or education status.

Physical Activity Variables

For descriptive purposes, the Paffenbarger Physical Activity Questionnaire (61) was examined to determine if this particular sample could be classified as physically active or inactive. Table 23 shows the average minutes per week, MET values, and number of activities for this sample, as reported on the Paffenbarger. Since the minutes per week data was skewed, the median value for minutes per week is also displayed in the table. According to the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM), individuals should engage in 30 minutes or more of moderate-intensity physical activity on most (preferably all) days of the week (62). Intensity can be defined as the rate of energy expenditure during exercise and is usually expressed in metabolic equivalents (METS). Moderate intensity activities are those performed at an intensity of about 4 to 6 METS. Therefore, the METS column in Table 23 refers to the mean intensity of the participants' activity. This sample is reaching the recommended activity intensity levels (around 5 METS), however, the amount of activity is insufficient to classify this sample as physically active (only about 75 minutes per week).

SPECIFIC AIM 1

The purpose of the first specific aim was to examine the association of carotid IMT with daytime and nighttime ABP. Standard covariates plus risk factors that significantly predicted IMT (waist circumference) were entered into the models. First, partial correlations, controlling for gender, age, race, clinic BP, and waist circumference were used to examine the association of IMT with daytime and nighttime BP in separate models. Carotid IMT was significantly associated with both daytime SBP (r=.18, p=.01) and nighttime SBP (r=.18, p=.01). These two values were, obviously, not significantly different. Carotid IMT was neither associated with daytime DBP (r=.11, p=.11) nor nighttime DBP (r=.09, p=.19).

Regression analysis was used to examine the extent to which associations involving daytime and nighttime ABP were independent. Daytime SBP, daytime DBP, nighttime SBP, and nighttime DBP were all entered separately into a regression model, controlling for gender, age, race, waist circumference, and clinic BP. When entered separately into the model, both daytime SBP ($F(1, 194)=6.33$, p=.01) and nighttime SBP ($F(1, 194)=6.46$, p=.01) significantly predicted carotid IMT, as reported above. However, when both daytime and nighttime SBP were entered simultaneously, both daytime SBP ($F(1,193)=1.81$, p=.18) and nighttime SBP ($F(1, 193)=1.94$, p=.17) lost their significance. Neither daytime DBP ($F(1,194)=2.53$, p=.11) nor nighttime DBP ($F(1, 194)=1.73$, p=.19) significantly predicted carotid IMT.

Exploratory analyses were examined differences in these associations as a function of hypertensive status. Hypertensive status significantly moderated the effects of daytime SBP (F for interaction $(1, 192)=4.57$, p=.01) and nighttime SBP (F for interaction $(1, 192)=4.81$, p=.009) on carotid IMT. Neither daytime SBP ($F(1, 128)=2.70$, p=.1) nor nighttime SBP($F(1, 128)=2.51$, p=.12) were significantly associated with carotid IMT in normotensive participants.

For hypertensive participants, however, both daytime SBP (F (1, 59)=8.70, p=.006) and nighttime SBP (F(1, 59)=5.90, p=.02) were significantly associated with carotid IMT. When both daytime SBP (F(1, 58)=3.22, p=.08) and nighttime SBP (F(1, 58)=1.08, p=.3) were entered simultaneously into a regression model, both lost their significance with carotid IMT.

Neither daytime DBP (F(1, 128)=.30, p=.58 nor nighttime DBP (F(1, 128)=.53, p=.47) were significantly associated with carotid IMT in normotensive participants. For DBP in the hypertensive group, daytime DBP (F(1, 59)=3.84, p=.06), but not nighttime DBP (F(1, 59)=.08, p=.78) was marginally associated with carotid IMT.

SPECIFIC AIM 2

Within-Person Analysis

The purpose of this aim was to examine the within-person association of daytime physical activity with daytime ABP. Multi-level modeling (Proc-Mixed) was used. Three measures of physical activity were employed as predictors: wrist-based accelerometry, waist-based accelerometry, and self-reported physical activity. Activity counts for both accelerometers were averaged over 1, 5, 10, and 15 minutes prior to each BP reading. Given the prevalence of low activity counts in conjunction with the positive skew of the data, quartiles were used for the accelerometry data except for the 1 minute intervals. About 50% of the distribution of activity counts for the minute prior to ABP reading were at 0 counts for both PA devices. Therefore, 1 minute intervals were classified into binary categories (0 counts, >0 counts). Tables 24 - 25 show the results of the within-person analysis for the 1, 5, 10, and 15 minute intervals. All the time intervals prior to ABP reading for both the wrist and waist-based accelerometer were

significant independent predictors of both daytime SBP and DBP. S elf-reported physical activity, which was based on the 10 minutes prior to ABP measurement, was also a significant predictor of both daytime SBP and DBP.

Mean daytime ABP readings were regressed on wrist and waist-based accelerometry variables (separate models for SBP and DBP) (Tables 26 – 27). Wrist accelerometry for SBP ($t=5.87$, $p<.001$) and DBP ($t=6.93$, $p<.0001$) was an independent, significant predictor when taken 1 minute prior to ABP measurement, but waist accelerometry for SBP ($t=.39$, $p=.69$) and DBP ($t=1.32$, $p=.19$) lost its significance. For all other time intervals, both wrist and waist accelerometry remained significant. Tables 28 - 29 show the results for the 10 min physical activity measure prior to ABP measurement. All three (wrist, waist, self-report) were entered simultaneously into the model. For daytime SBP, all three physical activity variables were associated with daytime SBP. However, for daytime DBP, only wrist accelerometry 10 minutes prior to ABP measurement remained a significant predictor.

Between-Person Analysis

Between-person analyses were conducted to determine the type of physical activity measure (wrist, waist, or self-report), and the time interval (1, 5, 10, 15 minutes) that has the greatest influence on daytime ABP. Activity values, as well as ABP values, were averaged across readings and days for each person. Due to its skewed distribution, mean waist accelerometry values were log transformed, while wrist accelerometry values had a normal distribution. Regression analysis was used to examine the association of daytime ABP with physical activity. Daytime SBP and DBP were examined separately. Each activity measure was placed into a regression model predicting daytime SBP and DBP. Table 30 displays the results

of the regression analysis for SBP. For wrist accelerometry, only mean 1 minute interval values prior to ABP readings ($F(1, 200)=14.17$, $p<0.001$) were significantly associated with daytime SBP. For waist accelerometry, mean values taken 5 minutes ($F(1, 200)=4.50$, $p=.04$), 10 minutes ($F(1, 200)=5.00$, $p=.03$), and 15 minute values ($F(1,200)=3.90$, $p=.05$) were significantly associated with daytime SBP. Based on the relative effect sizes of these results (shown in Table 30), it appears that average metabolic expenditure by waist accelerometry 10 minutes prior to ABP readings is more strongly associated with mean daytime SBP than either the 5 or 15 minute intervals. To determine if multiple time intervals would more strongly account for physical activity effects, combinations of the significant time interval variables for waist accelerometry were placed into a regression model predicting daytime SBP (Table 31). The results from this analysis indicated that combining these time intervals did not increase the variance accounted for in daytime SBP. Therefore, we decided to place waist accelerometry 10 minutes ($F(1, 200)=4.50$, $p=.04$) prior to ABP readings and mean activity counts via wrist accelerometry 1 minute ($F(1,200)=11.12$, $p=.001$) prior to ABP readings simultaneously into a final regression model predicting daytime SBP (Table 32). The final model suggests that when measured in this manner, between-person differences in physical activity just preceding ABP readings account for 9**%** of the variance in daytime ambulatory systolic blood pressure. When mean posture was added to the model, it accounted for an additional 2% of the variance in daytime SBP. For daytime DBP, it appears that only average wrist accelerometry one minute prior to ABP readings ($F(1, 200)=4.47$, $p=.04$) significantly predicts daytime DBP (Table 33). No waist accelerometry measures significantly predicted average ambulatory DBP. Time-averaged diary reports of physical activity prior to each ABP reading did not significantly predict either averaged daytime SBP ($F(1, 200)=1.17$, $p=.28$) or DBP ($F(1, 200)=2.24$, $p=.19$).

SPECIFIC AIM 3

The purpose of the third aim was to examine the association between daytime ABP and carotid IMT when controlling for mean daytime PA. Mean daytime activity scores that were most strongly associated with daytime ABP were added to a regression model predicting carotid IMT. When controlling for age, sex, race, waist circumference, clinic SBP, posture, one minute wrist accelerometry, and 10 minute waist accelerometry, daytime SBP was still significantly associated with carotid IMT ($F(1,191)=6.18$, $p=.01$). The partial correlation between between activity-adjusted daytime SBP and IMT ($r=.22$, $p=.0013$) was marginally larger ($p<.1$) than the partial correlation between IMT and daytime SBP not adjusted for activity ($r=.18$, $p=.01$). In a comparable model, daytime DBP was still not significantly associated with carotid IMT ($F(1, 191)= 2.12$, $p=.15$. Adjusting for mean posture did not significantly alter the relationship between daytime SBP and IMT, and therefore, was not adjusted for in the final model.

SPECIFIC AIM 4

The fourth specific aim was to compare nighttime ABP and daytime ABP with carotid IMT when controlling for concurrent daytime PA. Activity-adjusted daytime ABP refers to the daytime ABP value that remains after partialling out the effects of daytime physical activity. There was no significant difference between the partial correlation between activit- adjusted daytime SBP and IMT, on the one hand ($r=.22$, $p=.0013$) and nighttime SBP and IMT on the other ($r=.18$, $p=.01$).

When both daytime and nighttime SBP were entered simultaneously into a multiple regression model, nighttime SBP ($F(1,193)=1.70$, $p=.19$) lost its significance, but activity adjusted daytime SBP ($F(1,193)=3.47$, $p=.06$) was marginally associated with carotid IMT.

When stratified by hypertensive status, neither activity-adjusted daytime SBP ($F(1,128)=3.24$, $p=.07$) nor activity adjusted daytime DBP ($F(1,128)=.20$, $p=.66$) were significantly associated with carotid IMT in normotensive participants though there was a trend towards significance with daytime SBP. It appears that adjusting for PA may strengthen the association between daytime SBP ($F=3.24$ vs. $F=2.70$) and carotid IMT though it was not significant. For hypertensive participants, activity-adjusted daytime SBP ($F(1, 59)=9.24$, $p=.004$) was significantly associated with carotid IMT, but activity-adjusted daytime DBP ($F(1, 59)=3.76$, $p=.06$) was only marginally associated with carotid IMT. When both activity-adjusted daytime SBP and nighttime SBP were entered simultaneously into a regression model, controlling for age, sex, race, BMI, and clinic SBP, activity-adjusted daytime SBP remained a significant predictor ($F(1,58)=3.89$, $p=.05$) while nighttime SBP lost its association with carotid IMT ($F(1,58)=.71$, $p=.4$).

5.0 DISCUSSION

The purpose of this study was to examine the association of daytime and nighttime ABP with carotid IMT when controlling for daytime physical activity. Based on the results of previous literature, we hypothesized that nighttime, when compared with daytime ABP, would be more strongly associated with carotid IMT, but we expected these effects to be accounted for, in part, by confounding influence of PA on the association between daytime ABP and carotid IMT. Contrary to our expectation, however, we found that associations involving daytime and nighttime ABP with IMT were equivalent in magnitude. There are several factors which may account for discrepant findings between our study and previous work, including sample characteristics and methodological differences (for example, we used wrist accelerometry to determine sleep and wake time whereas most of the previous literature used set intervals such as 6am to 10pm for each person).

While we showed that ABP was associated with increased risk, our data also suggested that these associations were stronger among some individuals than among others. Similar to Boggia et al (27), we found that hypertensive status appeared to moderate the association between ABP and cardiovascular disease. Namely, both daytime and nighttime SBP were more strongly associated with carotid IMT in participants currently on hypertensive medication or had clinical hypertension.

One of the unique features of this study involved its use of objective measures of physical activity as a means of reducing confounding influences on ABP. In this respect, we found that both wrist and waist accelerometry, as well as self-report significantly predicted daytime ABP in within-person analyses. For between-subject analyses, we found that 9% of variance in daytime SBP was explained by physical activity. This finding was similar to Leary et al. who found that the percentage of variance in SBP explained by PA ranged from 7.1% to 10.7% between individuals though that particular sample was significantly younger and more active (46). Our study also supports the use of the combination of both a wrist and waist accelerometer for estimating PA since both the wrist and waist accelerometer were independently predictive of ABP. Interestingly, it appears that for wrist actigraphy, shorter intervals (1 minute) were more strongly associated with daytime ABP, while for waist actigraphy, 5 – 15 minute intervals had a greater influence on ABP fluctuations. This finding is partially supported by previous studies. Costa et al found that lower energy expenditure during ABPM is partly the result of the requirement for immobility for the ABP device to take an accurate measurement (63). Therefore, any large movements immediately before ABP assessments, which would more likely be captured by the waist accelerometer, may be avoided. However, smaller movements, which would more likely be captured by wrist accelerometry, would not be as likely to be avoided; there be more variability in these just prior to the ABP assessment, when compared to movements detected by the waist device, accounting for the greater predictive value of the wrist device at the 1 minute interval prior to ABP.

We hypothesized that adjusting for daytime PA would strengthen the association between daytime SBP and carotid IMT. Our hypothesis was partially supported. Activity-adjusted

daytime SBP was more closely associated with IMT than daytime SBP that was not adjusted for activity, though these differences were not statistically significant. In addition, activity-adjusted daytime SBP was a marginally significant independent predictor of IMT even after nighttime SBP was added to the model in a manner that was not the case when non-activity adjusted measures were used. When we stratified the sample by hypertensive status, activity-adjusted daytime SBP was only marginally associated with carotid IMT in the untreated group. Interestingly, activity-adjusted daytime SBP was more closely associated with IMT than nighttime SBP in the hypertensive group. Though we didn't find significant associations between ABP and carotid IMT in the normotensive group, this sample of people had reduced variance in IMT and ABP which may account for this difference between the groups.

Several limitations of this study should be noted. First, there were a significantly higher number of daytime ABP assessments over nighttime assessments. However, according to Llabre et al., who examined the number of ABP readings necessary to estimate BP with acceptable reliability, a total of 6 SBP measurements were needed to ensure adequate levels of generalizability (66). The mean number of nighttime ABP measurements for our study was 11, with the majority of participants having at least 6 nighttime measurements. Therefore, it is likely that there were a sufficient number of ABP readings for both nighttime as well as daytime ABP in his sample. Another potential limitation: the majority of the sample, even though it was representative of the Pittsburgh area, was mainly Caucasion, and therefore, these results may not be representative of other populations. In addition, a significant number of participants were excluded from this study due to missing data.

In addition to its limitations, this study also has considerable strengths. This is the first study, to our knowledge, that has examined the influence of daytime PA in altering the association between ABP and cardiovascular risk. Previous ABP literature has only examined daytime and nighttime ABP in a single 24 hour period. This study examined daytime ABP over a 3 day period and nighttime ABP over a 2 night period which increases the reliability of these results. Also, this study was one of the first to utilize both a wrist and waist accelerometer, along with self-report, to estimate daytime PA and its effect on daytime ABP. We were able to determine that the optimal time intervals for assessing the relationship between daytime PA and ABP may differ between PA devices, and that the combination of these devices are more likely to capture the effect of PA on daytime ABP. Both the wrist and waist accelerometer explained a significant amount of the variance in daytime ABP (6% for 1 minute wrist, 3% for 10 minute waist) that wouldn't be captured by the use of a single activity device. Finally, this was one of the first studies of this kind to use wrist accelerometry, an objective measure, rather than set daytime and nighttime intervals or self-report to determine sleep and wake times.

The results from this study tell us that acute physical activity suppresses the relationship between daytime SBP and carotid IMT, although the magnitude of this effect appears to depend on the population examined. Adjusting for physical activity may be more important for hypertensive populations or those that are physically active. For these populations, adjusting for physical activity may significantly alter the relationship between daytime ABP and carotid IMT, and therefore, it may be necessary for future studies to control for in order to better understand the relationship between daytime ABP and IMT. There are several areas that warrant further research. It would be of interest to examine the effect of nighttime PA on nighttime ABP and

carotid IMT. Unlike daytime PA, the effects of nighttime PA on nighttime ABP may add to the association of nighttime ABP and carotid IMT rather than suppress it. Finally, future studies should examine the differences among normotensives, hypertensives, and participants on hypertensive medication in the association of ABP and carotid IMT, as well as their response to exercise. Unfortunately, this study did not have enough subjects in order to examine each of these groups individually with a sufficient sample size in each. By examining these populations separately, we may better understand the underlying mechanisms for that may influence the association of both daytime and nighttime ABP with cardiovascular risk.

6.0 CONCLUSIONS

This was the first study, to our knowledge, to examine the relationship between daytime and nighttime ABP with carotid IMT when controlling for daytime PA. The utility of using both a wrist and waist accelerometer in examining PA was supported in this study. We did not confirm the superiority of nighttime ABP over daytime ABP in a general population. We did find partial support for the prognostic significance of daytime SBP when controlling for PA, which was found to be a suppressor variable, especially among hypertensive individuals. This finding supports the specific prognostic importance of daytime ABP and, to that extent, may support work on a greater understanding of the daytime variables that uniquely influence daytime ABP such as daily psychosocial stress, as potential correlates of cardiovascular risk.

APPENDIX A

CHARTS AND TABLES

A.1 APPENDIX SECTION

Table 1: ABP vs CBP in a general population

Reference	Study Population	Study Design	Measures	Results
***Hansen et al 2006 (8)**	N=1700 Danish general population, 47% female, aged 41 to 72 yrs, 9% taking antihypertensive medication	Prospective, mean follow-up of 9.5 yrs, ABPM was done every 15 min between 7am and 11pm and every 30 min between 11pm and 7 am.	CBP, 24 hr ABP, cardiovascular mortality, ischemic heart disease, stroke	In a multivariate Cox proportional hazard models that adjusted for CBP, ABP significantly predicted all endpoints (p<.001), while CBP lost its significance when ABP was adjusted for in the model (p>.17).
Hansen et al. 2007 (10)	N=7030 general population from IDACO, 44.8% women, mean age 56.2 yrs, 21.8% on antihypertensive medication	Prospective, median follow –up 9.5 yrs, ABPM was done every 15 to 30 min during the daytime. There was no ABPM during nighttime hours.	CBP, 24 hr ABP, fatal and nonfatal stroke, coronary events, cardiac events, composite cardiovascular endpoint: included all aforementioned endpoints plus cardiovascular mortality	In a multivariate Cox regression model that adjusted for CBP, daytime ABP was a significant predictor of cardiovascular mortality (p<.01) whereas CBP was not significant (p>.05).
Kikuya et al. 2005 (11)	N=1332 general population from Ohasama Study, 65% female, mean age 61.8 yrs	Prospective, mean follow-up 10.8 yrs	CBP, 24 hr ABP, mortality from cardiovascular disease and noncardiovascular disease	When CBP and ABP were simultaneously entered into a multivariate Cox regression model, only ABP was significantly

				related to cardiovascular mortality risk (p<.05).
Sega et al. 2005 **(12)**	N=2051 general population, 50% female, 25 to 74 yrs	Prospective, mean follow-up 10.92 yrs, ABPM was done every 20 min during the 24 hr period. HBPM was done at 7am and 7pm in the subject's home with a semiautomatic device.	CBP, 24 hr ABP, HBP, Cardiovascular mortality	Using Cox proportional hazards model, the risk of death increased more with a given increase in ABP than in CBP, but the overall ability to predict death was not significantly greater in ABP over CBP (p<.05).

*Other studies using the same population have found similar results using different cardiovascular endpoint.

Table 2: ABP vs CBP in a Hypertensive Population

Reference	Study Population	Study Design	Measures	Results
Dolan et al. 2005 **(13)**	N=5932 untreated hypertensives, 49% female, mean age 61.13 yrs	Prospective, mean follow-up of 7.9 yrs, ABPM done every 30 min over 24 hrs	CBP, 24 hr ABP, cardiac mortality, cardiovascular mortality	When entered into the same multivariate Cox proportional hazards regression model, ABP had significantly higher hazard ratios than CBP (p<.001)
Dolan et al. 2009 **(14)**	N=1905 treated hypertensives, 33% female, mean age 40.79 yrs	Prospective, median follow-up of 5.5 yrs, ABPM was done every30 min throughout a 24 hr period	CBP, 24 hr ABP, total cardiovascular events, total coronary events, fatal and nonfatal stroke	A multivariate Cox proportional hazards regression model found that systolic ABP was an independent predictor of stroke (p<.002) and both ABP and CBP were independent predictors of cardiovascular events (p<.002).
Staessan et al. 1999 **(15)**	N=808 untreated systolic hypertensives, 62% female, mean age 69.6 yrs, 42.6% treated with anti-hypertensive drugs	Prospective, mean follow-up 4.4 yrs, ABPM done every 30 min over 24 hrs.	CBP, 24 hr ABP, total and cardiovascular mortality, all cardiovascular endpoints, fatal and nonfatal cardiac endpoints	Using a multivariate Cox regression analysis, ABP significantly predicted cardiovascular mortality, all cardiovascular end points, and fatal and nonfatal stoke (p<.05), while CBP was not a significant predictor in untreated hypertensives.
Eguchi et al. 2008 **(16)**	N=1268 untreated hypertensives, 301 had type 2 diabetes, 62% female, mean age 70.4 yrs	Prospective, mean follow-up 4.17 yrs, ABPM was done every 30 min over a 24 hr period.	CBP, 24 hr ABP, stroke, fatal or nonfatal myocardial infarction, sudden cardiac death	When CBP and ABP were simultaneously entered into a multivariate Cox regression model, ABP was a significant predictor of CVD in both the diabetes and nondiabetes group (p<.001) while CBP lost its significance (p>.05).
Clement et al. 2003	N=1963 treated hypertensives, 48% female, mean age 56.5	Prospective, mean follow-up 5 yrs, ABPM was done at intervals of	CBP, 24 hr ABP, fatal and nonfatal cardiovascular events,	Using a multivariate Cox regression analysis, ABP was a

(17)	yrs	not more than 30 min between 8am and 8pm and at intervals of not more than 60 min between 8pm and 8am	fatal or nonfatal myocardial infarction or stroke, death from any cause	significant independent predictor of fatal and nonfatal cardiovascular events and fatal and nonfatal myocardial infarction or stroke (p<.05) after adjustment for CBP.

Table 3: ABP and IMT in a General Population

Reference	Study Population	Study Design	Measures	Results
Kamarck et al. 2002 **(18)**	N=216 general population, 48% female, 50-70 yrs old	Cross-sectional, ABPM and ACBPM was done every 45 min over a 2.5 hr period (4 readings total)	Manual CBP, automated CBP, ABP, carotid IMT (CCA, carotid bulb, internal carotid, mean)	Using regression models that adjusted for demographic covariates and measures of manual and automated CBP, ABP was significantly associated with IMT (p<.01).
Su et al. 2006 **(19)**	N=186 general population, 13% female, mean age 55.7 yrs	Cross-sectional, ABPM was done every 15 min from 7am to 10pm and every 30 min from 10pm to 7am.	CBP, 24 hr ABP, carotid IMT (CCA, carotid bulb, internal carotid artery, maximum)	A multivariate regression model that examined ABP and CBP separately found that ABP was a significant risk factor of carotid IMT at the CCA and carotid bulb (p<.05) while CBP was not significantly associated with any of the IMT measures (p>.05).
Nystrom et al. 2005 **(20)**	N=170 hypertensives and 23 normotensives, 31% female, mean age 54 yrs	Cross-sectional, ABPM was done at 20 min intervals throughout the 24 hr period.	CBP, 24 hr ABP, carotid IMT (CCA, mean)	Using Pearson correlations, this study found that carotid IMT significantly correlated with both ABP (p<.001) and CBP (p<.001) equally well.
Dechering et al. 2009 **(21)**	N=532 general population, 48.3% female, mean age 38.9 yrs	Cross-sectional, ABPM done every 20 min from 8am to 10pm and every 45 min from 10pm to 8am	CBP, 24 hr ABP, carotid IMT (CCA , mean)	In regression models that adjusted for CBP, systolic ABP was significantly associated with carotid IMT (p=.002), while CBP was not (p=.66)

Table 4: ABP and IMT in a Hypertensive Population

Reference	Study Population	Study Design	Measures	Results
Gaborieau et al. 2008 **(22)**	N=325 treated (70%) and untreated hypertensives, 41% female, mean age 64.5 yrs	Cross-sectional, HBPM was done over 4 days with 3 measures done in the morning and 3 measures in the evening. ABPM was done every 20 min by day and every 60 min at night over a 24 hr period.	CBP, HBP, 24 hr ABP, carotid IMT (CCA, mean)	Using linear regression, ABP (p<.0001) was more significantly associated with IMT than CBP(p<.01), though the difference was not significant.
Zanchetti et al. 2001	N=508 hypertensives with moderate	Cross-sectional, ABPM was done every 15 min	CBP, 24 hr ABP, carotid IMT (eight near	In a multiple regression analysis, systolic ABP

(23)	hypercholestrolaemia, 59.8% female, mean age 58.4 yrs	during the 24 hr period.	and far walls of the carotid bifurcations and CCA, mean and maximum)	was significantly associated with all carotid IMT measures ($p<.05$), while CBP was not significantly associated with IMT.
Mancia et al. 2001 **(24)**	N=1663 hypertensives, 45.6% female, 56.2 yrs, off of antihypertensive medication prior to study	Cross-sectional, ABPM was done every 15 min during the day and every 20 min during the night over a 24 hr period.	CBP, 24 hr ABP, carotid IMT (12 different carotid sites, mean and max)	Multiple regression analysis showed that systolic ABP was significantly associated with maximum and mean IMT ($p<.0001$) while CBP was not ($p>.05$).

Table 5: Daytime vs Nighttime ABP in a General Population

Reference	Study Population	Study Design	Measures	Results
Ben-Dov et al. 2007 **(25)**	N=3957 general population, aged 16 to 93 yrs, 58% on antihypertensive medications	Prospective, mean follow-up 6.5 yrs, ABPM done every 20 min between 6am and midnight and every 30 min between midnight and 6am for a 24 hr period	Daytime ABP, nighttime ABP, all-cause mortality	When entered into the same multivariate model, nighttime BP ($p<.001$)had a significantly higher hazard ratio then daytime BP, which suggests that it is a greater independent predictor of cardiovascular disease.
Pickering et al. 2007 **(26)**	N= 8945 general population, 47% female, mean age 60.29 yrs, participants using antihypertensive medication had them withdrawn at least 2 weeks before monitoring	Database from 7 prospective studies, mean follow-up 5.8 yrs, ABPM done every 15 to 30 min over 24 hour period	Daytime ABP, nighttime ABP, fatal and nonfatal stroke, cardiac events	When both daytime and nighttime SBP were included as predictors for cardiac events, only daytime SBP was statistically significant ($p=0.0004$), suggesting that daytime ABP may be a better predictor than nighttime ABP for cardiac events. When both daytime and nighttime ABP were included as predictors for stroke, nighttime ABP was a statistically stronger predictor ($p=0.002$) though daytime ABP was still a significant predictor ($p=0.008$) as well.
Boggia et al. 2007 **(27)**	N=7458 general population from IDACO, 46% female, mean age 56.8 yrs, 46% hypertensives with 48% on antihypertensive drugs	Prospective, median follow -up 9.6 yrs, ABP at intervals from 15 to 30 min during daytime and from 30 to 60 min at nighttime	Daytime ABP, nighttime ABP, fatal and nonfatal stroke, coronary events, cardiac events	In a multivariate regression model that adjusted for daytime BP, nighttime BP was a significant predictor of total, cardiovascular, and noncardiovascular mortality ($p<.0001$) while daytime BP lost its significance.
Hansen et al. 2006 **(8)**	N=1700 Danish general population, 47% female, aged 41 to 72 yrs , 9% were taking	Prospective, mean follow-up of 9.5 yrs, BP recordings made every 15 min between 7am to	Daytime ABP, nighttime ABP, cardiovascular mortality, ischemic heart disease, stroke	When systolic daytime and nighttime ABP were entered into the same multivariate

	antihypertensive medication	11pm and every 30 min between 11pm and 7am		model, only daytime ABP was a significant predictor (p=.02), whereas nighttime ABP lost its significance (p=.24). When diastolic daytime and nighttime ABP were entered, both daytime (p=.05) and nighttime BP (p=.02) were significant predictors of cardiovascular disease.
Kikuya et al. 2005 **(11)**	N=1332 general population from Ohasama Study, 65% female, mean age 61.8 yrs, 30.4% were taking antihypertensive medications	Prospective, mean follow-up 10.8 yrs, ABPM was done every 30 min over a 24 hr period.	Daytime ABP, nighttime ABP, mortality from cardiovascular and noncardiovascular disease	A multivariate Cox proportional hazards regression model found that, when both daytime and nighttime ABP were entered simultaneously, only nighttime systolic ABP was significantly related to cardiovascular mortality risk (p<.05).
Sega et al 2005 **(12)**	N=2051 general population, 50% female, 25 to 74 yrs	Prospective, mean follow-up 10.91 yrs, ABPM was done every 20 min during the 24 hr period. HBPM was done at 7am and 7pm with a semiautomatic device.	Daytime ABP, nighttime ABP, cardiovascular mortality	In a multivariate analysis, goodness of fit was improved by adding nighttime ABP to CBP (p=.003), but it was not improved when daytime ABP was added to CBP (p=.428)
Metoki et al. 2006 **(28)**	N=1360 general population from Ohasama Study, 64% female, mean age 61.3 yrs, 30% receiving antihypertensive medication	Prospective, mean follow-up 10.6 yrs, ABPM measured every 30 min for 24 hours, day broken into 2 hour segments with 4 ABP readings per segment	Daytime ABP, nighttime ABP, cerebro and cardiovascular disease, haemorrhagic stroke, cerebral infarction, heart disease	An elevated nighttime ABP was associated with increased cerebral infarction mortality and heart disease mortality (p<.002)whereas elevated daytime ABP was associated with increased intracerebral haemorrhage mortality (p<.002).

Table 6: Daytime vs Nighttime ABP in Hypertensives

Reference	Study Population	Study Design	Measures	Results
Fagard et al. 2008 **(29)**	N=3468 hypertensives, 55% female, mean age 61 yrs, 61.4% on antihypertensive medication	Meta-analysis from 4 prospective studies in Europe, median follow-up 6.57 yrs, ABPM was done every 15 min or at intervals of not more than 30 min during the daytime and every 30 min or not more than 60 min during the nighttime over 24 hours.	Daytime ABP, nighttime ABP, all-cause mortality, CV mortality, NCV mortality, coronary heart disease, fatal and nonfatal stroke, major CV events	In a multivariate Cox proportional hazards regression model, when adjusting for daytime ABP, nighttime ABP significantly predicted all-cause mortality CV mortality, CVD, CHD, and stroke (p<.05). When adjusting for nighttime ABP, daytime ABP did not significantly predict any of the endpoints(p>.05).
Dolan et al. 2005	N=5932 untreated hypertensives, 49%	Prospective, mean follow-up of 7.9 yrs	Daytime ABP, nighttime ABP, all-cause	In a multivariate Cox proportional hazards

(13)	female, mean age 61.13 yrs		mortality, cardiovascular, mortality , stroke, cardiac mortality	model that adjusted for daytime ABP, nighttime ABP significantly predicted total, cardiovascular, stroke, and cardiac mortality (p<.05), whereas daytime ABP was only a significant predictor of all-cause mortality (p<.05).
Dolan et al. 2009 **(14)**	N=1905 treated hypertensives, 33% female, ages 40-79 yrs	Prospective, median follow-up of 5.5 yrs, ABPM was done every 30 min throughout a 24 hr period	Daytime ABP, nighttime ABP, total cardiovascular events, total coronary events, fatal and nonfatal stroke	A multivariate Cox proportional hazards regression model found that nighttime systolic ABP was a more significant predictor of stroke (p<.007)and cardiovascular events (p=.004)than daytime ABP.
Staessan et al. 1999 **(15)**	N=808 untreated systolic hypertensives, 62% women, ≥ 60 yrs	Prospective, mean follow-up of 4.4 yrs, ABPM done every 30 min over a 24 hr period.	Daytime ABP, nighttime ABP, total and cardiovascular mortality, all cardiovascular endpoints, fatal and nonfatal cardiac endpoints	In a multivariate Cox regression model, nighttime ABP was a significant predictor of cardiovascular mortality, all cardiovascular, stroke, and cardiac endpoints (p<.05) while daytime ABP was not (p>.05).
Eguchi et al. 2008 **(29)**	N=1268 untreated systolic hypertensives, 301 had type 2 diabetes, 62% female, mean age 70.4 yrs,	Prospective, mean follow-up 4.17 yrs, ABPM was done every 30 min over a 24 hr period.	Daytime ABP, nighttime ABP, stroke, fatal or nonfatal myocardial infarction, sudden cardiac death	In a multivariate Cox regression model, the standard deviations of nighttime ABP was significantly associated with CVD (p<.05), independent of other covariates.
Fagard et al. 2008 **(31)**	N=302 hypertensives with CV disease out of a total population of 3295 hypertensives, 50 % female, mean age 69 yrs, 61.9% were taking antihypertensive medication	Meta-analysis from 3 prospective studies in Europe, median follow-up 6.7 yrs, ABPM was done every 15 min or at intervals of not more than 30 min during the daytime and every 30 min or at intervals of not more than 60 min during the nighttime during the 24 hr period.	Daytime ABP, nighttime ABP, all-cause mortality, cardiovascular mortality, major cardiovascular events	In a multivariate Cox regression analysis, when daytime and nighttime ABP were both included in the model, nighttime ABP significantly predicted all-cause mortality, CV mortality, and CV deaths (p<.05), while daytime ABP did not (p>.05).
Burr et al. 2008 **(32)**	N=1144 untreated hypertensives, 49% female, mean age 75.1 yrs	Prospective, mean follow-up 6.7 yrs, ABPM was done every 30 min over the 24 hr period.	Daytime ABP, nighttime ABP, cardiovascular mortality, cardiac mortality, stroke	In a multivariate Cox proportional hazards model, nighttime ABP was the highest independent predictor of cardiovascular events and mortality (p<..001).

Table 7: Nighttime ABP and Carotid IMT in a general population

Reference	Study Population	Study Design	Measures	Results
Shintani et al. 2007	N=775 general population, mean age	Cross-sectional, ABPM was done every 30 min	Daytime ABP, nighttime ABP, carotid IMT	When both daytime and nighttime systolic ABP

(33)	66.2 ± 6.2 yrs, 68.8% women, 39% taking antihypertensive medication.	during a 24 hr period	(mean, CCA)	were entered into the same multivariate regression analysis, only nighttime ABP was significantly associated with carotid IMT (p<.0001).
Sander et al. 1996 **(34)**	N= 208 hypertensive, 216 normotensive, > 55 yrs, 47% women	Cross-sectional, normotensives and hypertensives	24 hour ABP, BP variability, daytime ABP, nighttime ABP, carotid IMT (mean, CCA)	Using ANCOVA to examine the differences between hypertensives and norrmotensives, it was found that increased diurnal systolic BP and increased nocturnal BP were associated with sig larger IMT values in the hypertensive group (p<0.0001)
Cuspidi et al. 2001 **(35)**	N=118 untreated hypertensives, mean age 46 yrs, 38% female	Observational cross-sectional study, 2 groups: dippers, nondippers, ABPM was done at 15 min intervals during the daytime and 20 min intervals during the nighttime for two 24 hr periods within a 3 week period.	nocturnal BP dipping, carotid IMT (CCA, mean)	An independent samples t-test found mean IMT was significantly greater in non-dippers than in dippers (p=.04).
Muiesan et al. 1996 **(36)**	N=225 general population, 48-64 yrs, 48% women, 59 subjects were excluded for taking antihypertensive medication	Cross-sectional, ABPM was done every 20 min between 7am to 11pm and every 30 min between 11pm to 7am.	24 hour ABP, daytime ABP, nighttime ABP, carotid IMT(mean, CCA, carotid bifurcation, extracranial portions of the internal and external carotid arteries)	In a multiple regression analysis, mean nighttime systolic ABP was independently related to mean carotid IMT (p<.05).

Table 8: Nighttime ABP and Carotid IMT in Hypertensives

Reference	Study Population	Study Design	Measures	Results
Salvetti et al. 2001 **(37)**	N=284 hypertensive subjects (59 treated), mean age 58 yrs, 50% women	Cross-sectional, subjects divided into dippers, non-dippers, ABPM was done every 20 min from 7am to 11pm and 30 min from 11pm to 7am.	Nocturnal dip, carotid IMT (CCA, carotid bifurcation, extra cranial portions of internal and external carotid arteries, mean)	Using ANCOVA to analyze the difference between dippers and non-dippers, mean IMT of all three carotid measurements was significantly greater in non-dippers than in dippers (p<.05).
Pierdomenico et al. 1997 **(38)**	N=90 untreated hypertensives, 49 yrs, 44% female	Cross-sectional, 25 dippers, 25 non-dippers, ABPM was done every 15 min from 6am to midnight and at 30 min from midnight to 6am.	BP dipping, carotid IMT (CCA, mean)	The results from ANCOVA that compared dippers and non-dippers found that mean IMT was significantly higher in non-dippers than dippers (p<.02).
Desideri et al. 2007 **(39)**	N=50 untreated male hypertensives, mean age 53.8 yrs, 25 normotensive males, mean age 51.7 yrs	Cross-sectional, 25 hypertensive dippers, 25 hypertensive non-dippers, 25 controls, ABPM was done every 15 min from 7am to	24 hr ABP, nighttime ABP, nocturnal dip, carotid IMT (CCA, mean)	The results from ANOVA found comparing dippers, non-dippers, and controls found that mean carotid IMT was

		11pm and every 30 min from 11pm to 7am		significantly higher in non-dippers (.80 mm) and dippers (.73mm) than in controls (.48mm) ($p<.05$). Spearman correlations found a significant association between IMT and nighttime ABP ($p=.04$).

CBP = clinic blood pressure

ABP = ambulatory blood pressure

SBP = systolic blood pressure

DBP = diastolic blood pressure

CCA = common carotid artery

Table 9. Sample Characteristics (n=201)

Variable	n (%)	M (SD)	Range
Women	100 (49.75)		
Race			
White	176 (87.13)		
Black	19 (9.45)		
Asian	3 (1.57)		
Other	3 (1.57)		
Education Status			
High School or Less	46 (22.89)		
Some College	39 (19.40)		
Bachelor's Degree	58 (28.86)		
Graduate Degree	58 (28.86)		
Hypertensive Medication	57 (28.36)		

Age	66.86 (4.52)	56.1 – 76.7
BMI	27.62 (4.77)	16.12 – 47.78

*For gender, race, and education, the numbers in the tables represent the number of participants in that particular category, while the number in parenthesis indicates the % that number represents in the sample.

**For age and BMI, the numbers represent the mean value, while the numbers in parenthesis indicates the standard deviation.

Table 10: Demographic Characteristics by Hypertensive Status (n=201)

Variable	Hypertensive (n=57)	Normotensive (n=144)	p-value
Women	31 (46.97)	69 (51.11)	.58
Race			.37
White	57 (87.72)	119 (88.15)	
Non White	9 (13.64)	16 (11.85)	
Education Status			.64
High School or Less	18 (27.27)	28 (20.74)	
Some College	12 (18.18)	27 (20)	
Bachelor's Degree	16 (24.20)	42 (31.11)	
Graduate Degree	20 (30.30)	38 (28.15)	
Age	67.8 (4.54)	66.4 (4.45)	.04
BMI	28.09 (4.76)	27.43 (4.79)	.38

*For gender, race, and education, the numbers in the tables represent the number of participants in that particular category, while the number in parenthesis indicates the % that number represents in the sample.

**For age and BMI, the numbers represent the mean value, while the numbers in parenthesis indicates the standard deviation

Table 11: Excluded and Included participants demographics

Variable	Excluded (n=95)	Included (n=201)	p-value
N	98	191	
Women	56 (58.95)	100 (49.75)	.14
Age	67.32 (4.64)	66.95 (4.35)	.4
Race			
White	79 (83.16)	176 (87.56)	.11
Non White	16 (16.84)	25 (12.44)	
Education			.005
High School or Less	22 (23.16)	46 (22.89)	
Some College	35 (36.84)	39 (19.40)	
Bachelor's Degree	14 (14.74)	58 (28.86)	
Graduate Degree	24 (25.26)	58 (28.86)	
BMI	28.66 (4.72)	27.62 (4.77)	.09
Clinic SBP	119.2 (12.39)	118.8 (12.14)	.19
Clinic DBP	75.64 (7.86)	75.9 (7.58)	.87
IMT	.92 (.25)	.88 (.21)	.19

Table 12: Risk Factor Values for Entire Sample (n=201)

Variable	Total Sample (M, SD)	Desirable Range
Insulin (mLU/mL)	13.14 (6.1)	5 – 20 mLU/mL
Glucose (mg/dL)	100.8 (18)	70 – 110 mg/dL

Total Cholesterol (mg/dL)	205.71 (37.6)	< 225 mg/dL
HDL (mg/dL)	55.67 (16.1)	> 60 mg/dL
LDL (mg/dL)	124 (36)	< 130 mg/dL
Triglycerides (mg/dL)	127.3 (60.2)	78 – 158 mg/dL

Table 13: Correlation matrix for clinic and ambulatory SBP (n=201)

	Clinic SBP	Daytime SBP	Nighttime SBP
Clinic SBP	1.00	**.45***	**.36***
Daytime SBP	**.45***	1.00	**.63***
Nighttime SBP	**.36***	**.63***	1.00

Table 14: Correlation matrix for clinic and ambulatory DBP (n=201)

	Clinic DBP	Daytime DBP	Nighttime DBP
Clinic DBP	1.00	**.60***	**.47***
Daytime DBP	**.60***	1.00	**.62***
Nighttime DBP	**.47***	**.62***	1.00

***p<.0001**

Table 15: Covariates Predicting Daytime Systolic Blood Pressure

Covariates	F-value	P-value
Age	.24	.81
Sex*	3.14	.08
Race**	1.45	.23
Education***	.46	.5

*controlling for age
**controlling for age, sex,
***controlling for age, sex, race

Table 16: Covariates Predicting Nighttime Systolic Blood Pressure

Covariates	F-value	P-value
Age	.08	.78
Sex*	1.33	.25
Race**	.80	.37
Education***	.71	.4

*controlling for age
**controlling for age, sex,
***controlling for age, sex, race

Table 17: Clinic BP and ABP for the Total Sample (n=201)

Variable	Avg #	Mean (SD)	Range
Clinic SBP		118.8 (12.14)	88 - 169
Clinic DBP		75.9 (7.58)	56 - 97
Daytime SBP	48. 42	136.08 (15.03)	104.77 – 175.81
Daytime DBP	48.42	76.58 (7.38)	59.24 – 98.78
Nighttime SBP	11.03	118.93 (17.06)	76 – 178.20
Nighttime DBP	11.03	63.04 (8.52)	42.90 – 89.11

*Avg # refers to the mean number of BP readings collected over the 3 days and 2 nights.

Table 18: Clinic BP and ABP by Gender

Variable	Males (n=101)	Females (n=100)	P-value
Clinic SBP	117.9 (11.55)	119.5 (12.70)	.27
Clinic DBP	76.64 (7.16)	75.19 (7.86)	.17
Daytime SBP	137.8 (15.33)	134 (14.8)	.05
Daytime DBP	77.35 (7.33)	75.79 (7.37)	.16
Nighttime SBP	120.2 (16.41)	117.5 (17.68)	.29
Nighttime DBP	64.36 (7.87)	61.91 (8.96)	.04

Table 19: Clinic BP and ABP by Race

Variable	Whites (n=176)	Non-Whites (n=25)	P-value
Clinic SBP	118.5 (12.37)	121 (10.37)	.34

Clinic DBP	75.52 (7.20)	78.76 (9.29)	.1
Daytime SBP	136.7 (14.73)	131.7 (16.68)	.12
Daytime DBP	76.22 (7.1)	79.09 (8.79)	.07
Nighttime SBP	119.4 (17.3)	115.9 (15.21)	.35
Nighttime DBP	62.97 (8.3)	64.5 (8.68)	.4

Table 20: Clinic and ABP by Hypertensive Status

Variable	Hypertensive (n=66)	Normotensive (n=135)	P-value
Clinic SBP	122.2 (15.20)	117.1 (9.97)	.02
Clinic DBP	77.24 (8.95)	75.27 (6.68)	.08
Daytime SBP	137.9 (16.04)	135.9 (14.5)	.28
Daytime DBP	77.56 (7.56)	76.10 (7.27)	.19
Nighttime SBP	120.8 (18.97)	118 (16.04)	.28
Nighttime DBP	64.15 (9.78)	62.67 (7.82)	.26

Table 21: Covariates Predicting Carotid IMT

Covariates	F-value	P-value
Age	16.24	.0001

Sex*	14.12	.0002
Race**	.72	.4
Waist circumference***	5.10	.03
Clinic SBP****	.54	.47
Clinic DBP****	.28	.59

*controlling for age
**controlling for age, sex,
***controlling for age, sex, race
****controlling for age, sex, race, waist circumference

Table 22: Carotid IMT Values for Total Sample, by Gender, Race, Medication Status, and Age

Variable	Mean (SD)	Range	P-value
Total Sample (n=201)	0.88 (.21)	0.56 – 1.72	
Males (n=101)	0.94 (.21)	0.63 – 1.63	.0001
Females (n=100)	0.82 (.2)	0.56 – 1.72	
Whites (n=176)	0.88 (.21)	0.57 – 1.72	.12
Non-Whites (n=25)	0.82 (.20)	0.56 – 1.32	
Hypertensive (n=66)	0.93 (.22)	0.59 – 1.45	.03
Normotensive (n=135)	0.86 (.2)	0.56 – 1.72	
Younger (<66.95 yrs)	0.81 (.23)	0.56 – 1.72	.0001
Older (>66.95 yrs)	0.94 (.16)	0.56 – 1.40	

Table 23: Physical Activity Values for the Entire Sample (n=201)

Variable	Mean (SD)	Median	Range
Min/week	118.67 (119.42)	77.19	0 - 760
METS	4.92 (1.48)		0 - 10
# of activities	1.7		0 - 5

Table 24: Within Person results for Physical Activity and Daytime SBP (n=201)

PA device	1 minute	5 minute	10 minutes	15 minutes
Wrist	T=6.51, p<.0001	T=6.71, p<.0001	T=6.22, p<.0001	T=5.80, p<.0001
Waist	T=3.44, p=.0007	T=7.74, p<.0001	T=5.91, p<.0001	T=5.56, p<.0001
Self-Report	NA	NA	T=3.54, p<.001	NA

Table 25: Within Person Results for Physical Activity and Daytime DBP (n=201)

PA device	1 minute	5 minute	10 minutes	15 minutes
Wrist	T=7.47, p<.0001	T=8.69, p<.0001	T=8.93, p<.0001	T=9.42, p<.0001
Waist	T=4.54, p<.0001	T=7.17, p<.0001	T=6.09, p<.0001	T=7.34, p<.0001
Self-Report	NA	NA	T=3.31 p<.001	NA

Table 26: Within Person Results for Combined Wrist and Waist and Daytime SBP (n=201)

PA device		1 minute		5 minute		10 minutes		15 minutes	
Wrist	Waist	T=5.96, p<.001	T=.39, p=.69	T=3.55, p=.0005	T=5.42, p<.0001	T=4.16, p<.0001	T=3.25, p=.0013	T=3.90, p=.0003	T=3.06, p=.0026

Table 27: Within Person Results for Combined Wrist and Waist and Daytime DBP (n=201)

PA device		1 minute		5 minute		10 minutes		15 minutes	
Wrist	Waist	T=6.93, p<.0001	T=1.32, p=.19	T=6.34, p<.0001	T=3.14, p<.002	T=7.33, p<.0001	T=2.21, p=.03	T=7.12, p<.0001	T=3.15, p=.0019

Table 28: Results for 10 minute Waist, Wrist, and Self Report for Daytime SBP (n=201)

10 min PA measure	T-Value	P-Value
Wrist	4.04	.0001
Waist	2.65	.009
Self-Report	2.06	.04

Table 29: Results for 10 minute Waist, Wrist, and Self Report for Daytime DBP (n=201)

10 min PA measure	T-Value	P-Value
Wrist	7.33	.0001
Waist	1.91	.06
Self-Report	1.26	.21

Table 30: Between Person Results for Physical Activity and Daytime SBP (n=201)

PA device	1 minute	5 minute	10 minutes	15 minutes
Wrist	F=14.66, p=.0002,	F=.48, p=.49	F=.24, p=.62	F=.55, p=.46
Waist	F=2.39, p=.12	F=4.52, p=.03, f^2=.02	F=5.21, p=.02, f^2=.03	F=4.10, p=.04, f^2=.02
Self-Report	NA	NA	F=38, p=.58	NA

Table 31: Combination of Time Intervals of Waist Accelerometer on Daytime SBP (n=201)

PA Time Intervals	F-value	P-value
5 & 10 minutes	2.60	.08
5 & 15 minutes	2.40	.09
10 & 15 minutes	2.97	.05
5, 10, & 15 minutes	2.73	.04

Table 32: Regression Results of 1 minute wrist and 10 minute waist on Daytime SBP (n=201)

PA Device	F-value	P-value
1 minute wrist	14.97	.0001
10 minute waist	5.27	.02

Table 33: Between Person Results for Physical Activity and Daytime DBP (n=201)

PA device	1 minute	5 minute	10 minutes	15 minutes
Wrist	F=4.05, p=.05	F=.43, p=.51	F=.19, p=.85	F=.0, p=.97
Waist	F=.40, p=.53	F=.40, p=.53	F=.03, p=.87	F=.01, p=.94

Self-Report	NA	NA	F=1.17, p=.28	NA

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