Exercise Capacity and 24-h Blood Pressure in Prehypertensive Men and Women

Peter Kokkinos, Andreas Pittaras, Athanasios Manolis,
Demosthenes Panagiotakos, Puneet Narayan, Demitra Manjoros,
Richard L. Amdur, and Steven Singh

Background: Prehypertensive individuals are at increased risk for developing hypertension and cardiovascular disease compared to those with normal blood pressure (BP). Physically active, normotensive individuals are also at lower risk for developing hypertension than sedentary individuals. We assessed the relationship between fitness and 24-h ambulatory BP in prehypertensive men and women.

Methods: We assessed exercise capacity and 24-h BP in 407 men (age 51 ± 11 years) and 243 women (age 54 ±10 years) with resting systolic BP 120 to 139 mm Hg and diastolic BP of 80 to 89 mm Hg, defined as prehypertension. Fitness categories (low, moderate, and high) were established according to exercise time and age.

Results: Multiple regression analysis revealed that fitness status was inversely associated with ambulatory BP in both genders ($P < .001$). After adjusting for various confounders, individuals in the lowest fitness category had significantly higher 24-h, daytime, and night-time BP than those in the moderate and high fitness categories. For men, differences between low and moderate fitness categories were 6/4 mm Hg, 8/4 mm Hg, and 7/3 mm Hg for 24-h, daytime, and night-time BP, respectively ($P < .05$). For women, the differences were 8/5 mm Hg, 9/5 mm Hg, and 8/7 mm Hg for 24-h, daytime, and night-time BP, respectively. Similar differences were evident in both genders between low and high fitness category ($P < .05$).

Conclusions: Moderate physical activity promotes lower BP during a 24-h period in prehypertensive men and women. The risk for developing hypertension is likely to be lowered if moderate intensity physical activity in this vulnerable population is encouraged. Am J Hypertens 2006;19:251–258 © 2006 American Journal of Hypertension, Ltd.

Key Words: Prehypertension, ambulatory blood pressure, exercise capacity.

The relationship between blood pressure (BP) and risk of cardiovascular events is continuous, consistent, and independent of other risk factors.[1,2] Conversely, even small reductions in BP lead to significant reductions in the incidence of stroke, myocardial infarction, and heart failure.[3–5]

Epidemiologic data[6–10] and exercise training studies overwhelmingly support that regularly performed aerobic exercise lowers BP in patients with mild-to-moderate essential hypertension when compared to nonexercising controls.[11–13] Furthermore, cross-sectional and large-scale longitudinal population studies suggest that the relative risk for developing hypertension in sedentary men with normal BP at rest is approximately 35% to 70% higher when compared to their physically active peers.[14–16] Similarly, prehypertensive individuals, defined as those with resting systolic BP of 120 to 139 or diastolic BP 80 to 89,[1] are at twice the risk to develop hypertension as those with normal values.[17] Exercise is now recommended for the prevention and management of hypertension.[1,2]

Ambulatory BP provides a more comprehensive assessment of BP and is a good predictor of cardiovascular events and a better predictor of target organ damage than resting BP.[18–20] Information on BP assessments during a 24-h period in exercise studies is limited and findings inconclusive. Only five relatively small studies[21–25] and one large trial (HARVEST trial)[8] have used ambulatory devices. There are no studies assessing the relationship between ambulatory BP and fitness levels in prehypertensive men or women. Thus, to determine whether increased fitness is associated with lower BP during 24 h, we assessed the relationship between peak exercise time as

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From the Veterans Affairs Medical Center/Cardiology Division, Washington, DC; Georgetown University Medical Center, Washington, DC; Tzanio Hospital/Cardiology Department, Athens Greece; and Department of Nutrition and Dietetics, Harokopio University, Athens, Greece.

Address correspondence and reprint requests to Dr. Peter F. Kokkinos, Veterans Affairs Medical Center/Cardiology Division 50 Irving Street NW, Washington, DC 20422; e-mail: peter.kokkinos@med.va.gov

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assessed by a graded exercise test and 24-h BP in prehypertensive men and women.

Methods

Participants

Subjects were asked to participate in this project during a routine visit to the Cardiology Clinic at Tzanio Hospital, Women's Social Welfare clinic and a private Cardiology Clinic (Mediton) between 1998 and 2003. All sites are located in Athens and Pireaus, Greece. Nine hundred twenty-three subjects gave a written consent to undergo an exercise tolerance test and wear an ambulatory monitor for 24 h.

Of the 923, we identified 650 prehypertensive men and women with no evidence of overt coronary heart disease. They were included in this study. Two hundred forty-three were women (mean age 54 ±10 years; range 30 to 79 years) and 407 were men (mean age 51 ± 11 years; range 30 to 79 years). Subjects were included if they were: 1) not taking any cardiac, antihypertensive, or other medication that would affect BP; 2) had resting systolic BP of 120 to 139 mm Hg or resting diastolic BP of 80 to 89 mm Hg; 3) had no apparent chronic disease; 4) did not use tobacco products for at least 1 year; and 5) were not alcoholics. Those who agreed to participate and gave a written consent were scheduled for an exercise tolerance test (ETT). Participants who achieved 90% or more of the age-predicted maximal heart rate (HR) and had a normal exercise tolerance test (no evidence suggestive of ischemia) were included in the final analysis.

The baseline evaluation included a medical history and an interview about the current use of alcoholic beverages and coffee (in number of drinks per week), as well as their former smoking habits.

Exercise Testing, Fitness Assessment, and Classification

Resting BP and HR were recorded before the graded exercise test. The BP measurements began after subjects were seated in a chair for 5 min with their backs supported and their arms supported at heart level. Three BP readings were taken at 2-min intervals between readings. The third reading was recorded as the resting BP. The HR at this time was recorded as the resting HR. Standing BP and HR were then was assessed after the subject was standing for at least 1 min.

Physical fitness was assessed by the Bruce protocol. Exercise HR was recorded continuously and exercise BP was assessed at the end of each stage and at peak exercise. Exercise capacity was recorded as peak exercise time in minutes. Peak exercise workload was estimated on the basis of the speed and grade of the treadmill and recorded as metabolic equivalents (MET; 1 MET equals 3.5 mL of oxygen uptake per kilogram of body weight per minute).[26] Subjects were encouraged to exercise until volitional fatigue in the absence of symptoms or other indicators of ischemia. For more accurate estimated workload assessment of fitness, participants were not allowed to lean against handrails of the treadmill.

During exercise, BP was recorded at 2 min of each exercise stage and peak exercise, and within 1 min after the cessation of exercise. All resting and exercise BP assessments were made by indirect arm–cuff sphygmomanometry in the right arm.

Three fitness categories (low, moderate, and high), were established according to the peak exercise time achieved during the graded exercise test and adjusted for age[27] (Table 1).

Ambulatory BP Measurements

Twenty-four-hour arterial BP readings were obtained using a noninvasive ambulatory monitor (Spacelabs Inc. Issaquah, WA). Subjects reported to the clinic on a weekday and between 8 and 9 AM. They were oriented with the monitor and fitted with a standard, appropriately sized BP cuff. The ambulatory system was calibrated against a sphygmomanometer and was programmed to inflate automatically every 20 min between 8 AM and 11 PM, and every 30 min between 11 PM and 8 AM. Each participant was instructed to relax the arm throughout the inflation/deflation cycle. Readings were stored, analyzed, and printed by computer. Each reading was edited by the computer and manually, and outliers (systolic BP <80 mm Hg or >260 mm Hg; or diastolic BP <40 mm Hg or >150 mm Hg; and HR <40 or >150 beats/min) were deleted. Ten subjects met these criteria and were excluded form the final analysis. Ambulatory BP assessments for each participant occurred within 3 weeks from the time of the graded exercise test evaluation.

Data Analysis

Continuous variables are presented as mean ± standard deviation. One-way analysis of variance was performed to identify differences between men and women and among fitness categories for age, body weight, body mass index (BMI), resting HR, and BP measurements in both men and women. Post-hoc analyses with Bonferroni correction for the probability of type I error were used to identify differences between fitness categories. Simple regression analyses were performed to assess the relationship between fitness levels and ambulatory BP, resting BP exercise parameters, and subject characteristics. Multiple linear regression analysis was applied to evaluate the association between fitness categories on 24-h, daytime, and night-time BP levels, after adjusting for BMI and other potential confounding factors. Normality of the ambulatory BP was assessed by the Kolmogorov -Smirnov test. All reported *P* values are based on two-sided tests and compared to a significance level of 5%. The SPSS 11.5 (SPSS Inc., Chicago, IL) software was used for all the statistical calculations.

Table 1. Classification of fitness adjusted for age*

Age	*N*	Cutoff Time (sec)	Peak Exercise Time (sec)	MET
Low fitness men (*n* = 65)				
<30	—	≤630	—	—
30–39	12	≤600	543 ± 48	9.8 ± 0.7
40–49	15	≤570	522 ± 46	9.4 ± 0.7
50–59	16	≤540	485 ± 77	8.9 ± 1.2
60–69	14	≤510	423 ± 61	7.9 ± 1.0
≥70	8	≤450	349 ± 117	6.7 ± 1.9
Low fitness women (*n* = 60)				
<30	1	≤540	302	5.7
30–39	5	≤510	463 ± 32	7.4 ± 0.3
40–49	10	≤480	398 ± 72	6.8 ± 0.7
50–59	23	≤450	393 ± 57	6.7 ± 0.6
60–69	20	≤420	348 ± 63	6.2 ± 0.6
≥70	1	≤360	271	5.3
Moderate fitness men (*n* = 236)				
<30	3	631–809	689 ± 51	12.1 ± 0.8
30–39	31	601–799	680 ± 45	11.9 ± 0.7
40–49	94	571–719	642 ± 41	11.4 ± 0.6
50–59	68	540–689	606 ± 24	10.8 ± 0.4
60–69	27	510–629	554 ± 25	10.0 ± 0.4
≥70	13	450–599	601 ± 92	10.7 ± 1.5
Moderate fitness women (*n* = 86)				
<30	2	541–659	582 ± 50	8.7 ± 0.5
30–39	9	510–629	567 ± 31	8.6 ± 0.3
40–49	23	480–599	538 ± 30	8.2 ± 0.3
50–59	36	450–539	507 ± 23	7.9 ± 0.2
60–69	14	420–479	435 ± 12	7.1 ± 0.1
≥70	2	360–389	375 ± 0.7	6.5 ± 0.01
High fitness men (*n* = 106)				
<30	3	≥810	781 ± 0.5	13.5 ± 0.01
30–39	11	≥780	797 ± 24	13.8 ± 0.4
40–49	30	≥720	752 ± 30	13.1 ± 0.5
50–59	29	≥690	698 ± 56	12.2 ± 0.9
60–69	33	≥630	625 ± 37	11.0 ± 0.6
≥70	—	≥600	—	—
High fitness women (*n* = 97)				
<30	2	≥660	661 ± 0.5	9.6 ± 0.001
30–39	2	≥630	641 ± 16	9.4 ± 0.2
40–49	9	≥600	617 ± 20	9.1 ± 0.2
50–59	38	≥540	590 ± 35	8.8 ± 0.4
60–69	42	≥480	534 ± 44	8.2 ± 0.5
≥70	4	≥390	470 ± 49	9.5 ± 0.5

MET = metabolic equivalent (1 MET = 3.5 mL of O_2/kg/min).
* Based on the Bruce protocol.

Results

Men were significantly younger and had higher body weight, BMI, but lower resting HR than women. After adjusting for age, BMI, and resting HR, the daytime, night-time, and 24-h systolic BP were significantly lower in men than women (Table 2). Therefore the analysis was stratified by gender.

Men

Men in the moderate fitness category were significantly younger than men in the low and high fitness categories. Body weight and BMI were lower in the high fitness category when compared to those in the moderate and low fitness categories. Peak exercise time and MET level were significantly different among all fitness categories. Resting systolic BP and HR were similar among all fitness categories (Table 3). Age ($P = .001$) and resting HR ($P = .001$) were inversely associated with fitness status, even after adjusting for BMI. No association was observed between fitness status and resting systolic BP ($P = .64$). However, exercise time was inversely related with all ambulatory BP values ($P < .01$). The distribution of the daytime ambulatory systolic BP was moderately skewed (skewness = 0.675; SE = 0.123).

Unadjusted ambulatory BP values were significantly higher in the low fitness versus moderate and high fitness men ($P < .05$). The differences persisted after adjusting

Table 2. Characteristics of men and women

	Men (N = 107)	Women (N = 243)
Age	51 ± 11*	54 ± 10
Weight (kg)	82 ± 9.5*	67 ± 12
Body mass index (kg/m^2)	27.0 ± 2.6*	25.3 ± 3.9
Rest heart rate (beats/min)	78 ± 9*	82 ± 13
Rest systolic BP (mm Hg)	132 ± 7	133 ± 8
Rest diastolic BP (mm Hg)	78 ± 8	79 ± 8
24-h systolic BP (mm Hg)	135 ± 10*	138 ± 11
24-h diastolic BP (mm Hg)	81 ± 9	82 ± 9
Daytime systolic BP (mm Hg)	142 ± 10*	144 ± 12
Daytime diastolic BP (mm Hg)	86 ± 9	86 ± 9
Nighttime systolic BP (mm Hg)	121 ± 13*	126 ± 14
Nighttime diastolic BP (mm Hg)	74 ± 10	76 ± 11

* $P < .05$.

for age, resting diastolic BP, and BMI. Specifically, men in the low fitness category had significantly higher 24-h, daytime systolic and diastolic BP than men in the moderate and high fitness categories. Night-time diastolic BP was similar among groups. Comparisons between moderate and high fitness categories revealed no significant differences in any BP values (Table 4).

Multiple linear regression analysis confirmed that 24-h systolic and diastolic BP levels were inversely associated with fitness status (β coefficient ± SE per fitness group: −3.0 ± 0.76 mm Hg, P = .001 and −2.33 ± 0.59 mm Hg, P = .001, respectively), after adjusting for age, resting BP, HR, and BMI. Moreover, age (β coefficient ± SE: 0.11 ± 0.45, P = .022), BMI (0.38 ± 0.19, P = .044), and systolic BP at 3 min of exercise (0.51 ± 0.03, $P < .001$) were the best predictors of daytime systolic BP, after controlling for fitness levels. Similarly, the best predictors of daytime diastolic BP were age (−0.08 ± 0.03, P = .006), BMI (0.29 ± 0.13, P = .029), and diastolic BP at 3 min (0.84 ± 0.04, $P < .001$), after controlling for fitness levels.

Table 3. Characteristics of men and women according to fitness categories

	Low fitness (n = 65)	Moderate fitness (n = 236)	High fitness (n = 106)
Men			
Age	54 ± 13	49 ± 10*	51 ± 10
Weight (kg)	84.2 ± 11.5	82.3 ± 9.4	80.2 ± 8.0
Body mass index	28.0 ± 2.8	26.9 ± 2.5	26.5 ± 2.3*
Rest heart rate (beats/min)	79 ± 10	78 ± 9	76.0 ± 8
Rest systolic BP	133 ± 8	132 ± 7	131 ± 7
Rest diastolic BP	80 ± 7	78 ± 8	77 ± 9*
Treadmill time (sec)†	474 ± 92	625 ± 54	704 ± 72
MET†	8.6 ± 1.4	11.1 ± 0.8	12.3 ± 1.1
	Low fitness (n = 60)	**Moderate fitness (n = 86)**	**High fitness (n = 97)**
Women			
Age	55 ± 10	52 ± 10	57 ± 9†
Weight (kg)	73.6 ± 14.0	66.0 ± 9.6*	64.0 ± 10.0*
Body mass index (kg/m^2)	28.0 ± 4.6	25.0 ± 2.9*	24.0 ± 3.3*
Rest heart rate (beats/min)	87 ± 16	82 ± 12	79 ± 13*
Rest systolic BP (mm Hg)	133 ± 8	133 ± 7	132 ± 7
Rest diastolic BP (mm Hg)	82 ± 7	79 ± 7*	77 ± 9*
Treadmill time (sec)‡	381 ± 68	509 ± 51	566 ± 55
MET‡	6.6 ± 0.7	8.0 ± 0.5	8.6 ± 0.6

* Different from low fitness ($P < .05$);
† Different from moderate fitness ($P < .05$).
‡ Differences among all fitness categories ($P < .05$).

Table 4. Ambulatory blood pressure according to fitness categories

	Low Fit (n = 65)	Moderate Fit (n = 236)	High Fit (n = 106)
Men			
24-h systolic BP (mm Hg)	140 ± 10*	134 ± 10	133 ± 8
24-h diastolic BP (mm Hg)	84 ± 10*	80 ± 8	79 ± 9
Daytime systolic BP (mm Hg)	148 ± 12*	140 ± 9	141 ± 8
Daytime diastolic BP (mm Hg)	90 ± 9*	86 ± 8	85 ± 9
Night-time systolic BP (mm Hg)	127 ± 12*	120 ± 12	119 ± 13
Night-time diastolic BP (mm Hg)	77 ± 11	74 ± 9	73 ± 10
	Low Fitness (*n* = 60)	**Moderate Fitness (*n* = 86)**	**High Fitness (*n* = 97)**
Women			
24-h systolic BP (mm Hg)	142 ± 10*	136 ± 10	136 ± 11
24-h diastolic BP (mm Hg)	86 ± 8	80 ± 9	81 ± 9
Daytime systolic BP (mm Hg)	151 ± 10*	142 ± 11	141 ± 13
Daytime diastolic BP (mm Hg)	90 ± 7	85 ± 9	85 ± 10
Night-time systolic BP (mm Hg)	131 ± 12*	125 ± 13	124 ± 14
Night-time diastolic BP (mm Hg)	81 ± 9*	74 ± 10	73 ± 12

* Low fitness versus moderate and high fitness categories ($P < .05$).

Women

Women in the moderate and high fitness categories had significantly lower body weight and BMI than women in the low fitness category. High fitness women were older than those in the moderate fitness category. Resting diastolic BP was also significantly lower in the high versus low fitness women ($P = .029$). Peak exercise time ($P = .001$) and MET level ($P < .001$) were significantly different among the three fitness categories. Resting systolic BP was similar (Table 3). The distribution of the daytime ambulatory systolic BP was normal (skewness = 0.082; SE = 0.157).

Age ($P = .001$), resting diastolic BP ($P = .002$), and HR ($P = .02$) were inversely associated with exercise time, even after adjusting for BMI. No association was observed between fitness status and resting systolic BP ($P = .45$). However, exercise time was inversely related with all ambulatory BP values ($P < .01$).

Unadjusted ambulatory BP values were significantly higher in the low fitness versus moderate and high fitness women ($P < .05$). After adjusting for age, resting diastolic BP, HR, and BMI, women in the moderate and high fitness categories had significantly lower 24-h, daytime, and night-time systolic BP and night-time only diastolic BP than women in the low fitness category ($P < .05$). All BP values were similar between those in the moderate and high fitness categories (Table 4).

Multiple linear regression analysis confirmed that fitness status was inversely associated with 24-h, daytime, and night-time systolic BP (β coefficient ± SE per fitness group: −2.8 ± 0.8 mm Hg, $P = .001$, −4.3 ± 0.88 mm Hg, $P = .001$ and −3.05 ± 0.59 mm Hg, $P = .002$, respectively) and night-time diastolic BP (−3.22 ± 0.76 mm Hg, $P = .002$), after adjusting for age, resting diastolic BP, HR, and BMI. Moreover, age (β coefficient ± SE: 0.11 ± 0.45, $P = .022$), BMI (0.38 ± 0.19, $P = .044$), and systolic BP at 3 min of exercise (0.51 ± 0.03, $P < .001$) were the best predictors of daytime systolic BP, after controlling for fitness levels. Similarly, the best predictors of daytime diastolic BP were age (−0.08 ± 0.03, $P = .006$), BMI (0.29 ± 0.13, $P = .029$), and diastolic BP at 3 min (0.84 ± 0.04, $P < .001$), after controlling for fitness levels.

Discussion

Our findings support that higher fitness levels are associated with lower BP during a 24-h period in prehypertensive, middle-aged men and women. This is despite the similar systolic BP levels at rest among the three fitness categories. More specifically, the daytime, night-time, and 24-h systolic BP and night-time diastolic BP for men in the moderate fitness category were 8/4, 7/3, and 6/4 mm Hg lower than men in the low fitness category. The BP values were very similar between the moderate and high fitness categories. Similarly, the daytime, night-time, and 24-h BP values for women in the moderate fitness category were 9/5, 6/7, and 6/6 mm Hg respectively, lower than the BP of women in the lowest fitness category. The BP values were very similar between the moderate and high fitness categories.

The BP differences among our fitness categories in this study are greater that those reported by the HARVEST trial.[8] In that trial, only the 24-h diastolic BP was lower by 2 to 3 mm Hg in those who reported engaging in some physical activity for at least once a week during the previous 2 months versus those who reported engaging in no physical activity during the same period. Several factors may explain the relatively greater differences among the fitness categories we found. First, in the HARVEST trial, physical fitness was not measured and fitness categories were based on a questionnaire. Questionnaires are highly subjective and unreliable. Second, the criterion for qualifying as an exerciser (once a week during the previous 2 months) was too liberal and probably included a number of truly nonexercisers or at least individuals with minimum physical activity.

Our findings are more similar to those reported by some,[23–25] but not all[21,22] exercise intervention studies using 24-h BP monitoring. Two such studies reported reductions of approximately 5 to 7 mm Hg for systolic and diastolic BP,[24,25] whereas another study,[23] reported similar reductions (7 mm Hg) only in daytime systolic BP. Two studies[21,22] found no significant reduction in BP. The relatively small number of subjects in these studies[21,22] may explain the different findings. Finally, the daytime differences of approximately 8/5 mm Hg between the low fitness and those in the moderate and high fitness categories in our study are also relatively similar to the average change of 10.5/7.6 mm Hg reported by exercise studies assessing BP by auscultation.[12]

Our findings have clinical significance, particularly for the prehypertensive population. Prehypertensive individuals have double the risk for developing hypertension than those with normal BP.[17] Yet, it is not likely these individuals will receive antihypertensive medication or have their BP evaluated during 24 h. Thus, physical activity becomes even more essential for the prehypertensive to reduce the risk of developing hypertension, and must be promoted by health care professionals. In addition, a low exercise capacity in prehypertensive individuals should serve as a warning and an indicator for the clinician to further assess BP.

It is also important to note the striking similarity in BP values between the moderate and high fitness categories in our study. This suggests that exercise or fitness-related reductions in BP occur at a moderate level of physical activity with no additional changes beyond this level. For men between the ages of 30 to 70 years in the moderate fitness category, the MET level ranges from 12.1 to 10.7. For women of the same age range, the MET level is 8.7 to 6.5 (Table 1). This level of fitness is relatively easy to achieve for most middle-aged and older individuals, requiring no more than a brisk walk of 30 to 60 min, most days of the week.[28]

Finally, the higher daytime BP than resting BP evident in our subjects is of considerable interest. In more than 84% of men and 83% of women, the daytime systolic BP was greater than that at rest. This is in accord with the findings of some, but not all studies.[29–31] Evidence suggests that the higher daytime BP than clinical BP may be age related. In an Italian population, the increase in ambulatory pressure was much less with age compared to clinical pressure.[30] In the Danish study,[31] ambulatory BP was higher than resting BP in 86% of the men and 72% of the women aged 41 to 42 years. In the age group 71 to 72 years the corresponding BP values were 51% for men and 38% for women. As indicated by the investigators of that study, younger individuals are more likely to engage in physical activities during the day and therefore maintain higher daytime BP levels compared to casual readings at rest. In our current study, more than 75% of the men and 66% of the women were below the age of 60 years. The prevalence of higher ambulatory BP versus resting BP in our study is also very similar to that reported in the Danish population.

We also noted that more than 50% men and 52% women had daytime BP >135/85 mm Hg and could be characterized as having masked hypertension.[32] Furthermore, the prevalence of masked hypertension was much higher in the low fitness subjects versus those in the moderate and high fitness categories. For example, more than 73% of low fitness women and 66% of low fitness men had daytime BP >135/85 mm Hg compared to 45.9% and 47.5% of the moderate and high fitness women and men, respectively. This suggests that masked hypertension may be more prevalent in low fitness, prehypertensive individuals.

Regardless, the overall prevalence of masked hypertension in our subjects is much higher than that reported by other researchers.[33–35] Although an apparent explanation is not readily available, our data allow for some speculation. Smoking and excessive alcohol consumption does not appear as probable factors, as our subjects were not smokers nor were they consuming excessive alcohol. We present two most likely factors that explain, at least in part, the high prevalence of higher ambulatory versus resting BP and perhaps masked hypertension in our group. The first factor is the age of the participants. As mentioned earlier, more than 75% of the men and 66% of the women were below the age of 60 years. Younger individuals are more physically active during the day. As indicated by the PAMELA study,[30] ambulatory BP is highly dependent on daily activity. Second, participants in the current study were all prehypertensive. Previous reports included normotensive and prehypertensive subjects, thus, the percentage of those with higher ambulatory BP than casual BP or masked hypertension is likely to lower. To a certain extend, this notion is supported by our data. In our database, we identified 44 subjects with BP <120/80 mm Hg. In only four of these subjects (<10%) the daytime BP was more than 135/85 mm Hg (masked hypertension). Although this is a relatively small sample, this observation supports the intuitive assumption that the prevalence of masked hypertension may be higher in the prehypertensive subjects. Further assessment of this observation should be pursued in larger studies.

Limitations

The present study is a cross-sectional and therefore has several limitations. Because of the design we cannot provide causal relationships, but only state hypotheses that could be evaluated in randomized clinical trials. The population consists of white Greeks and may not represent other ethnic groups. The level of daily activity is also not known.

Conclusions

Our findings provide evidence that regularly performed physical activity is essential for the prehypertensive individual to achieve a lower BP throughout the day. The level of physical activity necessary to attain the required fitness for lower 24-h BP is attainable by most middle-aged and older individuals. This is of particular clinical significance for the prehypertensive individual who is not likely to receive antihypertensive medication. Therefore, health care professionals must promote moderate intensity physical activity to reduce the risk of developing hypertension in this vulnerable population.

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