sciendo

10.2478/AMB-2025-00053

ORIGINAL ARTICLE

AMBULATORY BLOOD PRESSURE PARAMETERS IN ANTIHYPERTENSIVE DRUG-NAÏVE SUBJECTS WITH PREDIABETES

N. Stoynev[1,2], T. Tankova[2]

[1]Department of Physiology and Pathophysiology, Medical Faculty, Medical University – Sofia, Bulgaria
[2]Department of Endocrinology, Medical Faculty, Medical University – Sofia, Bulgaria

Abstract: *The aim of this study was to evaluate ambulatory blood pressure characteristics in subjects with prediabetes who have not been treated with antihypertensive drugs. The assessment was not only targeting undiagnosed hypertension but also the "white-coat" hypertension (WCH), masked hypertension (MaskH) and abnormal circadian blood pressure patterns (non-dippers, extreme dippers). One hundred and twenty subjects (56 males, 64 females), of mean age 44.72 ± 12.49 years, were included in the study. After evaluation of glucose tolerance the participants were divided into two groups: Group 1 – subjects with prediabetes; and Group 2 (Control group) – subjects with normal glucose tolerance (NormGT). All participants were without previously diagnosed hypertension and had never received any antihypertensive drug. Standard anthropometric parameters – weight, height and waist circumference, were measured in all subjects. Blood pressure was measured by ambulatory blood pressure monitoring. No significant differences in the anthropometric parameters have been observed. The ambulatory blood pressure monitoring identified higher prevalence of undiagnosed hypertension among the subjects with prediabetes (52.17% vs 43.24% in the control group). The prevalence of masked hypertension was lower among the subjects with prediabetes (13.33%), compared to NormGT (28.88%). For WCH the prevalence in prediabetes (27.27%) was slightly lower than in the control group (34.48%). The analysis of the circadian pattern of ambulatory blood pressure demonstrated higher prevalence of "non-dippers" in the group with prediabetes (36.96% vs 28.38%), while the prevalence of "extreme dippers" was close to that of the control group (8.69% vs 9.46%). The high prevalence of undiagnosed hypertension among subjects with prediabetes suggests that ambulatory blood pressure monitoring could be used on a regular basis in the evaluation of subjects with prediabetes considered normotensive. The method could also be important to identify "non-dippers" as the prevalence of this pattern tends to be higher in prediabetes.*

Key words: *prediabetes, hypertension, ambulatory blood pressure monitoring, non-dippers*

Corresponding author: *Nikolay Stoynev, MD, Department of Physiology and Pathophysiology, Medical Faculty, Medical University – Sofia, 2 Zdrave Str., Sofia 1431, Bulgaria, tel: +359 898 582991, email: nstoynev@medfac.mu-sofia.bg*

ORCID: *0000-0003-2763-9528 – N. Stoynev*

ORCID: *0000-0002-7572-1131 – T. Tankova*

Received: *14 February 2025;* ***Revised/Accepted:*** *11 May 2025*

INTRODUCTION

The term prediabetes includes two conditions – impaired fasting glucose (IFG) and impaired glucose tolerance (IGT). Both disorders are not classified as diseases but as conditions associated with increased risk of diabetes [1, 2]. Some authors accept the combination of the two conditions as a third category – combined glucose intolerance [3, 4]. Prediabetes is associated with increased cardiovascular risk [1, 2]. Meta-analysis performed by McMaster University Evidence Based Practice Center has demonstrated that the relative risk for future fatal cardiovascular events is 1.28 in IFG and 1.66 in IGT compared to subjects with normal glucose tolerance [5]. Some data indicate that the combined glucose intolerance is associated with higher cardiovascular risk compared to subjects with isolated IFG or isolated IGT [6].

Ambulatory blood pressure monitoring is already broadly used in clinical practice but the studies involving subjects with prediabetes are still limited. The aim of this study was to evaluate ambulatory blood pressure characteristics in subjects with prediabetes who have not been treated with antihypertensive drugs (even prescribed for other reasons). The assessment was not only targeting undiagnosed hypertension but also the presence of "white-coat" hypertension (WCH), masked hypertension (MaskH) and abnormal circadian blood pressure patterns (non-dippers, extreme dippers).

MATERIALS AND METHODS

One hundred and twenty subjects (56 males, 64 females), of mean age 44.72 ± 12.49 years, were included in the study. We have recruited only participants at high risk for developing diabetes. Glucose tolerance was evaluated according to 2006 WHO criteria [7]. After evaluation of glucose tolerance the participants were divided in two groups: Group 1 – subjects with prediabetes; and Group 2 (Control group) – subjects with normal glucose tolerance (NormGT) (Table 1). All participants were without previously diagnosed hypertension and had never received any antihypertensive drug. All subjects signed an informed consent.

Table 1. Distribution of the subjects with prediabetes and with normal glucose tolerance (NormGT) evaluated with ambulatory blood pressure monitoring

Group	Number	Age (years)	Males	Females
Group 1 (prediabetes)	46	46.87 ± 11.15	23	23
Croup 2 (control group, NormGT)	74	43.38 ± 13.33	33	41

Standard anthropometric parameters – weight, height and waist circumference, were measured in all subjects. Blood pressure was measured by ambulatory blood pressure monitoring (Oscar 2, SunTech Medical Instruments, USA). Before the ambulatory monitoring, two standard blood pressure measurements with a sphygmomanometer (after 5 min of rest, with 5 minutes interval between the two measurements) were performed in each subject. Evaluation of blood pressure was performed according to ESH Guidelines [8].

Statistical analysis

Student T-test was used to determine whether any significant differences in anthropometric parameters between the two groups were present. For the comparisons of the prevalence of the studied parameters between the groups Fisher's exact test has been applied. The accepted level of statistical significance was $p<0.05$.

RESULTS

No significant differences in the anthropometric parameters were observed between the group with prediabetes and the control group (Table 2).

Table 2. Anthropometric parameters of the two studied groups that were evaluated with ambulatory blood pressure monitoring

	Group 1 (prediabetes)		Control group (NormGT)
BMI (kg/m^2)	31.29 ± 5.54	p>0.05	30.76 ± 7.71
Waist circumference (cm)	104.17 ± 14.38	p>0.05	100.63 ± 15.08

The ambulatory blood pressure monitoring has identified a higher prevalence of undiagnosed hypertension among the subjects with prediabetes (Figure 1).

No significant difference in the anthropometric parameters was observed between hypertensive and normotensive individuals, neither among the subjects with prediabetes (Table 3), nor among the subjects with NormGT (Table 4).

The prevalence of masked hypertension was lower among the subjects with prediabetes compared to NormGT (Figure 2). As for the WCH, the prevalence in Group 1 was slightly lower than in the control group (Figure 3).

The analysis of the circadian pattern of ambulatory blood pressure demonstrated higher prevalence of "non-dippers" in the group with prediabetes, while the prevalence of "extreme dippers" was close to the one in the Control group (Figure 4).

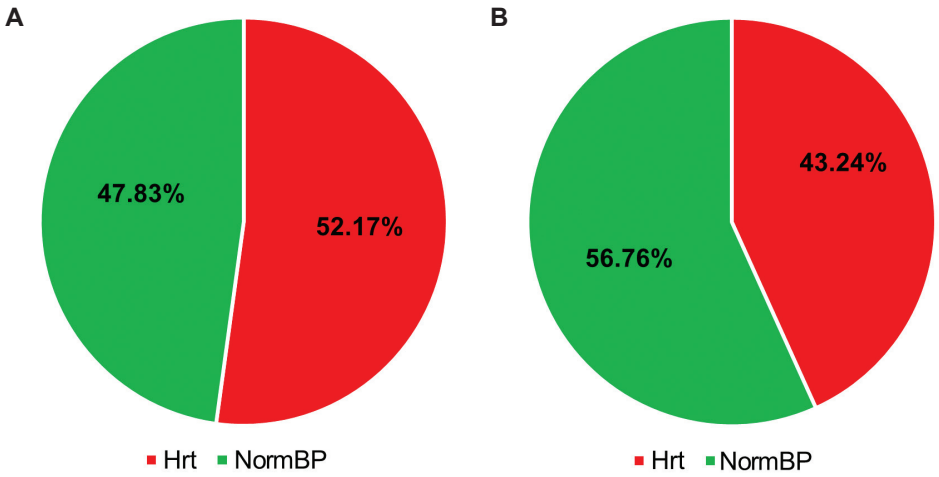

Fig. 1. Prevalence of hypertension (Hrt) and normal values of blood pressure (NormBP) evaluated with ambulatory blood pressure monitoring among the subjects with prediabetes (A) and the subjects with normal glucose tolerance (B); the differences did not reach statistical significance (p>0.05)

Table 3. Anthropometric parameters in hypertensive and normotensive subjects with prediabetes

Group	Number	Age (years)	BMI (kg/m^2)	Waist circumference (cm)
Hypertensive	24	48.08 ± 11.71	32.13 ± 6.03	106.02 ± 16.73
		p>0.05	p>0.05	p>0.05
Normotensive	22	45.55 ± 10.61	30.39 ± 4.92	102.23 ± 11.49

Table 4. Anthropometric parameters in hypertensive and normotensive subjects with NormGT

Group	Number	Age (years)	BMI (kg/m^2)	Waist circumference (cm)
Hypertensive	32	45.14 ± 14.04	30.74 ± 9.23	103.30 ± 16.14
		p>0.05	p>0.05	p>0.05
Normotensive	42	41.15 ± 12.64	30.78 ± 6.41	98.58 ± 14.07

# p<0.05 vs Control group

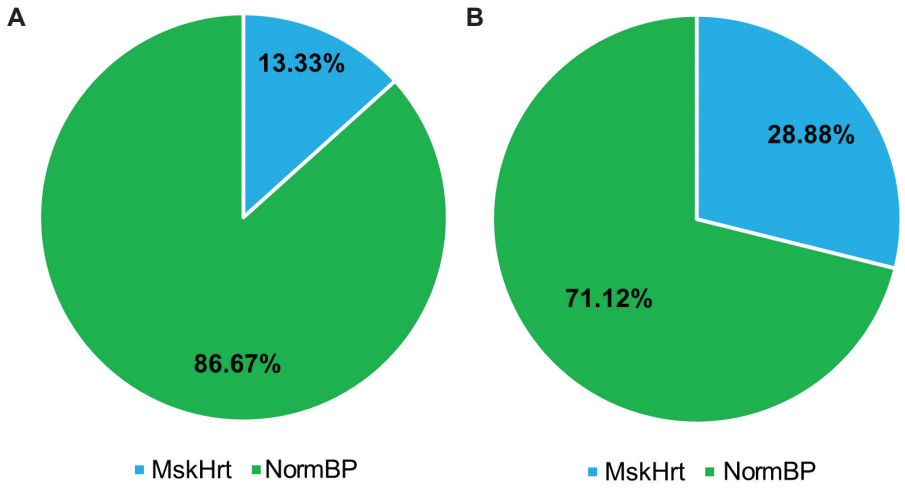

Fig. 2. Percentage of masked hypertension (MskHrt) and normal ambulatory values of blood pressure (NormBP) among the subjects with normal office values of blood pressure – in Group 1 (prediabetes) (A) and in the Control group (normal glucose tolerance) (B)

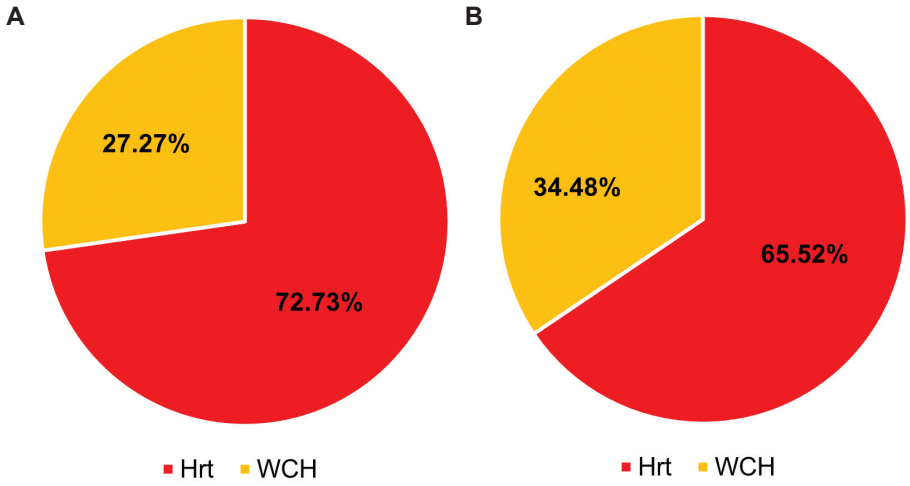

Fig. 3. Percentage of "white-coat" hypertension (WCH) and hypertension (Hrt) among the subjects with elevated office values of blood pressure – in Group 1 (prediabetes) (A) and in the Control group (normal glucose tolerance) (B); the differences did not reach statistical significance (p>0.05)

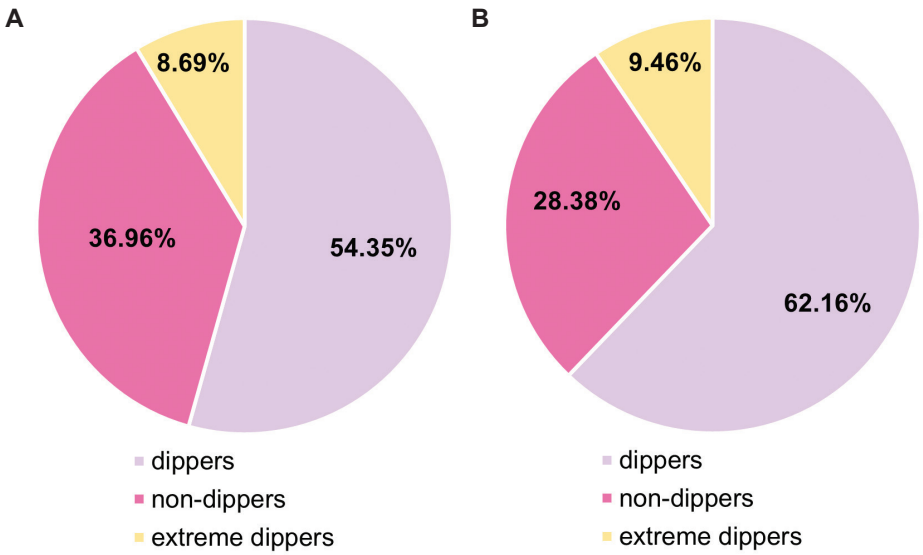

Fig. 4. Percentage of "dippers", "non-dippers" and "extreme dippers" in Group 1 (prediabetes) (A) and in the Control group (normal glucose tolerance) (B); the differences did not reach statistical significance (p>0.05)

DISCUSSION

In our study, the prevalence of hypertension was higher among individuals with prediabetes (52.17%) as compared to the Control group with normal glucose tolerance (43.24%). An important aspect of the explanation of these results is that the Control group in our study consisted of selected healthy individuals from the general population who were at increased risk of diabetes but were still normoglycemic, rather than randomly chosen healthy controls. A previous study in the same clinical center has indicated a prevalence of hypertension of 56.7% among individuals with isolated IFG, 66.1% among individuals with isolated IGT and 69.2% in subjects with combined glucose intolerance. These data reflect the general prevalence of hypertension among the participants without using blood pressure monitoring [6]. Data from other European countries also indicate a higher prevalence of hypertension in prediabetes (42.67%) compared to a control group (25%) [9]. The recently published data from Health Examinees Gem (HEXA-G) Study in South-Korean population have demonstrated approximately 29% prevalence of hypertension among 10358 individuals with prediabetes. However, the study did not include ambulatory blood pressure monitoring when defining the individuals as normotensive [10]. Another recent study in South-Korean population demonstrated 44.03% prevalence of hypertension among 2294 subjects with prediabetes.

The hypertensive individuals reported in this study were subjects with previously known diagnosis [11]. Our data suggest the potential benefit of the regular use of ambulatory blood pressure monitoring in subjects with prediabetes that still have not been diagnosed with hypertension.

The prevalence of masked hypertension in this study was significantly lower in subjects with prediabetes (13.33%) as compared to the Control group (28.88%). Ishikawa et al. have observed a 10,3% prevalence of masked hypertension among subjects with normal office values of blood pressure, the prevalence being higher (34,5%) among the individuals with high normal office values of blood pressure [12]. More recent data in 676 subjects with prediabetes demonstrated a 12.29% prevalence of masked hypertension among individuals with normal office values of blood pressure. Just as in our study, the lower prevalence of masked hypertension in prediabetes compared to NormGT in this study was associated with higher prevalence of clinical hypertension [13].

In our study the prevalence of "white-coat" hypertension among the individuals with prediabetes (27.27%) was slightly lower than in the Control group (34.48%). These results are close to the range 20-30% for the WCH in most general population studies [8]. However, some authors have reported a lower prevalence in the general population – Kotsis et al. have observed 17.9% WCH among individuals with high office values of blood pressure [14], while in the Finn-Home study the observed prevalence was even lower – 15.2% [15]. The only study that has assessed WCH in prediabetes has demonstrated a 31.6% prevalence [13].

The observed prevalence of "non-dipper" circadian pattern in this study was higher in the group with prediabetes. Limited data are available in this aspect among subjects with prediabetes. In a small study including 7-day ambulatory blood pressure monitoring in individuals with prediabetes, the prevalence of "non-dippers" was 16.67%, but this study included a too limited number of patients [16]. A study in a Croatian population has demonstrated a 48.67% prevalence of "non-dipper" status among 150 subjects with prediabetes, the percentage of "non-dippers" being higher among the individuals with untreated hypertension [17].

The HEIJO-KYO study in Japan has demonstrated higher nocturnal values of blood pressure in prediabetes compared to NormGT only when prediabetes was in combination with chronic kidney disease; prediabetes without chronic kidney disease did not demonstrate higher night values of blood pressure as compared to NormGT [18]. According to some authors, subjects with combined glucose intolerance have higher nocturnal values of blood pressure than individuals with isolated IFG, isolated IGT and NormGT [19].

Very limited data are available about "extreme dipper" pattern in subjects with prediabetes. Only one study has provided information about a 33.3% prevalence of "extreme dippers" but in a very limited number of patients [16].

CONCLUSIONS

The high prevalence of undiagnosed hypertension among subjects with prediabetes suggests that ambulatory blood pressure monitoring could be used on a regular basis in the evaluation of subjects with prediabetes considered normotensive. The method could also be important to identify "non-dippers" as the prevalence of this pattern tends to be higher in individuals with prediabetes.

Ethical statement: *This study has been performed in accordance with the ethical standards as laid down in the Declaration of Helsinki.*

Informed Consent from Participants: *Informed consent was obtained from all participants included in the study.*

Conflict of Interest Statement: *The authors declare no conflicts of interest related to this work.*

Funding: *The authors did not receive any financial support from any organization for this research work.*

REFERENCES

1. Unwin N, Shaw J, Zimmet P, et al. Impaired glucose tolerance and impaired fasting glycaemia: the current status on definition and intervention. Diabet Med. 2002; 19(9):708-23.
2. American Diabetes Association. Standards of Medical Care in Diabetes – 2017. Diabetes Care. 2017; 40 (Suppl. 1):S1-S135.
3. Hanefeld M, Koehler C, Fuecker K, et al. Insulin secretion and insulin sensitivity pattern is different in isolated impaired glucose tolerance and impaired fasting glucose: the risk factor in Impaired Glucose Tolerance for Atherosclerosis and Diabetes study. Diabetes Care. 2003; 26(3):868-74.
4. Meyer C, Pimenta W, Woerle HJ, et al. Different mechanisms for impaired fasting glucose and impaired postprandial glucose tolerance in humans. Diabetes Care. 2006; 29(8):1909-14.
5. McMaster University Evidence Based Practice Center. Diagnosis, prognosis and treatment of impaired glucose tolerance and impaired fasting glucose. Evidence Report 128. 2005.
6. Chakarova N. Cardiovascular risk in prediabetic conditions – impaired fasting glucose and impaired glucose tolerance [in Bulgarian] Dissertation, 2011, Sofia.
7. World Health Organization. Definition and diagnosis of diabetes mellitus and intermediate hyperglycemia. Report of a WHO/IDF consultation. Geneva, WHO, 2006.

8. Williams B, Mancia G, Spiering W, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. Eur Heart J 2018; 39: 3021-3104.
9. Festa A, D'Agostino R Jr, Hanley AJ, et al. Differences in insulin resistance in nondiabetic subjects with isolated impaired glucose tolerance or isolated impaired fasting glucose. Diabetes. 2004; 53(6):1549-55.
10. Nabila S, Kim JE, Choi J, et al. Associations Between Modifiable Risk Factors and Changes in Glycemic Status Among Individuals With Prediabetes. Diabetes Care. 2023; 46(3):535-543. doi: 10.2337/dc22-1042.
11. Li Z, Kang S, Kang H. Development and validation of nomograms for predicting cardiovascular disease risk in patients with prediabetes and diabetes. Sci Rep. 2024; 14(1):20909. doi: 10.1038/s41598-024-71904-3.
12. Ishikawa J, Schwartz JE, Pickering TG. Pre-diabetes is Associated with Masked Hypertension. Circulation. 2009; 120:S1060.
13. Geijerstam PA, Engvall J, Östgren CJ, et al. Home Blood Pressure Compared with Office Blood Pressure in Relation to Dysglycemia. Am J Hypertens. 2022; 35(9):810-819.
14. Kotsis V, Stabouli S, Toumanidis S, et al. Target organ damage in „white coat hypertension" and „masked hypertension". Am J Hypertens 2008; 21: 393-399.
15. Hänninen MR, Niiranen TJ, Puukka PJ, et al. Determinants of masked hypertension in the general population: the Finn-Home study. J Hypertens 2011; 10: 1880-1888.
16. Gupta AK, Greenway FL, Cornelissen G, et al. Prediabetes is associated with abnormal circadian blood pressure variability. J Hum Hypertens. 2008; 22(9):627-33.
17. Jug J, Delalić Đ, Bralić Lang V, et al. Prediabetes, Non-Dipping Profile and Hypertension-A Recipe for Increased Arterial Stiffness. Biomedicines. 2023; 11(4):1065. doi: 10.3390/biomedicines11041065.
18. Obayashi K, Saeki K, Kurumatani N. Nighttime BP in Elderly Individuals with Prediabetes/Diabetes with and without CKD: The HEIJO-KYO Study. Clin J Am Soc Nephrol. 2016; 11(5):867-74.
19. Kwon BJ, Kim DW, Park MW, et al. Clinical implications of combined glucose intolerance in treatment-naïve hypertensive patients. Clin Exp Hypertens. 2018; 40(8):762-771.