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Sex Differences in the Impact of BMI on Length of Hospital Stay in Hypertensive Patients Admitted to a Cardiology Department: A Retrospective Cohort Study

Katarzyna Łokieć[1,2], Bartosz Uchmanowicz[3], Adrian Kwaśny[2], Grzegorz Kubielas[3,4], Jacek Smereka[5], Stanisław Surma[6], Anthony Dissen[7], Michał Czapla[5,8,9]

[1]Department of Propaedeutic of Civilization Diseases, Medical University of Lodz, Lodz, Poland; [2]Institute of Dietetics, The Academy of Business and Health Science, Lodz, Polska; [3]Department of Nursing, Faculty of Nursing and Midwifery, Wroclaw Medical University, Wroclaw, Poland; [4]Department of Health Care Services, Polish National Health Fund, Central Office in Warsaw, Warsaw, Poland; [5]Department of Emergency Medical Service, Faculty of Nursing and Midwifery, Wroclaw Medical University, Wroclaw, Poland; [6]Department of Internal Medicine and Clinical Pharmacology, Medical University of Silesia, Katowice, Poland; [7]School of Health Sciences, Stockton University, Galloway, NJ, USA; [8]Institute of Heart Diseases, University Hospital, Wroclaw, Poland; [9]Group of Research in Care (GRUPAC), Faculty of Health Sciences, University of La Rioja, Logroño, Spain

Correspondence: Michał Czapla, Department of Emergency Medical Service, Wroclaw Medical University, ul. Parkowa 34, 51-616, Wroclaw, Poland, Email michal.czapla@umw.edu.pl

Background and purpose: Body mass index (BMI), as a straightforward measure, is widely used in clinical practice, and its results are linked to HT and patient prognosis. This study aimed to ascertain if sex differences exist in the prognostic significance of BMI at the time of admission to the cardiology unit, and how this impacts the LOHS for patients suffering from hypertension.

Patients and methods: A retrospective analysis of the medical records of 486 patients admitted urgently with a diagnosis of HT to the Cardiology Department at University Hospital in Wroclaw (Poland) between January 2017 and June 2021 was conducted.

Results: Women accounted for 53% of the study group and were older than men (64.7±12.8 vs 60.5±11.8, p=0.466). The mean BMI in women was 28.49±5.39 and in men 29.14±4.88. In an unadjusted linear regression model BMI results were not independent predictors of LOHS in either sex. After adjusting the model for comorbidities and blood test results, significant independent predictors of LOHS in women were LDL (B=−0.02, p<0.001), HDL (B=−0.043, p=0.012), TC (B=0.015, p=0.007), and hsCRP (B=0.02, p=0.013), while in men they were LDL (B= −0.026, p<0.001), HDL (B= −0.058, p=0.003), and TC (B=0.022, p=0.002).

Conclusions: The result of BMI assessed at the time of a patient's admission to the cardiology department is not a significant predictor of LOHS in both men and women with hypertension.

Keywords: hypertension, obesity, BMI, sex differences, LOHS

Introduction

Cardiovascular disease (CVD) represents a formidable challenge in public health, with hypertension (HT) standing as a predominant global health concern currently estimated to be affecting one-third of the adult population.[1] The World Health Organization underscores the criticality of this issue, noting that inadequate treatment of HT is pervasive with approximately 80% of HT patients receiving suboptimal care. Enhancing treatment coverage could potentially avert up to 76 million deaths by 2050.[1] The intricacies of hospitalization for HT patients, notably the Length of Hospital Stay (LOHS), are influenced by a confluence of factors including, but not limited to, obesity status and multimorbidity.[2] Furthermore, the complexity of CVD correlates with an prolonged LOHS, necessitating an astute prediction model for LOHS to optimize healthcare outcomes.[3]

Research and findings within the medical literature highlight BMI as a pivotal, modifiable determinant impacting patient prognosis.[4] BMI, as a straightforward measure, is widely used in clinical practice, and its results are linked to HT

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and patient prognosis. Elevated BMI may be associated with worsening blood pressure control and mortality.[5] The simplicity and cost-effectiveness of BMI measurement make it as clinically significant as, if not more than, precise measures of total adiposity.[6] Obesity, particularly marked by excessive visceral fat, is a known exacerbator of HT due to the resultant hormonal and inflammatory alterations impairing vascular endothelium function. Thus, weight management is fundamental in treating obesity-related metabolic sequelae.[7,8] The relationship between BMI and all-cause mortality in patients with hypertension (HT) appears to follow a U-shaped curve.[9] Both underweight (BMI < 18.5 kg/m²) and obesity (BMI ≥ 30 kg/m²) may prolong LOHS and worsen patient prognosis.[10,11]

Additionally, burgeoning research on sex differences in HT has revealed disparities in disease prevalence, public awareness, and sex-specific cardiovascular risk and pathophysiology.[12,13] Notwithstanding advancements in HT management, these sex disparities remain inadequately addressed, leading to potential suboptimal treatment outcomes, particularly for women.[14,15] This gap highlights the exigency for in-depth exploration of sex-dependent determinants in HT's clinical trajectory. Remarkably, the nexus between BMI, sex, and LOHS in HT remains under-researched, signifying a pivotal area for future inquiry. This dearth of data justifies the imperative for comprehensive studies to elucidate these interrelations, potentially informing tailored treatment strategies in HT management. As such, the purpose of this research was to ascertain if sex differences exist in the prognostic significance of BMI at the time of admission to the cardiology unit, and how this impacts the LOHS for patients suffering from hypertension.

Materials and Methods

Study Design and Setting

The study conducted a retrospective analysis of the medical records of 486 patients who were urgently admitted with a diagnosis of arterial hypertension (ICD10: I10) to the Cardiology Department (Institute of Heart Diseases), in University Hospital in Wroclaw (Poland) between January 2017 and June 2021 was conducted.

Study Population and Data

The analysis incorporated the medical records of all patients who met the following inclusion criteria: emergency admission to the Institute of Heart Diseases for HT, and those aged ≥18 years. Finally, data from 486 patients were analyzed, including the following: BMI, length of hospital stay (LOHS), HT grade, comorbidities: heart failure (HF), diabetes mellitus (DM), chronic kidney disease (CKD), a history of cerebral stroke (CS) or myocardial infarction (MI), and laboratory tests: triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), total cholesterol (TC), high-sensitivity C-reactive protein (hsCRP), albumin, transferrin, procalcitonin, thyroid-stimulating hormone (TSH), potassium (K), sodium (Na) and haemoglobin AC1 (HbA1c). The WHO criteria were used to classify patients as obese (BMI ≥ 30 kg/m^2), overweight (BMI 25–29.9 kg/m^2), normal body weight (BMI 18.5–24.9 kg/m^2), and underweight (BMI < 18.5 kg/m^2).[16] The BMI score was calculated and recorded in the patient's medical record by the physician at the time of admission to the hospital.

Ethical Considerations

The study was conducted following the principles of the Declaration of Helsinki and approved by the independent Bioethics Committee of Wroclaw Medical University, protocol no. KB-837/2022. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The Bioethics Committee determined that obtaining informed consent from patients was not required due to the retrospective design of the study, which involved the analysis of anonymized medical records.

Statistical Analysis

For comparing qualitative variables across groups, the chi-squared test was applied, incorporating Yates' correction for 2×2 tables. Where contingency tables exhibited low values, Fisher's exact test was employed as a substitute. The Mann–Whitney test facilitated comparisons of quantitative variables between two groups. To assess the influence of specific variables on continuous outcomes, linear regression analysis was conducted, presenting regression parameters along with

their 95% confidence intervals. The significance threshold for all statistical analyses was established at 0.05. Calculations were performed using R version 4.3.0.

Results

Analysis of Sex Differences

The study included a total of 586 patients hospitalized due to hypertension. Women constituted 54.8% (n = 321) of the study population, while men accounted for 45.2% (n = 265). The mean age of participants was 63.3 years (SD = 12.7), with a median age of 65 years. The mean BMI was 28.8 kg/m² (SD = 5.16), with 19.4% of patients classified as having normal weight (BMI 18.5–24.9), 31.9% as overweight (BMI 25–29.9), and 30.9% as obese (BMI ≥30). Only 1.2% of the study population was underweight (BMI < 18.5).

Hypertension grades were distributed as follows: grade 1 (20.7%), grade 2 (50.9%), and grade 3 (18.9%). The average length of hospital stay (LOHS) was 3.53 days (SD = 2.78), with obese individuals experiencing a mean hospital stay of 3.4 ± 2.43 days, and underweight individuals staying the longest at 5.14 ± 2.27 days. Detailed demographic and clinical characteristics are presented in Table 1.

For sex differences, women were significantly older than men and had significantly higher HDL, TC, TSH, and Na levels, while men had significantly higher K levels (Table 1).

Table 1 Group Characteristics: Sex Differences

Parameter		Female (N=257)	Male (N=229)	Total (N=486)	p
Lengh of hospital stay [days]	Mean (SD) Median (quartiles) Range	3.4 (2.81) 3 (1–5) 1–21	3.15 (2.47) 3 (1–4) 1–19	3.28 (2.66) 3 (1–4) 1–21	p=0.466
Age [years]	Mean (SD) Median (quartiles) Range	64.7 (12.84) 67 (57–73) 22–93	60.56 (11.76) 62 (54–68) 22–89	62.75 (12.5) 64 (56–71) 22–93	p<0.001*
HT grade	Grade 1 Grade 2 Grade 3 Unknown	47 (18.29%) 139 (54.09%) 47 (18.29%) 24 (9.34%)	51 (22.27%) 114 (49.78%) 38 (16.59%) 26 (11.35%)	98 (20.16%) 253 (52.06%) 85 (17.49%) 50 (10.29%)	p=0.465
BMI [kg/m^2]	18.5–24.9 <18.5 25.0–29.9 ≥30	68 (26.46%) 4 (1.56%) 91 (35.41%) 94 (36.58%)	44 (19.21%) 3 (1.31%) 95 (41.48%) 87 (37.99%)	112 (23.05%) 7 (1.44%) 186 (38.27%) 181 (37.24%)	p=0.251
HF	No Yes	220 (85.60%) 37 (14.40%)	199 (86.90%) 30 (13.10%)	419 (86.21%) 67 (13.79%)	p=0.778
DM	No Yes	190 (73.93%) 67 (26.07%)	158 (69.00%) 71 (31.00%)	348 (71.60%) 138 (28.40%)	p=0.27
CKD	No Yes	225 (87.55%) 32 (12.45%)	194 (84.72%) 35 (15.28%)	419 (86.21%) 67 (13.79%)	p=0.44
CS	No Yes	222 (86.38%) 35 (13.62%)	199 (86.90%) 30 (13.10%)	421 (86.63%) 65 (13.37%)	p=0.973
MI	No Yes	240 (93.39%) 17 (6.61%)	215 (93.89%) 14 (6.11%)	455 (93.62%) 31 (6.38%)	p=0.968

(*Continued*)

Table 1 (Continued).

Parameter		Female (N=257)	Male (N=229)	Total (N=486)	p
TG [mg/dl]	Mean (SD) Median (quartiles) Range Missing	125.74 (58.44) 115 (88–149) 37–390 10	136.48 (74.5) 118 (83–164) 43–447 11	130.77 (66.59) 115 (87–153) 37–447 21	p=0.503
LDL [mg/dl]	Mean (SD) Median (quartiles) Range Missing	136.72 (58.71) 135 (91–171) 23–370 10	126.97 (52.35) 124 (88.5–158.5) 35–415 14	132.18 (55.99) 131 (89–167) 23–415 24	p=0.085
HDL [mg/dl]	Mean (SD) Median (quartiles) Range Missing	57.07 (14.27) 56 (48–64.5) 15–107 10	49.29 (12.99) 48 (40–57) 9–87 12	53.43 (14.21) 52 (44–61) 9–107 22	p<0.001*
TC [mg/dl]	Mean (SD) Median (quartiles) Range Missing	196.77 (53.64) 189 (159–234) 54–341 11	185.19 (48.47) 181 (150.25–214) 77–415 11	191.33 (51.55) 185.5 (153–226) 54–415 22	p=0.017*
CRP [mg/l]	Mean (SD) Median (quartiles) Range Missing	7.5 (26.45) 2.07 (1.1–4) 0.16–321.25 38	7.59 (23.68) 1.9 (1.01–4.24) 0.2–254.98 37	7.54 (25.17) 2.05 (1.06–4.16) 0.16–321.25 75	p=0.631
Albumin [g/dl]	Mean (SD) Median (quartiles) Range Missing	3.45 (0.62) 3.5 (3.3–3.7) 1.8–4.5 242	3.64 (0.8) 3.8 (2.9–4.4) 2.6–4.5 220	3.52 (0.68) 3.55 (3.13–3.95) 1.8–4.5 462	p=0.59
Transferrin [g/l]	Mean (SD) Median (quartiles) Range Missing	2.51 (0.53) 2.37 (2.08–3.01) 1.77–3.43 244	2.35 (0.72) 2.25 (1.93–2.54) 0.93–3.84 211	2.42 (0.64) 2.27 (2.04–2.8) 0.93–3.84 455	p=0.423
Procalcitonin [ng/mL]	Mean (SD) Median (quartiles) Range Missing	2.43 (10.4) 0.03 (0.02–0.16) 0.01–50.01 234	1.56 (4.17) 0.08 (0.03–0.61) 0.01–18.15 209	2.02 (8.04) 0.05 (0.02–0.3) 0.01–50.01 443	p=0.225
TSH3 [uIU/mL]	Mean (SD) Median (quartiles) Range Missing	1.69 (1.39) 1.46 (0.96–2.06) 0.01–15.11 7	1.52 (1.12) 1.23 (0.75–1.93) 0.01–7.14 11	1.61 (1.27) 1.34 (0.86–2.04) 0.01–15.11 18	p=0.023*
K [mmol/l]	Mean (SD) Median (quartiles) Range Missing	4.2 (0.5) 4.19 (3.93–4.42) 3.06–7.02 2	4.35 (0.52) 4.28 (4.02–4.6) 3.29–7.37 3	4.27 (0.51) 4.23 (3.97–4.49) 3.06–7.37 5	p=0.002*
Na [mmol/]	Mean (SD) Median (quartiles) Range Missing	140.09 (2.97) 141 (139–142) 127–148 2	139.72 (2.68) 140 (139–141) 128–152 3	139.92 (2.84) 140 (139–142) 127–152 5	p=0.009*

(*Continued*)

Table 1 (Continued).

Parameter		Female (N=257)	Male (N=229)	Total (N=486)	p
HbA1c [%]	Mean (SD)	6.13 (1.04)	6.05 (0.97)	6.09 (1)	p=0.145
	Median (quartiles)	5.9 (5.6–6.2)	5.8 (5.5–6.2)	5.8 (5.5–6.2)	
	Range	4.3–10.7	4.6–10	4.3–10.7	
	Missing	84	55	139	

Notes: Quantitative variables: Mann–Whitney test'; p - qualitative variables: chi-squared or Fisher's exact test. *Statistically significant (p<0.05).
Abbreviations: BMI, body mass index; CKD, chronic kidney disease; CS, cerebral stroke; DM, diabetes mellitus; HF, heart failure; HDL, high-density lipoprotein; HbA1c, haemoglobin AC1; hsCRP, high-sensitivity C-reactive protein; HT, Hypertension; K, potassium; LDL, low-density lipoprotein; LOHS, length of hospital stay; MI, myocardial infarction; NA, sodium;; TC, total cholesterol; TG, triglycerides; TSH, thyroid-stimulating hormone.

Analysis Concerning the Prevalence of Obesity

In women with obesity, there were significantly lower concentrations of CRP ($p < 0.001$) and lower TSH levels ($p = 0.016$) compared to women without obesity. HDL levels were also significantly lower in women with obesity ($p = 0.005$). In terms of comorbidities, women with obesity exhibited a lower prevalence of diabetes mellitus (DM) but a higher prevalence of Cushing's syndrome (CS) compared to their non-obese counterparts. For men, obesity was associated with significantly higher TG levels ($p = 0.002$) and lower HDL levels ($p < 0.001$). Men with obesity had a higher prevalence of DM ($p = 0.005$) and a lower prevalence of CS ($p = 0.048$) compared to men without obesity (Table 2).

Effect of BMI on Length of Hospitalization

An unadjusted linear regression analysis indicated that none of the examined variables significantly independently predicted the duration of hospital stays for both men and women, as shown in Table 3.

The subsequent model was adjusted for comorbidities, past medical conditions, and laboratory tests results. Laboratory test results were included in the multivariate model if the missing data did not exceed 20%. For women, a significant independent predictors of LOHS was LDL (B=−0.02, <0.001), HDL (B=−0.043, p=0.012), TC (B=0.015, p=0.007) and hsCRP (B=0.02, p=0.013), as shown in Table 4.

For men, a multivariate linear regression model revealed that LDL (B= −0.026, p<0.001), HDL (B= −0.058, p=0.003), and TC (B=0.022, p=0.002) were significant independent predictors of the length of LOHS, as detailed in Table 5.

Discussion

The main objective of this study was to evaluate the prevalence of sex differences in the prognostic influence of BMI, recorded at admission to the cardiology department, on the LOHS in patients with HT. Contrary to our previous research, which did not segregate patients by sex, and suggested that both underweight and obesity (as defined and classified by BMI) influenced LOHS in a univariate analysis, this study, with a sex-specific focus, did not reveal any significant association between BMI score and LOHS in either women or men diagnosed with HT.[4]

There is a notable absence of literature assessing sex differences in the prognostic impact of BMI, recorded at admission to the cardiology unit, on the length of hospital stay (LOHS) in patients with hypertension. This is surprising, considering that underweight BMI has been significantly associated with an elevated risk of mortality from various causes, including hypertension.[17] In contrast, studies on other cardiovascular diseases have explored sex differences in the impact of BMI on LOHS.[2,18–20] Additionally, scientists are increasingly focusing on women, who are often under-represented in CVD research, to better understand their unique risk profiles and improve their clinical outcomes.[21,22]

We have shown that BMI was not associated with the length of hospital stay in either women or men with arterial hypertension. From a clinical point of view, this is very important, because arterial hypertension is the most common cardiovascular risk factor, occurring in over 29% of the adult population.[23,24] Moreover, a large percentage of people with arterial hypertension are characterized by abnormal body weight (excess body weight is one of the most important risk factors for arterial hypertension).[25] This means that a large proportion of patients urgent hospitalized in cardiology

Table 2 Group Characteristics: Obesity Status (BMI ≥ 30 Kg/m^2)

Parameter	Group	Female			Male		
		Non-Obese (N=163)	Obese (N=94)	p	Non-Obese (N=142)	Obese (N=87)	p
LOHS [days]	Mean (SD) Median (quartiles) Range	3.31 (2.84) 3 (1–5) 1–21	3.56 (2.76) 3 (1–5) 1–15	0.308	3.1 (2.72) 3 (1–4) 1–19	3.23 (2) 3 (1–4.5) 1–9	0.161
Age [years]	Mean (SD) Median (quartiles) Range	64.57 (14.04) 67 (58–73) 24–93	64.94 (10.53) 65 (57–72) 22–85	0.484	61.51 (12.5) 62 (55–70) 22–89	59.01 (10.31) 61 (52–66) 30–82	0.167
HT grade	Grade 1 Grade 2 Grade 3 Unknown	32 (19.63%) 85 (52.15%) 27 (16.56%) 19 (11.66%)	15 (15.96%) 54 (57.45%) 20 (21.28%) 5 (5.32%)	0.552	34 (23.94%) 69 (48.59%) 21 (14.79%) 18 (12.68%)	17 (19.54%) 45 (51.72%) 17 (19.54%) 8 (9.20%)	0.542
HF	No Yes	143 (87.73%) 20 (12.27%)	77 (81.91%) 17 (18.09%)	0.274	123 (86.62%) 19 (13.38%)	76 (87.36%) 11 (12.64%)	1
DM	No Yes	122 (74.85%) 41 (25.15%)	68 (72.34%) 26 (27.66%)	0.769	108 (76.06%) 34 (23.94%)	50 (57.47%) 37 (42.53%)	0.005*
CKD	No Yes	138 (84.66%) 25 (15.34%)	87 (92.55%) 7 (7.45%)	0.099	116 (81.69%) 26 (18.31%)	78 (89.66%) 9 (10.34%)	0.151
CS	No Yes	142 (87.12%) 21 (12.88%)	80 (85.11%) 14 (14.89%)	0.792	118 (83.10%) 24 (16.90%)	81 (93.10%) 6 (6.90%)	0.048*
MI	No Yes	151 (92.64%) 12 (7.36%)	89 (94.68%) 5 (5.32%)	0.708	133 (93.66%) 9 (6.34%)	82 (94.25%) 5 (5.75%)	1
TG [mg/dl]	Mean (SD) Median (quartiles) Range Missing	119.96 (57.36) 110 (81–144.75) 37–390 5	136 (59.23) 122 (101–155) 47–384 5	0.01*	122.8 (61.94) 106 (77–143) 43–447 5	159.63 (87.57) 133 (94–207) 50–433 6	0.002*
LDL [mg/dl]	Mean (SD) Median (quartiles) Range Missing	136.76 (64.3) 134 (86–175) 23–370 5	136.64 (47.53) 137 (100–166) 56–268 5	0.585	128.47 (46.46) 133 (90–162) 42–272 7	124.42 (61.25) 113 (84.25–144.75) 35–415 7	0.175
HDL [mg/dl]	Mean (SD) Median (quartiles) Range Missing	59.03 (15.68) 58 (48–68.75) 15–107 5	53.6 (10.56) 53 (48–59) 31–87 5	0.005*	51.38 (12.93) 50 (42–59) 9–87 6	45.78 (12.41) 45 (36–52) 23–84 6	<0.001*

TC [mg/dl]	Mean (SD) Median (quartiles) Range Missing	197.61 (56.46) 194 (157–233.75) 54–341 5	195.26 (48.45) 184.5 (164.75–234.25) 77–316 6	0.894	188.26 (48.75) 178 (155–218) 77–370 5	180 (47.84) 183 (145–207) 84–415 6	0.245
CRP [mg/l]	Mean (SD) Median (quartiles) Range Missing	8.42 (32.47) 1.92 (0.86–3.37) 0.16–321.25 25	5.92 (9.86) 3.16 (1.59–5.61) 0.37–65.84 13	<0.001*	8.12 (29.11) 1.69 (0.9–3.71) 0.2–254.98 29	6.83 (12.49) 2.36 (1.2–6.4) 0.35–80.97 8	0.067
Albumen [g/dl]	Mean (SD) Median (quartiles) Range Missing	3.46 (0.71) 3.5 (3.3–3.8) 1.8–4.5 152	3.42 (0.36) 3.55 (3.35–3.62) 2.9–3.7 90	0.844	3.33 (0.78) 3.05 (2.75–3.95) 2.6–4.4 136	4.27 (0.4) 4.5 (4.15–4.5) 3.8–4.5 84	0.092
Transferrin [g/l]	Mean (SD) Median (quartiles) Range Missing	2.55 (0.49) 2.37 (2.18–3.01) 2.02–3.43 154	2.42 (0.69) 2.37 (1.88–2.92) 1.77–3.17 90	0.604	2.24 (0.7) 2.18 (1.99–2.54) 0.93–3.84 130	2.58 (0.79) 2.31 (1.97–3.26) 1.86–3.57 81	0.574
Procalcitonin [ng/mL]	Mean (SD) Median (quartiles) Range Missing	3.6 (12.86) 0.03 (0.02–0.16) 0.01–50.01 148	0.22 (0.42) 0.04 (0.03–0.13) 0.02–1.21 86	0.625	2.69 (5.92) 0.34 (0.07–1.14) 0.02–18.15 133	0.64 (1.71) 0.06 (0.02–0.12) 0.01–5.75 76	0.109
TSH [ulU/mL]	Mean (SD) Median (quartiles) Range Missing	1.76 (1.14) 1.57 (1–2.2) 0.01–7.66 5	1.58 (1.74) 1.33 (0.89–1.89) 0.11–15.11 2	0.016*	1.54 (1.11) 1.22 (0.73–2.02) 0.07–6.07 8	1.48 (1.15) 1.23 (0.86–1.68) 0.01–7.14 3	0.972
K [mmol/l]	Mean (SD) Median (quartiles) Range Missing	4.18 (0.5) 4.18 (3.9–4.47) 3.06–7.02 1	4.23 (0.49) 4.2 (3.97–4.41) 3.34–6.84 1	0.587	4.41 (0.57) 4.3 (4.04–4.68) 3.52–7.37 2	4.25 (0.41) 4.26 (3.99–4.46) 3.29–5.78 1	0.083
Na [mmol/]	Mean (SD) Median (quartiles) Range Missing	139.9 (3.26) 140 (138.25–142) 127–148 1	140.42 (2.38) 141 (139–142) 133–145 1	0.362	139.75 (2.88) 140 (138–141) 128–152 2	139.68 (2.34) 140 (139–141) 131–146 1	0.965
HbA1c [%]	Mean (SD) Median (quartiles) Range Missing	6.1 (1.01) 5.9 (5.5–6.2) 4.9–10.2 58	6.18 (1.09) 5.9 (5.68–6.3) 4.3–10.7 26	0.287	5.92 (0.84) 5.7 (5.5–6.1) 4.6–9.6 37	6.24 (1.12) 5.9 (5.5–6.5) 4.7–10 18	0.092

Notes: *Statistically significant (p<0.05) p - Qualitative variables: chi-squared or Fisher's exact test. Quantitative variables: Mann–Whitney test.

Abbreviations: BMI, body mass index; CKD, chronic kidney disease; CS, cerebral stroke; DM, diabetes mellitus; HF, heart failure; HDL, high-density lipoprotein; HbA1c, haemoglobin AC1; hsCRP, high-sensitivity C-reactive protein; HT, Hypertension; K, potassium; LDL, low-density lipoprotein; LOHS, length of hospital stay; MI, myocardial infarction; NA, sodium; TC, total cholesterol; TG, triglycerides; TSH, thyroid-stimulating hormone.

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Table 3 Impact of BMI on Length of Hospitalization Unadjusted Model

Model 1- Unadjusted								
Trait			**N**	**LOHS (Mean±SD)**	**B**	**95% CI**		**p**
Female	BMI [kg/m^2]	18.5–24.9	68	2.90±2.39	Ref.			
		<18.5	4	5.00±2.71	2.103	−0.725	4.931	0.146
		25.0–29.9	91	3.55±3.12	0.652	−0.229	1.534	0.148
		≥30	94	3.56±2.76	0.667	−0.208	1.542	0.137
Male	BMI [kg/m^2]	18.5–24.9	44	3.00±3.13	Ref.			
		<18.5	3	5.33±2.08	2.333	−0.559	5.226	0.115
		25.0–29.9	95	3.07±2.53	0.074	−0.81	0.958	0.87
		≥30	87	3.23±2.00	0.23	−0.667	1.127	0.616

Note: p - statistically significant (p<0.05).
Abbreviation: BMI, body mass index.

Table 4 Multivariate Linear Regression Model – Female

Trait		**Parameter**	**95% CI**		**p**
BMI [kg/m^2]	18.5–24.9	ref.			
	<18.5	1.646	−2.236	5.528	0.407
	25.0–29.9	0.586	−0.393	1.564	0.242
	≥30	0.225	−0.74	1.189	0.649
Age	[years]	0.021	−0.009	0.051	0.169
HT grade	Grade 1	ref.			
	Grade 2	−0.201	−1.22	0.818	0.699
	Grade 3	0.826	−0.431	2.084	0.2
HF	No	ref.			
	Yes	1.121	−0.148	2.39	0.085
DM	No	ref.			
	Yes	0.704	−0.193	1.602	0.126
CKD	No	Ref.			
	Yes	1.287	−0.092	2.665	0.069
Stroke	No	Ref.			
	Yes	0.247	−0.807	1.302	0.647
MI	No	Ref.			
	Yes	0.94	−0.719	2.6	0.268
TG	[mg/dl]	−0.003	−0.01	0.004	0.434

(*Continued*)

Table 4 (Continued).

Trait		Parameter	95% CI		p
LDL	[mg/dl]	−0.02	−0.029	−0.012	<0.001*
HDL	[mg/dl]	−0.043	−0.076	−0.01	0.012*
TC	[mg/dl]	0.016	0.004	0.027	0.007*
CRP	[mg/l]	0.02	0.004	0.036	0.013*
TSH3	[ulU/mL]	−0.131	−0.399	0.138	0.341
K	[mmol/l]	0.191	−0.637	1.019	0.652
Na	[mmol/]	−0.111	−0.246	0.024	0.109

Note: p - multiple linear regression *Statistically significant (p<0.05).
Abbreviations: BMI, body mass index; CKD, chronic kidney disease; CS, cerebral stroke; DM, diabetes mellitus; HF, heart failure; HDL, high-density lipoprotein; hsCRP, high-sensitivity C-reactive protein; HT, Hypertension; LDL, low-density lipoprotein; MI, myocardial infarction; NA, sodium; TC, total cholesterol; TG, triglycerides; TSH, thyroid-stimulating hormone.

Table 5 Multivariate Linear Regression Model – Male

Trait		Parameter	95% CI		p
BMI [kg/m^2]	18.5–24.9	Ref.			
	<18.5	0.96	−3.633	5.552	0.683
	25.0–29.9	−0.465	−1.592	0.662	0.42
	≥30	−0.507	−1.674	0.661	0.396
Age	[years]	−0.012	−0.052	0.027	0.539
HT grade	Grade 1	Ref.			
	Grade 2	−0.893	−1.883	0.096	0.079
	Grade 3	−0.447	−1.713	0.82	0.49
HF	No	Ref.			
	Yes	−0.093	−1.348	1.161	0.885
DM	No	Ref.			
	Yes	0.201	−0.671	1.072	0.653
CKD	No	Ref.			
	Yes	−0.094	−1.435	1.248	0.891
Stroke	No	Ref.			
	Yes	−0.264	−1.573	1.046	0.694
MI	No	Ref.			
	Yes	1.127	−0.637	2.89	0.213
TG	[mg/dl]	−0.004	−0.011	0.003	0.277
LDL	[mg/dl]	−0.026	−0.036	−0.016	<0.001*

(*Continued*)

Table 5 (Continued).

Trait		Parameter	95% CI		p
HDL	[mg/dl]	−0.058	−0.096	−0.02	0.003*
TC	[mg/dl]	0.022	0.009	0.035	0.002*
CRP	[mg/l]	0.008	−0.018	0.034	0.553
TSH3	[uIU/mL]	0.173	−0.182	0.527	0.341
K	[mmol/l]	0.081	−0.889	1.051	0.87
Na	[mmol/]	0.086	−0.071	0.243	0.284

Note: p - multiple linear regression *Statistically significant ($p<0.05$).
Abbreviations: BMI, body mass index; CKD, chronic kidney disease; CS, cerebral stroke; DM, diabetes mellitus; HF, heart failure; HDL, high-density lipoprotein; hsCRP, high-sensitivity C-reactive protein; HT, Hypertension; LDL, low-density lipoprotein; MI, myocardial infarction; NA, sodium; TC, total cholesterol; TG, triglycerides; TSH, thyroid-stimulating hormone.

departments will most likely suffer from arterial hypertension and overweight/obesity. In such patients, it is worth knowing the factors indicating a greater likelihood of longer hospitalization. Some studies have shown that higher body weight was associated with better prognosis and shorter hospitalization time (eg in patients hospitalized due to exacerbation of HF).[26] This is the so-called "obesity paradox", or rather, as more detailed analyses have shown - The "BMI paradox". In our previous study, we showed that extending the analysis of the effect of BMI on the prognosis of patients with heart failure with reduced ejection fraction (HFrEF) to include a history of stroke eliminated the "BMI paradox".[27] BMI, although commonly used to diagnose obesity, is a parameter that poorly reflects the actual content of adipose tissue. In a meta-analysis of 32 studies conducted by Sommer et al, it was found that the use of BMI to diagnose obesity (defined by the percentage of fat mass) was characterized by low sensitivity (detection of the disease in a priori sick population) 51.4% (95% CI: 38.5–64.2) and good specificity (exclusion of the disease in a priori healthy individuals) 95.4% (95% CI: 90.7–97.8) in women and 49.6% (95% CI: 34.8–64.5) and 97.3% (95% CI: 92.1–99.1) in men.[28] Therefore, the exclusive use of BMI in the diagnosis of obesity may result in its under-identification. BMI does not always have explanatory power for assessing body weight, as it does not consider the percentage distribution of fat (not reflect the distribution of visceral adipose tissue) and non-fat body mass in the total body weight. Moreover, BMI does not assess the mass or strength of skeletal muscles. These parameters are extremely important in the context of assessing the prognosis of patients.[27] Moreover, the "obesity paradox" is observed in more physically active individuals with better glycemic control.[29–31] Analysis of the relationship between BMI and prognosis, extended to include treatment, region, age, gender, systolic blood pressure, heart rate, renal function, left ventricular ejection fraction, BMI, NYHA functional class, HF etiology, HF duration, previous hospitalization due to HF, history of diabetes, atrial fibrillation and NT-proBNP eliminates the "obesity paradox". The use of the waist-to-hip ratio (WHR) correlates better with the prognosis of patients.[32] We have shown that the predictors of longer hospitalization were parameters related to lipid profile and inflammation markers (in each sex were LDL, HDL, TC, and in women specifically, hsCRP levels). It is worth emphasizing that BMI does not fully correlate with the LDL level.[33] Obesity does not always coexist with metabolic disorders, which is why we distinguish between metabolically healthy obesity (MHO) and metabolically unhealthy obesity (MUO). Moreover, we can also distinguish between metabolically unhealthy normal body weight (MUNW). Both MUO and MUNW are characterized by a higher cardiovascular risk and a worse prognosis.[34] It is worth remembering that obese patients with arterial hypertension are characterized by a higher risk of poor blood pressure control, which may also contribute to a worse prognosis.[35] Based solely on BMI measurement, it is impossible to distinguish whether the patient has MHO or MUO, and even less so MUNW. From the clinical point of view and cardiovascular risk, it is not the average BMI (usually measured on admission to the hospital) that is important, but the long-term BMI variability. It has been shown that higher BMI variability was a significant risk marker associated with

adverse cardiovascular events independent of mean BMI across major racial and ethnic groups.[36] Very interesting results were provided by the study by Yoshida et al, which found that the influence of BMI on prognosis depended on the specific cardiovascular disease (among which acute HF, acute myocardial infarction, acute aortic dissection, ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage were at higher risk in patients with AHF or IS. Age was a significant factor influencing prognosis independently of BMI.[37] A factor that may have a significant impact on prognosis in patients with arterial hypertension, regardless of BMI and gender, is its duration. It was shown that longer arterial hypertension duration was associated with increased cardiovascular risk and overall death in a linear fashion, and these associations were independent of blood pressure control levels.[38] Blood pressure variability during hospitalization also significantly affects the prognosis of patients and may contribute to prolonging the duration of hospital stay.[39] Elevated hsCRP levels indicate the presence of low-grade inflammation, which contributes to the occurrence of many diseases, not only cardiovascular diseases and may also affect the general condition of hospitalized patients with arterial hypertension.[40] While some laboratory results in our study such as LDL, HDL, TC, and hsCRP were significant predictors of LOHS in the multivariate analysis, all these values were within normal ranges, indicating that their clinical relevance may be limited despite statistical significance. Therefore, the results of our study indicate that the prediction of the length of hospitalization in patients with hypertension should be approached holistically and many factors should be taken into account and interpreted as a whole (and not individual parameters, and especially not only BMI).

Study Limitation

Due to the study's retrospective design, patients' body composition was not examined using methods such as electrical bioimpedance, and no anthropometric measurements were taken. The study was based solely on BMI results and did not assess the patients' actual body composition. It should be noted that sex differences in anthropometric measurements could potentially affect prognosis, representing a limitation of the study. Laboratory tests were not standardized (each time the doctor decided to perform tests), resulting in differences between patients. The lack of standardized testing could have introduced variability and bias into the results. Additionally, the manuscript does not account for the medications used by the patients, which could significantly impact the length of hospitalization and study outcomes, particularly with regard to lipid parameters and CRP levels. The omission of this critical information may introduce bias and limit the interpretation of the findings, as the effects of various drugs on these parameters are well-documented. Furthermore, the assessment of the long-term survival of HT patients was limited due to legal restrictions on access to patient data under Polish law. Another limitation of this study is its single-center design, as the data were derived from patients admitted to one cardiology department. This may restrict the generalizability of our findings to other healthcare settings or populations with different characteristics. However, the hospital serves a diverse patient population from urban and rural areas, which partially supports the representativeness of the sample. Nonetheless, future multicenter studies are needed to validate and expand upon our results.

Conclusions

Underweight (BMI < 18.5 kg/m²), overweight (BMI 18.5–24.9 kg/m²), and obesity (BMI ≥ 30 kg/m²), as assessed by body mass index at the time of admission to the cardiology department, were not significant independent predictors of length of hospitalization in either men or women with hypertension. Further prospective studies are necessary to investigate factors related to sex differences and nutritional status, including the utilization of alternative nutritional status indicators beyond BMI, and their impact on the length of hospitalization in this group of patients.

Disclosure

The authors report no conflicts of interest in this work.

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