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Effect of different body mass index on hand grip strength, endurance and body function in hypertensive patients

Esraa Ali A El-Sayed[1], Omaima Kattabei[2], Ahmed Saber El-ghorieb[3], Raina R Mohamed[4]
[1] Department of Basic Science, Demonstrator of Physical Therapy, Faculty of Physical Therapy, Benha University, Qalyubia, Egypt
[2] Professor of Physical Therapy, Department of Basic Science, Faculty of Physical Therapy, Cairo University, Cairo, Egypt
[3] Lecturer of Medicine, Department of Internal Medicine, Faculty of Medicine, Menoufia University, Menoufia, Egypt
[4] Assistant Professor of Physical Therapy, Department of Basic Science, Faculty of Physical Therapy, Cairo University, Cairo, Egypt

Abstract
Background: Hypertension (HTN) is a common health problem of the cardiovascular system that known as "silent killer", It is one of the major avoidable risk factors for noncommunicable diseases that contributes to early death and disability.
Purpose: to examine the impact of different BMI on HGS, HGE, and body function in hypertensive patients.
Materials and Methods: One Hundred Twenty subjects of both sex participated in this study, their age was ranging between 40-69 years, they were randomly allocated into 2 groups equal Normal group (Group A) involved 60 healthy subjects without HTN and hypertension group (Group B) involved 60 patients with HTN. Each group divided into 3 equal sub-groups (normal weight BMI from ≥18.5 to <25 kg/m², overweight BMI from ≥25 to <30 kg/m², as well as Obese BMI ≥ 30 kg/m²), each BMI sub-group included 20 subjects. BMI was measured by Digital Platform Weighing Scale, Hypertension was assessed by Mercury Sphygmomanometer, Hand Grip strength along with Hand Grip Endurance were measured by Digital Hand Dynamometer of the dominant hand and body function by using the SF-36 questionnaire.
Results: Post-hoc test revealed that handgrip strength was more in overweight BMI subgroup in both normal and hypertension groups with a mean of 31.0 ±6.71 and 29.4 ±6.75 kg respectively, also endurance time was more in overweight BMI subgroup in both normal and hypertension groups with a mean of 134.8 ±21.5 and 127.1 ±37.5 s. No significant correlation between BMI with HGS, HGE, and endurance time (P>0.05) in both normal and hypertension groups, but there were significant differences (P<0.05) in mean values of HGS among normal group and hypertension group in obese BMI subgroup, moreover there were significant differences (P<0.05) in mean values of total score SF-36 questionnaire between normal group and hypertension group for normal BMI (P=0.002) and obese BMI (P=0.044) subgroups. But, there wasn't statistical significant difference (P>0.05) in mean values of total score SF-36 questionnaire between both groups for overweight BMI subgroup (P=0.129).
Conclusion: There was significantly negative moderate relation between BMI and body function. However, there were no significantly relations among BMI with HGS and HGE.

Keywords: Hypertension, body mass index, hand grip strength, hand grip endurance, endurance time, obesity, body function

Introduction

Hypertension (HTN) is an urgent health problem in Egypt, that affects nearly one billion people worldwide. The term "high blood pressure" (BP) is another name for it because it affects the arteries. As a result, the heart has to work more than usual to pump blood through the blood vessels. Nearly 1.28 billion individuals (ranging in age from 30 to 79 years old) suffer with hypertension, with the majority residing in low- and middle-income nations according to the world health organization (WHO) [1]. Population growth rate, aging, and behavioral risk factors such poor diet, smoking, alcohol abuse, obesity, prolonged stress, elevated cholesterol, and inactivity are risk factors for the spread of hypertension [2].

According to the WHO, obesity has been described as an abnormal or excessive buildup of fat. Obesity in adults is a well-established risk factor for hypertension, gaining weight raises the incidence of primary hypertension by 65–75%, which is a risk factor for cardiovascular disorders [3,4]. Approximately 4.7 million premature deaths are caused by obesity each year, Egypt has the 18th-highest prevalence of obesity in the world, according to the WHO [5].

The capacity of a set of muscles to withstand a certain force is known as their muscle strength. It is closely related to the neuromuscular system, and the more effectively the nervous system can activate muscle fibers, the stronger the muscle [6]. Reduced skeletal muscle health is linked to modifiable factors such as vitamin D levels, anthropometry, BMI, physical activity, diet, and bone mineral density. Decreased muscular mass, strength, and physical function are other risks associated with malnutrition [7].

Handgrip weakness can impair a person's capacity to carry out daily tasks, which can affect their quality of life [8]. Muscle strength and functional activities are closely related, and assessing muscular strength can help determine who is most at risk for decreased mobility in later life. A popular method for estimating muscular strength, particularly upper extremity muscle strength, is handgrip strength [9].

Handgrip strength has been linked to a number of anthropometric measurements, such as height, weight, in addition to body mass index (BMI). It has been discovered

that handgrip strength and BMI are positively correlated, meaning that handgrip strength rises with an increase in BMI and vice versa [10]. It is also influenced by age, gender and body size [11]. In addition, physical activity and nutritional status are also influential factors [12]. However, few researches have focused on investigating the correlation between HTN and HGS especially for the middle-aged and older populations [10,13].

The capacity of a muscle to exert force against a force for a certain amount of time, expressed in seconds, is known as hand grip endurance (HGE) [14,15]. It is related to its capacity to tolerate the power generated during an activity. The capacity to keep one's muscular force constant is another definition of HGE. It is commonly utilized for assessing physical performance [16]. HGS and HGE are the essential parameters for assessing the muscular strength of the upper limbs. A different relationship among BMI, HGS, as well as HGE has only been demonstrated in a small number of prior studies [10,16,17]. This study aimed to examine the impact of various BMI, HGE, HGS along with body function in hypertensive individuals from Egypt.

Materials and Methods

Study design

This research is a cross-sectional study carried out at the Outpatient Clinics of the Faculty of Physical Therapy, Benha University, in the period from August 2024 to December 2024. A research ethics committee at Cairo University's Faculty of Physical Therapy in Egypt (NO: P.T.REC/012/005290) approved the study before the study could begin. The research adhered to the regulations laid by the Helsinki Declaration concerning human participants.

Participants

One-hundred and twenty subjects from both gender (46 males and 74 females) were took-part in this study, their age was ranging from 40 to 69 years while their BMI from 18.5 to > 30 kg/m². They were assigned randomly into 2 equals groups. Group A (Normal) involved 60 healthy subjects without HTN and Group B (hypertension) involved 60 patients with HTN. Each group divided into 3 equal sub-groups of BMI (n=20) for each subgroup (normal weight BMI ≥18.5 to <25 kg/m², overweight BMI ≥25 to <30 kg/m², along with obese ≥ 30.0 kg/m².

The subjects were excluded if they had the followings acute disorder affecting the cervical spine, shoulder, elbow, or hand in the dominant arm, cognitive disorders, or difficulty understanding the study data, chronic conditions such as arthritis affecting the elbow, wrist or hand, history of Musculoskeletal disorders, and hand pain or deformity [15,18]. Body height was measured by using a stadiometer in meters and weight in kilograms. Calculation of BMI was done utilizing Quetelet's index. HTN was measured by using Mercury Sphygmomanometer**,** HGS and HGE were measured by Digital Hand Dynamometer and body function by using 36-item short form (SF-36).

Randomization

Participants were randomly allocated into two equivalent groups (A and B) by a blinded independent investigator. This process involved opening sealed envelopes that included computer-generated randomization sequentially numbered index cards, utilizing the Statistical Package for the Social Sciences (SPSS) program (version 25 for Windows, IBM SPSS, Chicago, IL, USA) as shown in Figure (1).

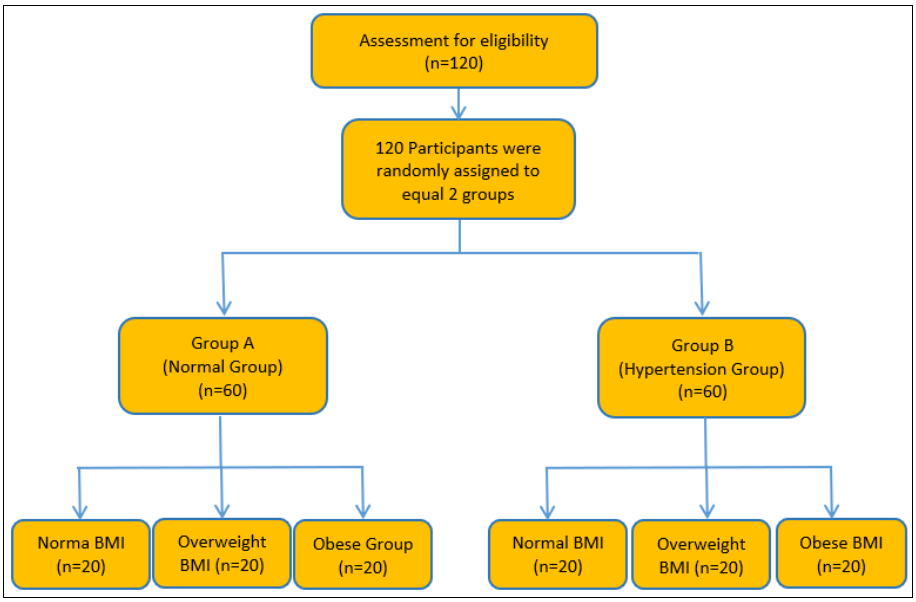

Fig 1: Participants flow chart

Instrumentations

A-Digital Platform Weighing Scale

This device measures mass or weight [19,20]. The system operates utilizing a strain gauge load cell. Analog scales utilize springs to measure the weight of an item, whereas digital scales translate the force exerted by the weight into an electrical signal. It has excellent reliability and validity in static limb loading measurement [21].

B-Stadiometer

It refers to a piece of medical equipment used to measure human height**.** It typically consists of an adjustable sliding horizontal headgear positioned atop the head and a ruler. Stadiometers are used for clinical testing and experiments, as well as for standard medical examinations [22]. High levels of validity and reliability were demonstrated by the portable stadiometer for measuring height [23].

C-Mercury Sphygmomanometer

It is considered the gold standard. A blood pressure monitor, also referred to as a blood pressure gauge, is a device utilized for measuring blood pressure. The device consists of an inflatable cuff that compresses and subsequently releases the underlying artery in a controlled fashion, along with a measuring unit (the mercury) that quantifies the pressure, and an inflation mechanism that can be either an electrically operated pump or a manually operated bulb and valve. When employing the auscultatory method, a stethoscope and manual sphygmomanometers are utilized [24,25,26].

D-Hand Held Dynamometer

The CAMRY EH101 Dynamometer is used in this study, It is consisted of ON/SET button, The arrows up and down can be used to navigate between user profiles, The gender icon can be Changed from male to female by Press either up or down arrow, The age icon can be changed by pressing the up or down arrow. it provides excellent reliability and validity. In clinical practice, this tool can be used as a practical, reliable and inexpensive way to measure grip strength [27,28,29,30,31].

E-The Stopwatch

It used to count the time in seconds for measuring HGE.

F-The 36-item short form (SF-36)

It is a widely used questionnaire to assess a population's overall health-related quality of life (HRQOL) [32]. It is brief, has excellent sensitivity to changes in health state, and a high standard of validity and reliability [33]. The 36-item short form health survey is a widely utilized, self-reported measure of health outcomes that is well-researched. The study is centered on the objective assessment of HRQOL as stated in the Medical Outcomes Study [34].

Procedure

The therapist explained all study procedures to the participants carefully, followed by recording the demographic data of each participant as Age, Weight, Height, and BMI. Each patient signed an informed consent form and the patient personal sheet.

- **BMI Assessment:**

The body weight of every individual was determined using a digital platform weighing scale and expressed in kilograms, with individuals standing barefoot and dressed in light clothing. The BMI for each individual was determined using the following formula: BMI is calculated by dividing weight in kilograms by the square of height in meters^2. Body Height of each participant was measured by using stadiometer in meters, standing against a wall with bare feet, with heels together and looking straight. The measurement was recorded in centimeters and converted to meters.

- **Hand Grip Strength Assessment:**

The participants were instructed to seat on an armless chair with flexion 90° at hip and knee and hold dynamometer by dominant hand with their shoulders with 0° abduction, they have their wrists neutral, forearms at a neutral angle, and elbows flexed at a 90-degree angle. The participants followed a verbal command of "slowly push, push, push, push, and relax" for each trial to make sure they are applying maximum pressure for 3 seconds. The participants were also asked to squeeze the dynamometer as hard as possible without the sensation of pain. Verbal instructions and a practice test were provided to each participant prior to the test. Each measurement was taken three times, with a 10-to 20-second delay between each, and reported in kilograms. The maximum handgrip strength was determined by using the maximum value.

- **Hand grip endurance assessment:**

The participants were given the task of maintaining a handgrip strength of one-third of their maximum for an extended period of time, which they were then asked to record utilizing a stopwatch in seconds.

- **Body function assessment:**

The 36-item short form survey questionnaire is a brief, multifunctional health survey consisting of just 36 questions. The assessment includes eight scale profiles measuring functional health as well as well-being: Physical Functioning (PF), Role Limitations caused by Physical Problems (RP), Bodily Pain (BP), General Health (GH), Vitality (VT), Social Functioning (SF), Role Limitations caused by Emotional Problems (RE), Mental Health (MH), in addition to a single-item scale on Health Transition. The SF-36 may be self-administered, conducted electronically, or conducted by a trained interviewer either in person or via telephone. The scores are measured by recoding pre-coded numerical values using the scoring key found. A greater score demonstrates a more positive state of health. Keep in mind that every item is scored. Additionally, each item has a score between 0 and 100, with 0 and 100 being the lowest and highest possible values, respectively. The percentage of the total possible score attained is represented by the scores.

Statistical analysis:

Data were examined for tests of normality as well as homogeneity of variance. The data was found to follow a normal distribution ($P>0.05$) following the elimination of outliers identified by box and whiskers plots, according to a normality test of data utilizing the Shapiro-Wilk test. There was also no statistically significant difference ($P>0.05$) when tested for homogeneity of variance using Levene's test. After using parametric analysis, we find that the data follows a normal distribution. Version 25 of the statistical SPSS Package for Windows was used to perform the statistical analysis (SPSS, Inc., Chicago, IL). Quantitative data are reported as mean and standard deviation for subject's age, height, weight, BMI, HGS, HGE, ET, and SF36 total score variables. The gender variable is used for reporting qualitative data as a frequency (%). The gender variable was compared using a chi-square test, both within and between groups. The study employed a mixed-design 2 x 3 x 2 MANOVA-test. The first independent variable had two levels: the tested group impact (normal group compared to hypertension group). The second level measured the impact of BMI subgroups (normal BMI, overweight BMI, along with obese BMI). The third level measured the impact of gender (males and females). Pairwise comparisons of the investigated variables within and between groups were conducted using the Bonferroni test (Post hoc-tests) where the P-value was significant from the MANOVA test. There was statistical significance in all analyses at the 0.05 level of probability ($P < 0.05$).

Results

- **Subject characteristics:**

There were no significant differences in the groups with respect to the following baseline demographic variables: age, weight, height, BMI), as well as gender distribution ($p > 0.05$) between normal group and hypertension group (normal BMI, overweight BMI and obese BMI subgroups as shown in Table (1).

Table 1: Within and between group comparison for clinical general characteristics

Variables	Items	BMI subgroups			*P*-value[2]
		Normal (n=20)	Overweight (n=20)	Obese (n=20)	
Age (years)	Normal group	48.0 ±3.93	48.9 ±4.34	48.2 ±2.84	0.607
	Hypertension group	48.8 ±4.99	48.6 ±7.07	49.9 ±6.77	0.493
	P-value[1]	0.629	0.856	0.149	
Gender (males: females)	Normal group	9 (45.0%):11 (55.0%)	7 (35.0%):13 (65.0%)	9 (45.0%):11 (55.0%)	0.760
	Hypertension group	8 (40.0%): 12 (60.0%)	9 (45.0%):11 (55.0%)	4 (20.0%):16 (80.0%)	0.393
	P-value[1]	0.749	0.519	0.091	

P-value: probability value; *Significant (P<0.05); P-value[1]: Probability value within each BMI subgroup; P-value[2]: Probability value among BMI subgroups

The statistical analysis for main variable outcomes (weight, BMI, HGS, HGE, ET, and SF36) between normal group and hypertension group is shown in Table (2). No statistically significant differences in mean values of weight, BMT, HGS in addition to HGE between normal group and hypertension group for normal BMI, overweight BMI and obese BMI subgroups. A significant difference was observed in BMI between both groups in obese BMI subgroup. A significant difference was observed in HGS between both groups in obese BMI subgroup. A significant difference was observed in HGE between both groups in obese BMI subgroup. A significant difference was observed in mean values of total score SF-36 questionnaire between normal group and hypertension group for normal BMI and obese BMI subgroups. But, there were no statistical significant difference in mean values of total score SF-36 questionnaire between both groups for overweight BMI subgroup.

Table 2: Within and between group comparison for main outcome variables

Variables	Items	BMI subgroups			*P*-value[2]
		Normal (n=20)	Overweight (n=20)	Obese (n=20)	
Weight (kg)	Normal group	64.5 ±4.87	81.7 ±7.52	102.6 ±19.19	0.0001*
	Hypertension group	65.7 ±8.48	81.1 ±11.12	105.3 ±14.37	0.0001*
	MD (Change)	1.2	0.6	2.7	
	95% CI	-6.27 – 8.65	-6.79 – 8.12	-4.73 – 10.18	
	P-value[1]	0.753	0.860	0.470	
BMI (kg/m^2)	Normal group	22.9 ±1.66	28.3 ±1.32	36.8 ±4.63	0.0001*
	Hypertension group	22.7 ±1.47	28.0 ±1.53	39.7 ±4.19	0.0001*
	MD (Change)	0.2	0.3	2.9	
	95% CI	-1.50 – 2.04	-1.49 – 2.05	1.09 – 4.63	
	P-value[1]	0.767	0.756	0.002*	
Hand grip strength (HGS)	Normal group	24.0 ±3.87	31.0 ±6.71	27.8 ±6.84	0.001*
	Hypertension group	23.1 ±2.85	29.4 ±6.75	24.2 ±5.19	0.001*
	MD (Change)	0.9	1.6	3.6	
	95% CI	-2.53 – 4.47	-1.95 – 5.04	0.09 – 7.09	
	P-value[1]	0.584	0.384	0.044*	
Hand grip endurance (HGE)	Normal group	8.0 ±1.29	10.3 ±2.23	9.2 ±2.28	0.001*
	Hypertension group	7.6 ±0.95	9.8 ±2.25	8.0 ±1.73	0.001*
	MD (Change)	0.4	0.5	1.2	
	95% CI	-0.84 – 1.49	-0.65 – 1.68	0.03 – 2.36	
	P-value[1]	0.584	0.384	0.044*	
Endurance time (ET)	Normal group	93.4 ±23.28	134.8 ±21.5	116.3 ±29.5	0.001*
	Hypertension group	90.3 ±24.2	127.1 ±37.5	107.4 ±34.15	0.001*
	MD (Change)	3.1	7.7	8.9	
	95% CI	-15.07 – 21.27	-10.47 – 25.87	-9.32 – 27.02	
	P-value[1]	0.736	0.403	0.337	
SF-36 questionnaire	Normal group	71.5 ±7.40	73.5 ±7.00	56.3 ±13.80	0.0001*
	Hypertension group	60.0 ±5.16	68.0 ±14.24	48.8 ±16.30	0.0001*
	MD (Change)	11.5	5.5	7.4	
	95% CI	4.29 – 18.72	-1.65 – 12.77	0.19 – 14.62	
	P-value[1]	0.002*	0.129	0.044*	

MD: mean difference; CI: confidence interval, P value: probability value; *Significant (P<0.05); P-value[1]: Probability value within each BMI subgroup; P-value[2]: Probability value among BMI subgroups

Post-hoc test and mean differences among pairwise of BMI subgroups comparisons within normal group and hypertension group for main variable outcomes (weight, BMI, HGS, HGE, ET, and SF36) are illustrated in Table (3).

Table 3: Pairwise comparison (Post-hoc test) between groups for main outcome variables

Variables	BMI subgroups	Post-hoc test			
		Normal group		Hypertension group	
		MD	*P*-value[1]	MD	*P*-value[2]
Weight (kg)	Normal vs. overweight	17.2	0.0001*	15.4	0.0001*
	Normal vs. obese	38.1	0.0001*	39.6	0.0001*
	Overweight vs. obese	20.9	0.0001*	24.2	0.0001*
BMI (kg/m^2)	Normal vs. overweight	5.4	0.0001*	5.3	0.0001*
	Normal vs. obese	13.9	0.0001*	17.0	0.0001*
	Overweight vs. obese	8.5	0.0001*	11.7	0.0001*
Hand grip strength (HGS)	Normal vs. overweight	7.0	0.0001*	6.3	0.001*
	Normal vs. obese	3.8	0.097	1.1	1.000
	Overweight vs. obese	3.2	0.229	5.2	0.012*
Hand grip endurance (HGE)	Normal vs. overweight	2.3	0.0001*	2.2	0.001*
	Normal vs. obese	1.2	0.097	0.4	1.000
	Overweight vs. obese	1.1	0.229	1.8	0.012*
Endurance time (ET)	Normal vs. overweight	41.4	0.0001*	36.8	0.0001*
	Normal vs. obese	22.9	0.042*	17.1	0.192
	Overweight vs. obese	18.5	0.136	19.7	0.102
SF-36 questionnaire	Normal vs. overweight	2.0	1.000	8.0	0.089
	Normal vs. obese	15.2	0.0001*	11.2	0.008*
	Overweight vs. obese	17.2	0.0001*	19.2	0.0001*

MD: mean difference; CI: confidence interval *Significant (P<0.05), P-value1: probability value between pairwise of BMI subgroups within normal group, P-value2: probability value between pairwise of BMI subgroups within hypertension group

The statistical analysis for main variable outcomes (weight, BMI, HGS, HGE, ET, and SF36) among normal group and hypertension group related to gender is presented in Table (4).

Table 4: Within and between group comparison for main outcome variables related to gender

Variables	Items	BMI subgroups (Males)			*P*-value[2]	BMI subgroups (Females)			*P*-value[3]
		Normal	Overweight	Obese		Normal	Overweight	Obese	
Weight (kg)	Normal group	65.4 ±5.35	85.3 ±5.51	115.9 ±14.1	0.0001*	63.8 ±4.58	79.7 ±7.90	91.7 ±15.8	0.0001*
	Hypertension group	68.0 ±11.10	89.2 ±10.9	108.5 ±15.27	0.0001*	64.2 ±6.24	74.4 ±5.39	104.3 ±14.45	0.0001*
	MD (Change)	2.6	3.9	7.4		0.4	5.3	12.6	
	95% CI	-7.5 – 12.6	-6.6 – 14.3	-4.1 – 19.0		-8.2 – 9.0	-3.1 – 12.9	4.3 – 20.8	
	P-value[1]	0.614	0.466	0.208		0.928	0.212	0.003*	
BMI (kg/m^2)	Normal group	22.7 ±1.81	28.0 ±1.16	39.2 ±4.84	0.0001*	23.1 ±1.60	28.4 ±1.42	34.9 ±3.62	0.0001*
	Hypertension group	22.3 ±1.54	29.0 ±1.67	38.9 ±3.57	0.0001*	22.9 ±1.44	27.1 ±1.56	40.0 ±4.46	0.0001*
	MD (Change)	0.4	1.0	0.3		0.2	1.2	4.9	
	95% CI	-2.2 – 3.0	-1.7 – 3.7	-2.7 – 3.2		2.0 – 2.4	-0.9 – 3.4	2.8 – 7.1	
	P-value[1]	0.766	0.462	0.856		0.850	0.262	0.0001*	
Hand grip strength (HGS)	Normal group	26.2 ±3.77	38.3 ±4.51	32.7 ±6.05	0.0001*	22.2 ±3.02	27.0 ±3.63	23.8 ±4.48	0.0001*
	Hypertension group	25.2 ±2.52	35.1 ±2.83	31.1 ±5.41	0.009*	21.6 ±2.04	24.8 ±5.29	21.9 ±2.46	0.041*
	MD (Change)	0.9	3.2	1.6		0.6	2.2	1.8	
	95% CI	-2.7 – 4.7	-0.6 – 7.0	-2.6 – 5.9		-2.5 – 3.8	-0.9 – 5.3	-1.1 – 4.8	
	P-value[1]	0.607	0.103	0.439		0.695	0.163	0.231	
Hand grip endurance (HGE)	Normal group	8.7 ±1.25	12.7 ±1.50	10.9 ±2.01	0.0001*	7.41 ±1.00	9.03 ±1.21	7.94 ±1.49	0.0001*
	Hypertension group	8.4 ±0.84	11.7 ±0.94	10.3 ±1.80	0.009*	7.2 ±0.68	8.28 ±1.76	7.33 ±0.82	0.041*
	MD (Change)	0.3	1.0	0.6		0.2	0.8	0.6	
	95% CI	-0.9 -1.5	0.2 – 2.3	-0.8 – 1.9		-0.8 -1.28	-0.3 – 1.7	-0.3 -1.6	
	P-value[1]	0.607	0.103	0.439		0.695	0.163	0.231	
Endurance time (ET)	Normal group	104.4 ±17.74	146.1 ±20.03	124.2 ±22.3	0.014*	84.3 ±24.0	128.7 ±20.4	109.8 ±25.9	0.019*
	Hypertension group	98.2 ±22.8	137.78 ±20.3	113.8 ±27.2	0.001*	85.0 ±24.6	118.45 ±46.5	105.3 ±36.7	0.021*
	MD (Change)	6.1	8.36	10.4		0.6	10.3	4.4	
	95% CI	-2.1.3 – 33.7	-20.2 – 36.9	21.2 – 42.0		-23.0 – 24.3	-12.9 – 33.5	-18.0 – 27.01	
	P-value[1]	0.657	0.563	0.515		0.958	0.381	0.694	
SF-36 questionnaire	Normal group	73.5 ±5.86	79.2 ±3.40	56.2 ±14.84	0.0001*	69.8 ±8.33	70.5 ±6.57	56.3 ±13.80	0.039*
	Hypertension group	62.5 ±4.65	71.8 ±15.07	56.0 ±15.65	0.005*	58.3 ±4.95	64.9 ±13.43	46.51 ±16.44	0.0001*
	MD (Change)	11.0	7.4	0.2		11.4	5.6	9.8	
	95% CI	0.1 – 22.05	-3.9 – 18.8	-12.4 – 12.8		2.0 -12.4	-3.6 – 14.8	0.8 – 18.8	
	P-value[1]	0.048*	0.199	0.975		0.017*	0.231	0.032*	

MD: mean difference; CI: confidence interval, P-value: probability value; *Significant (P<0.05); P-value[1]: Probability value within each BMI subgroup; P-value[2]: Probability value among BMI subgroups within males; P-value[3]: Probability value among BMI subgroups within females

Post-hoc test and mean differences among pairwise of BMI subgroups comparisons within normal group and hypertension group for main variable outcomes (weight, BMI, HGS, HGE, ET, and SF36) related to gender are illustrated in Table (5).

Table 5: Pairwise comparison (Post-hoc test) between groups for main outcome variables related to gender

Variables	BMI subgroups Pairwise	Post-hoc test							
		Normal group				Hypertension group			
		Males		Females		Males		Females	
		MD	*P*-value	MD	*P*-value	MD	*P*-value	MD	*P*-value
Weight (kg)	Normal vs. overweight	19.9	0.001*	15.9	0.001*	21.2	0.0001*	10.2	0.068
	Normal vs. obese	50.5	0.0001*	27.9	0.0001*	40.5	0.0001*	40.1	0.0001*
	Overweight vs. obese	30.6	0.0001*	12.0	0.019*	19.3	0.004*	29.9	0.0001*
BMI (kg/m^2)	Normal vs. overweight	5.3	0.0001*	5.3	0.0001*	6.7	0.0001*	4.2	0.001*
	Normal vs. obese	16.5	0.0001*	11.8	0.0001*	16.6	0.0001*	17.1	0.0001*
	Overweight vs. obese	11.2	0.0001*	6.5	0.0001*	9.9	0.0001*	12.9	0.0001*
Hand grip strength (HGS)	Normal vs. overweight	12.1	0.0001*	4.8	0.008*	9.9	0.0001*	3.2	0.138
	Normal vs. obese	6.5	0.002*	1.6	0.996	5.9	0.028*	0.3	1.000
	Overweight vs. obese	5.6	0.016*	3.2	0.129	4.0	0.194	2.9	0.194
Hand grip endurance (HGE)	Normal vs. overweight	4.0	0.0001*	1.6	0.008*	3.3	0.0001*	1.1	0.138
	Normal vs. obese	2.2	0.002*	0.5	0.996	1.9	0.028*	0.1	1.000
	Overweight vs. obese	1.8	0.016*	1.1	0.129	1.4	0.194	0.9	0.194
Endurance time (ET)	Normal vs. overweight	41.7	0.014*	44.4	0.001*	39.5	0.016*	33.5	0.018*
	Normal vs. obese	19.8	0.437	25.5	0.118	15.6	1.000	20.3	0.208
	Overweight vs. obese	21.9	0.395	18.9	0.327	24.0	0.409	13.2	0.753
SF-36 questionnaire	Normal vs. overweight	5.6	0.986	0.7	1.000	9.2	0.289	6.5	0.507
	Normal vs. obese	17.3	0.005*	13.4	0.020*	6.48	0.961	11.8	0.026*
	Overweight vs. obese	22.9	0.0001*	14.1	0.009*	15.7	0.044*	18.4	0.0001*

MD: mean difference; CI: confidence interval *Significant (P<0.05), P-value[1]: probability value between pairwise of BMI subgroups within normal group, P-value[2]: probability value between pairwise of BMI subgroups within hypertension group

Discussion

In this study, it was aimed to examine the impact of normal, overweight, and obese BMI on HGS, HE and body function in hypertensive patients. The results of this study showed that a significant difference was observed (P>0.05) in mean values of patient's age, weight, height, and BMI between normal group and hypertension group for normal BMI, overweight BMI, and obese BMI subgroups while no statistically significant differences was observed (P>0.05) in mean values of HGS among normal group and hypertension group for normal BMI (P=0.584) and overweight BMI (P=0.384) subgroups. While a significant difference was observed (P<0.05) between both groups in obese BMI subgroup (P=0.044) and there were significant differences (P<0.05) in mean values of HGS among normal, overweight, and obese BMI subgroups within normal group (P=0.001) and hypertension group (P=0.001).

The statistical analysis showed that there were no statistically significant differences (P>0.05) in mean values of endurance time between normal group and hypertension group for normal BMI (P=0.736), overweight BMI (P=0.403), and obese BMI (P=0.337) subgroups and a significant difference (P<0.05) was noted in mean values of endurance time among normal, overweight, and obese BMI subgroups within normal group (P=0.0001) as well as hypertension group (P=0.0001).

The explanation of this result that ethnic differences lead to different in anthropometric measures and abdominal fat distribution and because many factors affect body fat content besides weight to height relationship such as dietary habits, lack of activity, age and genetic factors which lead to unhealthy bodies and increase body fat percentage. Abdominal fat distribution varies by ethnicity and is related to traditional anthropometric measurements [35,36,37,38].

This study's findings that men with normal BMI exhibited a statistically significant negative correlation among BMI and HGS (i.e., an increase in BMI was associated with a decline in HGS) were in agreement with those of Dhananjaya et al. (2017), who had shown that obesity reduces HGS and HGE. The negative connection between body mass index and hip girth score was not statistically significant in obese men. Although the negative correlation among BMI and HGS was not statistically significant, it was also seen in overweight females. Males who were overweight or obese showed a slight negative correlation with HGE. The explanation of this study is that in the obese participants increase fat accumulation that led to decrease type I and increase type II muscle fibers which lead to impairment of muscle strength with obesity. The results of this study corroborated previous research showing an inverse correlation between fat mass and type I fibers and a positive correlation between type II fibers [10].

Consistent with Salim's (2023) findings, the present study found that BMI negatively correlated with both hand grip endurance as well as HGS, with the overweight BMI subgroup of male individuals exhibiting the strongest handgrip strength across both groups. So that obesity led to decrease HGS and HGE [15].

The present study's findings aligned with those of Ravisankar et al (2005), the females in the overweight BMI classification had the greatest HGS, with a mean of 175±62 kg. In the overweight group, both males and females had the longest mean handgrip endurance time, at 104±40 and 102±37 seconds, respectively. While it stands to reason that effort, cardiorespiratory fitness, as well as skeletal muscle performance would have a significant impact on HGE, this finding is explained by the fact that skeletal muscle mass, contractility, and skeletal muscular strength all play a role in determining muscle strength [35].

The current study's findings aligned with those of Shrestha et al (2020). Specifically, the females in the pre-obese BMI category had the greatest HGS and HGE, with mean values of 29±2.87 kg and 161.00±95.75 s, respectively. Findings showing that individuals with normal BMI have the strongest grips on objects can be explained by the fact that their muscles become stronger as their BMI drops, whereas those with low BMIs have weaker grips because their energy levels are too low [38].

This study's findings ran counter to those of Dhananjaya et al (2017). Among men with BMI, the study found a negative correlation between BMI and HGS; among men with obesity, the correlation was weaker. While there was no correlation in the normal and obese female individuals, there was a weak negative correlation among overweight females with HGS and BMI. Among men who were overweight or obese, there was a modest negative correlation between HGE and [10]. An individual's age, sex, build, muscular strength, arm length, and nutrition all have a role in the development of HGS and HGE. such as waist size, hip size, abdominal fat percentage, skin fold thickness, and body mass index (BMI) for more accurate results, and in the obese individuals, Type II fibers have a positive correlation with fat mass whereas type I fibers have an inverse correlation. This variation could be explained by the Hand-Grip strength influenced by change in genetic and environmental factors in different regions [39].

The findings of this study disagreed with the study created by Lad et al (2013), the results of this study revealed that in male the underweight as well as overweight groups had a lesser grip strength (with a mean of 33.1±4.29 and 31.16±2.06 kg respectively) and endurance (with a mean of 132±54.92 and 109.67±48.22 s respectively) than the normal weight group (HGS mean 33.33±2.58 kg and HGE mean 199.73±29.09 s). In comparison to the normal weight as well as overweight groups, the underweight females exhibited superior grip strength (HGS mean 27.07±4.50 kg) compared to the other two groups (26.8±3.25 and 24.5±6.37 kg, respectively). While the normal weight group had a higher grip endurance (HGE mean 140.8±28.35 s) than both the underweight and overweight groups (with a mean of 115.3±45.77 and 101.73±50.75 s respectively). According to the explanation behind these findings, BMI is only a measure of total body mass; it doesn't account for fat proportion and, as an index, is unable to identify the difference between weight changes caused by changes in muscle mass and those caused by changes in body fat percentage. It is possible that the underweight group had respectable muscle mass, and that the overweight group had greater muscle mass than fat [40].

The results of the correlational analyses between BMI and SF36 score within normal group and hypertensive group showed that there was significantly ($P<0.05$) negative moderate relation among BMI and SF36. The explanation of these results is that obesity is associated with decreased physical activity and mobility [41].

This result of this study came in accordance with the results created by Doll et al (2000), 14,868 individuals with age 18 to 64 years, divided to 5 groups according to BMI (underweight, normal weight, overweight, moderately obese, morbidly obese). Based on the findings of this study, being overweight or obese is linked to lower psychological and physiological health [42].

This study's findings corroborated those of Apovian et al (2002), which found that older women with a higher BMI had significantly reduced upper as well as lower body function [43]. The results also showed that there is an association among obesity and functional performance. This study's findings corroborated those of Corica et al (2006), which found that the severity of obesity is associated with an increase in the quality-of-life impairment experienced by obese individuals [44].

Limitations of this study

First: Age of all participants was specified from 40 to 69 year,

Second: All participants were Egyptian with same environmental factors,

Third: So larger sample size will be needed. Additional studies will be needed to examine the impact of different BMI on HGS, HGE and body function in hypertensive patients with different ethnic and different ages groups rather than from 40-69 years old and investigate the effect of environment on HGS, HGE and body function.

Conclusion

Our conclusion that there was no correlation among BMI and HGS was supported by both the scope and depth of our investigation, and HGE between normal and hypertension subjects but there was a correlation in HGS and HGE between normal and hypertension subjects in obese subgroup, and that male participants had better handgrip strength and endurance than female participants in overweight BMI in both normal and hypertension subjects, also there was significantly negative moderate relation between BMI and body function.

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