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By Widya Inarah Nadhilah Hamid

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Comparison of obesity based on various obesity indices in metabolic dysfunction-associated fatty liver disease (MAFLD) subjects

Widya Inarah Nadhilah Hamid[1], Andi Makbul Aman[1], Haerani Rasyid[1], Syakib Bakri[1], Nu'man As Daud[1], Arifin Seweng[2]

[1]Department of Internal Medicine, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia
[2]Department of Public Health and Community Medicine, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia

Corresponding author:
Widya Inarah Nadhilah Hamid,
E-mail: diellanadhilah@gmail.com

ABSTRACT

Background. Metabolic dysfunction-associated fatty liver disease (MAFLD) is a terminology that describes the condition of fatty liver accompanied by metabolic disorders. Previous studies have shown obesity is associated with MAFLD, but fatty liver can also be observed in non-obese individuals. The obesity measurement index can reflect obesity levels and can be used as a screening tool for metabolic diseases such as MAFLD. In addition to Body Mass Index (BMI), there are several other measurement indices, such as Waist Circumference (WC), Waist-to-Height Ratio (WHtR), as well as Body Fat Percentage (BF%) and Fat Mass Index (FMI). This study aims to see the comparison of obesity prevalence in MAFLD patients based on various measurement indices.

Materials and Methods. This study was conducted at Wahidin Sudirohusodo Hospital in Makassar, Indonesia, using an observational study with a cross-sectional design. The various obesity indices were performed once the patient was newly diagnosed with MAFLD. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25.0.

Results. This study consisted of 44 males (57.9%) and 32 females (42.1%), with an average age 41.8 years. The prevalence of obesity based on various indices in MAFLD subjects was as follows: WHtR (100%), LP (88.2%), FMI (86.8%), BF% (86.8%), and BMI (80.3%).

Conclusions. The prevalence of obesity in MAFLD subjects was highest when measured by the WHtR index, followed by WC, FMI, BF%, and lowest when measured by BMI.

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Keywords: Metabolic Dysfunction-Associated Fatty Liver Disease, Obesity, Body Mass Index, Waist Circumference, Waist-to-Height Ratio, Bioelectrical Impedance

Abbreviations:

BF% : Body Fat Percentage

BIA : Bioelectrical Impedance Analysis

BMI : Body Mass Index

FMI : Fat Mass Index

MAFLD: Metabolic dysfunction-associated fatty liver disease

WC : Waist Circumference

WHtR : Waist-to-Height Ratio

INTRODUCTION

Metabolic dysfunction-associated fatty liver disease (MAFLD) is defined as excessive accumulation of fat (>5%) in liver cells through histological examination, imaging or specific blood biomarkers accompanied with at least 1 of 3 metabolic criteria: overweight/obesity, type 2 diabetes mellitus or the presence of at least 2 metabolic deregulatory factors [1].

Metabolic dysfunction-associated fatty liver disease consists of a spectrum of histological disorders, ranging from steatosis, steatohepatitis, hepatofibrosis and cirrhosis [2]. The increased lipolysis in adipose tissue leads to an increased accumulation of lipids in the liver. This process is affected by an unhealthy, high-calorie diet, lack of physical activity and obesity [3,4].

Obesity is an excessive or abnormal accumulation of fat or adipose tissue in the body that interferes with health and is a risk factor for cardiometabolic diseases [5]. The current consensus indicates that the overall distribution of fat is a primary determinant of disease risk rather than the total amount. A relatively higher amount of visceral adipose tissue compared to peripheral and subcutaneous adipose tissue is associated with a greater risk of metabolic disorders and is directly related to inflammation and liver fibrosis, insulin resistance, and liver steatosis [6,7].

Body mass index (BMI) is a simple measurement of obesity status, while waist circumference (WC) reflects abdominal fat and can represent visceral adipose tissue better than BMI. The waist–hip ratio (WHR) and waist-to-height ratio (WHtR) are anthropometric indices based on WC and also reflect abdominal fat, and they are reported as better indicators of metabolic syndrome than BMI [8]. Bioelectrical Impedance Analysis (BIA) is a non-invasive measurement of body composition and is very useful in large epidemiological studies. This method is used to determine body fat percentage (BF%). Other obesity indicators do not measure BF% due to their inability to differentiate fat mass from lean body mass [9,10]. Several literature indicate that BF% and fat mass index (FMI, fat mass in kilograms divided by height in square meters) can serve as measurement tools to identify metabolic syndrome [11,12].

Numerous studies indicate that the prevalence of obesity, as measured by BMI, in individuals with MAFLD across Asian countries varies between 54.12% and 72.1% [13-15]. The objective of our study is to compare the prevalence of obesity among patients with MAFLD using various obesity measurement indices, including simple anthropometric measurements (BMI, WC, and WHtR) and bioelectrical impedance analysis metrics (BF% and FMI).

MATERIALS AND METHODS

Study design and setting: An observational study with a cross-sectional design was conducted among 76 patients with newly diagnosed MAFLD at Wahidin Sudirohusodo Hospital in Makassar, Indonesia, from July to October 2024. This hospital serves as referral center in Eastern Indonesia.

Study population

Inclusion criteria: The inclusion criteria for this study comprised individuals over 18 years of age diagnosed with MAFLD, who visited Wahidin Sudirohusodo Hospital and expressed their willingness to participate by signing an informed consent form.

Sample size and sampling technique: The minimum sample size for our study was 72, utilizing a sample size formula. Participants were chosen through purposive sampling, ensuring that specific criteria were met for inclusion. Prior to participation, written informed consent was obtained from each individual, following a thorough explanation of the procedures they would be involved in. Anthropometric measurements and Bioelectrical Impedance Analysis (BIA) using seca mBCA 525 were carried out on all study subjects.

Objective criteria: MAFLD (Metabolic Dysfunction-Associated Fatty Liver Disease) is defined by the presence of hepatic steatosis observed through abdominal ultrasound or CT scan, along with at least one of the following three conditions: overweight/obesity, Type 2 Diabetes Mellitus, or the presence of metabolic syndrome. According to various measurement indices, an individual is classified as obese if their Body Mass Index (BMI) is ≥ 25.0 kg/m², waist circumference (WC) is ≥ 90 cm for men and ≥ 80 cm for women, Waist-to-Height Ratio (WHtR) is ≥ 0.5, body fat percentage (BF%) is $\geq 25\%$ for men and $\geq 35\%$ for women, and Fat Mass Index (FMI) is ≥ 6.6 kg/m² for men and ≥ 9.5 kg/m² for women.

Statistical Analysis: Data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. The results will be presented in a narrative format, supplemented by tables to enhance clarity and understanding of the findings.

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Ethical considerations: This study has been approved by the Research Ethics Committee of the Faculty of Medicine, Hasanuddin University through the publication of an ethical approval letter number 436/UN4.6.4.5.31/PP36/2024. The study adhered to the ethical principles, ensuring the protection of participants' rights and confidentiality.

RESULTS

Characteristics of research subjects

In this study, a total of 44 male and 32 female participants, aged 24 to 70 years (mean age: 41.8 ± 11.1 years), were enrolled. Of the participants, 67.1% were aged ≤45 years, while 25% were older than 45 years. Hypertension was present in 45 participants (59.2%), diabetes mellitus (DM) in 14 participants (18.4%), and 13 participants (17.1%) were classified as pre-diabetic. The average triglyceride level was 129.5 ± 72 mg/dL, with 31.6% of subjects exceeding levels ≥150 mg/dL. The mean HDL cholesterol level was 45.1 ± 10.6 mg/dL. (Table 1)

The assessment of obesity indices in this study showed a BMI ranging from 21.91 to 40.71 kg/m², with a mean of 28.43 ± 4.15 kg/m². Waist circumference (WC) varied from 74 to 130 cm, with a mean of 97.33 ± 10.73 cm. The WHtR ranged from 0.50 to 0.77, with a mean of 0.60 ± 0.06. Body fat percentage (BF%) ranged from 22.4% to 48.6%, with a mean of 36.06 ± 6.62%, while FMI ranged from 5.6 to 17.9, with a mean of 10.35 ± 2.08. Abdominal ultrasound revealed fatty liver disease in 33 participants (43.4%) with grade 1, 24 participants (31.6%) with grade 2, and 19 participants (25%) with grade 3 (Table 1).

Comparison of obesity in MAFLD based on various obesity indices

Based on BMI measurements, 15 subjects (19.7%) were classified as non-obese, while 61 subjects (80.3%) were classified as obese. Waist circumference (WC) measurements identified 9 subjects (11.8%) as non-obese, with 67 subjects (88.2%) categorized as obese. In contrast, the WHtR indicated obesity in all participants (100%). (Table 2)

Bioelectrical Impedance Analysis (BIA) for BF% identified obesity in 66 subjects (86.8%), and the FMI also revealed obesity in 86.8% of participants, in alignment with the BF% findings. Overall, a higher proportion of obesity was observed in males compared to females across nearly all obesity indices. However, in terms of BF%, obesity was found in 87.5% of females and 86.4% of males (Table 2).

DISCUSSION

Obesity is the accumulation of excessive fat or adipose tissue in the body. An increase in adipose tissue can enhance lipolysis and lead to an increased accumulation of lipids in the liver [2]. Therefore, one of the criteria used for a positive diagnosis of MAFLD is the presence of hepatic steatosis accompanied by being overweight or obese, as measured by BMI [1]. Several studies indicate that the prevalence of obesity based on BMI among MAFLD in Asian countries ranges from 54.12% to 72.1% [13-15].

In this study, a total of 76 subjects with MAFLD who met the inclusion criteria were obtained from the outpatient clinic at Wahidin Sudirohusodo Hospital during the period of July – October 2024. The proportion of male subjects was higher at 57.9% compared to 42.1% female subjects, with 67.1% of subjects being under 45 years of age. This result is consistent with Peng's study in the United States, where the proportion of males (52.51%) with MAFLD was higher than females (47.49%) [16]. Based on clinical characteristics, only 18.4% of subjects had diabetes mellitus (DM) and 17.1% were pre-diabetic, yet 59.2% had hypertension. Low HDL levels were found in only 47.4% of subjects, and elevated triglycerides in only 31.6% of subjects. Overall, the proportion of subjects with hypertension was higher than those with dyslipidemia and DM.

The assessment of obesity measurement indices in this study showed a BMI with an average of 28.43 ±4.15 kg/m², and a WC with an average of 97.33±10.73 cm. These anthropometric characteristics align with a study in China by Duan et al., which reported an average WC of 96.7±8.618 cm and a BMI of 28±3.2, but are lower compared to studies in Iran and the United States [15-17]. For the WHtR, the average was found to be 0.60±0.06. This result is consistent with the study by Guotai et al. on the Japanese population, indicating that if WHtR is around 0.4–0.6, the risk of Non-Alcoholic Fatty Liver Disease (NAFLD) should be carefully evaluated [18]. The BIA (bioelectrical impedance analysis) assessment showed BF% ranging from 22.4% to 48.6%, with an average of 36.06±6.62, and FMI ranging from 5.6 to 17.9, with an average of 10.35±2.08. These findings are consistent with the study by Jinwook et al., where the cut-off value for BF% for liver fat accumulation is 24.35%, and the cut-off for FMI is 6.46 [19].

The highest prevalence of obesity was found using the WHtR measurement (100%), followed by WC (88.2%), BF% (86.8%), FMI (86.8%), and BMI (80.3%). This indicates that obesity measured by WHtR has the highest sensitivity for detecting MAFLD compared to other indices studied. This finding aligns with Zhang's study in Tangshan, China, which showed WHtR had the highest sensitivity for detecting NAFLD at 72.7%, followed by FMI (72%), WC (71.1%), BMI (70.5%), and BF% (69.2%) [12]. A meta-analysis by Ashwell et al. in 2011 also indicated that WHtR is a better predictor of cardiometabolic disorders than WC and BMI [20]. However, this study differs from Peng et al.'s findings in the United States, which showed higher sensitivity for BMI (74.32%) compared to WHtR (73.72%) [16].

In our study, obesity based on BMI was the lowest (80.3%), though this is still higher than in previous studies. Wang et al. found that only 66% of MAFLD subjects in an Asian population were classified as obese based on BMI [14]. Yuan et al.'s 2017-2019 study in Beijing, China, showed an obesity prevalence based on BMI of just 54.12% in MAFLD patients. Similarly, Taheri et al.'s research on an Iranian population found a BMI-based obesity prevalence of 72.1% in MAFLD patients [13,15].

In males, the highest obesity proportion was observed with WHtR (100%), followed by WC (93.18%), FMI (90.91%), BF% (86.36%), and BMI (86.36%). These results differ slightly from Zhang et al.'s study, which found the highest sensitivity for NAFLD in males with FMI (78.9%), followed by WHtR (73%), WC (72.3%), and BMI (66.8%) [12]. However, Peng et al. found that BMI had the highest sensitivity for MAFLD in males (82.17%), followed by WC (79.62%) and WHtR (76.43%) [16]. A retrospective study at a major hospital in China by Wang et al. in 2021 reported that WC had the highest sensitivity in male subjects (81%) compared to WHtR (75.7%) for MAFLD [14].

In females, the highest obesity proportion was also observed with WHtR (100%), followed by BF% (87.5%), FMI (81.25%), WC (81.25%), and BMI (71.88%). This finding is consistent with Zhang et al.'s study, which showed WHtR had the highest sensitivity (93.8%) for detecting NAFLD in females, followed by WC (91.4%), FMI (67.9%), BF% (64.2%), and BMI (49.4%) [12]. In Wang et al.'s study of females, WC had the highest sensitivity (89.2%) for detecting MAFLD, followed by WHtR (88.3%) and BMI (87.5%) [14].

Our study found that obesity based on WHtR in MAFLD subjects had a higher prevalence than BMI, a commonly used parameter for MAFLD detection. Literature suggests that BMI may be less effective because it does not distinguish between fat mass and lean body mass. Additionally, it is known that visceral fat is closely associated with metabolic disorders and liver steatosis. Thus, measurements that assess fat mass, body fat proportion, and central obesity, such as BIA or anthropometry using waist circumference, are considered more effective than BMI [12,21,22]. Our results can be used as basic data for further research to assess WHtR's ability as a predictor of MAFLD and determining the cut off value for MAFLD.

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CONCLUSION

The highest prevalence of obesity in MAFLD subjects was found using the WHtR measurement, followed by WC, FMI, BF%, and the lowest using BMI.

Conflict of interest: The authors declare no conflict of interest.

Author's contributions:

Widya Inarah Nadhilah Hamid, Andi Makbul Aman, and Haerani Rasyid were the principal investigators of the study and drafted the manuscript. Widya Inarah Nadhilah Hamid and Arifin Seweng collected and analyzed the data. Syakib Bakri and Nu'man As Daud contributed to the concept and design of the study. Andi Makbul Aman, Haerani Rasyid and Syakib Bakri revisited the manuscript and critically evaluated the intellectual contents. All authors participated in the final draft preparation, manuscript revision, and critical evaluation of the intellectual contents. All authors have read and approved the content of the manuscript and confirmed the accuracy or integrity of any part of the work.

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TABLES

Table 1: Characteristics of the Research Subject

Variable	Category	Frequency (n)	Percentage (%)	Min	Max	Mean	SD
Gender	Female	32	42,1				
	Male	44	57,9				
Age	≤45 years	51	67,1	24	70	41,8	11,1
	>45 years	25	32,9				
Fasting Blood Glucose	DM	14	18,4	70	237	106,6	36
	Pre-Diabetes	13	17,1				
	Normal	49	64,5				
Hypertension	Yes	45	59,2				
	Not	31	40,8				
Triglycerides	<150	52	68,4	44	475	131,08	72,99
	≥150	24	31,6				
HDL	<40(M)/<50(F)	36	47,4	15	86	45	10,7
	≥40(M)/≥50(F)	40	52,6				
BMI				21,91	40,71	28,43	4,15
WC				74,0	130,0	97,33	10,73
WHtR				0,50	0,77	0,60	0,06
BF%				22,40	48,60	36,06	6,62
FMI				5,60	17,90	10,35	2,80
USG (Fatty Liver)	Grade 1	33	43,4				
	Grade 2	24	31,6				
	Grade 3	19	25,0				

BMI: Body Mass Index, LP: Waist Circumference, WHtR: Waist to height ratio, BF%: Body Fat Percentage, FMI: Fat Mass Index, M: Male, F: Female

Table 2. Comparison of Obesity in MAFLD based on various Obesity Measurement Indices

Variable	Obese	Non-Obese
	n(%)	n(%)

Body Mass Index (kg/m^2)	61 (80.3%)	15 (19.7%)
Male	38 (86.36%)	6 (13.64%)
Female	23 (71.88%)	9 (28.13%)
Waist Circumference (cm)	67 (88.2%)	9 (11.8%)
Male	41 (93.18%)	3 (6.82%)
Female	26 (81.25%)	6 (18.75%)
Waist to Height Ratio	76 (100%)	0
Male	44 (100%)	0
Female	32 (100%)	0
Body Fat %	66 (86.8%)	10 (13.2%)
Male	38 (86.36%)	6 (13.64%)
Female	28 (87.5%)	4 (12.5%)
Fat Mass Index	66 (86.8%)	10 (13.2%)
Male	40 (90.91%)	4 (9.09%)
Female	26 (81.25%)	6 (18.75%)