CLINICAL NUTRITION
DOI: 10.12957/demetra.2021.45633

DEMETRA
Alimentação, Nutrição & Saúde

Emerson Iago Garcia e Silva[1]
Sarah Emanuely Macêdo Guedes[2]
Bárbara Evelin de Souza Cunha[2]
Camilla Araújo de Brito[3]

[1] Universidade de Pernambuco, Programa de Pós-Graduação em Ciência e Tecnologia Ambiental para o Semiárido. Petrolina, PE, Brasil.

[2] Faculdade Pernambucana de Saúde, Departamento de Nutrição. Recife, PE, Brasil.

[3] Instituto de Medicina Integral Professor Fernando Figueira, Departamento de Nutrição. Recife, PE, Brasil.

Correspondence
Emerson Iago Garcia e Silva
emerson.iago@hotmail.com

Glycemic homeostasis and anthropometric markers associated with insulin resistance in patients with non-alcoholic fatty liver disease

Homeostase glicêmica e marcadores antropométricos associados à resistência insulínica em pacientes portadores de doença hepática gordurosa não alcoólica

Abstract

Objective: To determine predictive anthropometric measurements associated with insulin resistance in patients with non-alcoholic fatty liver disease. ***Methods:*** This was a cross-sectional, quantitative study conducted at two outpatient clinics in Recife-PE. The study group was formed by individuals of both sexes over 18 years of age with non-alcoholic fatty liver disease diagnosed via abdominal echography. The anthropometric variables collected were: waist circumference, body mass index, conicity index, waist-to-hip ratio, and waist-to-height ratio. Insulin resistance was determined through the homeostasis model assessment: insulin resistance (HOMA-IR). The Mann–Whitney U test and correlation tests were performed to understand the differences between the variables. ***Results:*** 75 individuals participated in the study, most of whom were female (85%) and with age over 60 years (44%). Insulin resistance was high in the population, being present in more than half of the individuals (73%). Except for the body mass index and waist-to-hip ratio, all other indices showed a significant association between the presence of insulin resistance and non-alcoholic hepatic steatosis: waist-to-height ratio (p= 0.004), conicity index (p= 0.031), and waist circumference (p= 0.001). In the correlation test, only the waist circumference (r= 0.2184; p= 0.05) and the waist-to-hip ratio (r = 0.2310; p= 0.04) were associated. ***Conclusions:*** The anthropometric indicators are applicable tools in clinical practice and in the context of non-alcoholic fatty liver disease; however, waist circumference and the waist-to-height and waist-to-hip ratios provided the best predictions.

Keywords: Anthropometry. Chronic non-communicable diseases. Insulin resistance. Hepatic steatosis.

Resumo

Objetivo: Determinar medidas antropométricas preditivas associadas à resistência à insulina em pacientes portadores de doença hepática gordurosa não alcoólica. ***Métodos:*** Estudo transversal, quantitativo, realizado em dois centros ambulatoriais de Recife-PE. O público foi formado por indivíduos de ambos os sexos, acima de 18 anos, com diagnóstico de doença hepática gordurosa não alcoólica via ecografia abdominal. As variáveis antropométricas coletadas foram: circunferência da cintura, índice de massa corporal, índice de conicidade, razão cintura-quadril e cintura-estatura. A resistência à insulina foi determinada através do *Homeostasis model assessment: insulin resistance* (HOMA-IR). Para entender as diferenças entre as variáveis, o teste de U Mann-Whitney e testes de correlação foram realizados. ***Resultados:*** Participaram 75 indivíduos com predominância do sexo feminino (85%) e com idade superior a 60 anos (44%). A resistência à insulina foi elevada na população, perfazendo mais da metade

(cc) BY

dos indivíduos (73%). Com exceção do índice de massa corporal e da razão cintura-quadril, demais índices apresentaram associação estatisticamente significativa entre a presença da resistência à insulina com a esteatose hepática não alcoólica: razão cintura-estatura (p=0,004), índice de conicidade (p=0,031) e circunferência da cintura (p=0,001). No teste de correlação, apenas a circunferência da cintura (r =0,2184; p=0,05) e a razão cintura-quadril (r =0,2310; p=0,04) associaram-se. ***Conclusões:*** Os indicadores antropométricos são ferramentas aplicáveis na prática clínica e no contexto de doença hepática gordurosa não alcoólica; contudo, a circunferência da cintura e as razões cintura-estatura e cintura-quadril apresentaram as melhores predições.

Palavras-chave: Antropometria. Doenças crônicas não transmissíveis. Resistência à insulina. Esteatose hepática.

INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is a clinical condition characterized by abnormal fat accumulation in the liver without a history of significant alcohol consumption,[1] being increasingly recognized as the hepatic manifestation of metabolic syndrome.[2] It is currently the most common cause of liver disease in western countries, and its incidence has increased in Asian nations.[3,4] It comprises two etiopathogenic processes: non-alcoholic hepatic steatosis (HS) and non-alcoholic steatohepatitis (NASH). HS is defined by the presence of hepatic steatosis without hepatocellular injury in the form of ballooned hepatocytes, while NASH is defined by hepatic steatosis in addition to hepatocyte injury and inflammation.[5]

NAFLD is intimately associated with metabolic diseases, such as type 2 diabetes mellitus (DM2), insulin resistance (IR), and obesity, of which IR is the most common physiopathological basis.[6] Furthermore, previous findings showed that NAFLD could increase the risks of DM2 and its complications in patients.[7] On the other hand, additional events revealed that the prevalence and mortality rates of NAFLD in patients with DM2 were also significantly higher.[8]

IR is considered one of the main risk factors for cardiovascular diseases as it is associated with conditions such as glucose intolerance, DM2, dyslipidemias, arterial hypertension, among other metabolic alterations, including NAFLD.[9] However, despite its importance for public health, IR is not often diagnosed in clinical practice, although being important for the diagnosis, monitoring, and treatment of some diseases.

The method considered as the gold standard for detecting this alteration is the euglycemic-hyperinsulinemic clamp,[9] a high-cost, invasive technique that demands much time, making it unfeasible for clinical practice. Another method is the homeostasis model assessment: insulin resistance (HOMA-IR), which has a high agreement with the gold-standard test. However, the HOMA-IR is not widely employed as the assessment of the fasting glycemia and insulinemia levels used in its calculation demands invasive collections, limiting the practicality of the method.[9]

In this scenario, there is a growing need to develop practical, fast, non-invasive, low-cost, and easily applicable methods that can be associated with insulin resistance. Anthropometric markers obtained by employing simple instruments easily found in professional practice can be useful in this case as some of them have an already verified association with visceral fat accumulation.[9]

Considering the emergency of NAFLD as a public health problem and knowing that IR is one of its triggers, studies are required in order to assess the related anthropometric markers, especially in this group, in which it shows an alarming increase and an unfavorable and insidious prognosis. Therefore, the identification of IR deserves greater attention by health entities as it constitutes a way to predict important clinical conditions with enormous morbimortality potential, such as diabetes, cardiovascular events, and NAFLD itself. In view of this, the premise of this study was to determine predictive anthropometric measurements associated with insulin resistance in patients with non-alcoholic fatty liver disease.

METHOD

Ethical aspects

This study was part of a larger project named "Clinical and nutritional parameters of patients with non-alcoholic hepatic steatosis and its relationship with metabolic syndrome," approved by the Research Ethics Committee of the Instituto de Medicina Integral Professor Fernando Figueira (Institute of Integrative Medicine Professor Fernando Figueira) under the number 64898517.1.0000.5201. All participants were explained about the nature and perspectives of the project. The participation of the individuals occurred upon signing the Informed Consent Form (TCLE).

Study design

This is a cross-sectional, multicenter study with a quantitative approach conducted at the Nutrition outpatient clinics of the Instituto de Medicina Integral Professor Fernando (Institute of Integrative Medicine Professor Fernando Figueira) and Instituto do Fígado de Pernambuco (Liver Institute of Pernambuco), two healthcare centers directed towards the local population and surrounding areas located in Recife-PE, Brazil.

Data collection began in April and ended in November 2017. The sampling followed a non-probability convenience approach with patients from the health units. As inclusion criteria, only the individuals with non-alcoholic hepatic steatosis diagnosed via abdominal echography (USG) of both sexes and age over 18 years were part of the sample. Active drinkers, individuals using steatogenic or hepatotoxic drugs, individuals diagnosed with some hereditary liver disorder or seropositivity for hepatitis B (HVB) and C (HVC), and patients with disabling diseases (rheumatic, neuromuscular, osteoarticular, or degenerative diseases) were excluded. All information was checked in the medical record to verify its veracity according to the anamnesis.

Anthropometric measurements and indices

The anthropometric measurements performed on the first occasion were: weight (Kg), height (m), waist circumference (WC), and hip circumference (HC). Both circumferences were established in centimeters (cm). Weight was measured with a digital balance (Welmy®, model W300) coupled to a stadiometer, with a capacity of 300 kg and precision of 50g; the subjects wore light clothes, standing erect and with their back to the equipment, with the feet placed together and the arms alongside the body, looking forward, and standing still in this position.

Height (m) was measured orthogonally, with the subjects standing erect and with their back to the equipment, and with the mobile part of the stadiometer positioned above the head, with sufficient pressure to compress the hair. WC was measured with the patient standing and using an inelastic measuring tape at the midpoint level between the last rib and the iliac crest.[10] These values were analyzed according to the criteria of the World Health Organization (WHO).[11] Hip circumference was measured at the maximum length of the gluteus that could be assessed.[10]

The following indices were calculated based on the anthropometric measurements:

1) Body mass index (BMI) – calculated as the ratio of body weight (kg) to squared height (m^2). The interpretation was based on the WHO criteria [12] for the non-elderly. The population was stratified by considering the BMI as: underweight (< 18.5 kg/m^2); normal weight or eutrophic (18.5kg/m^2 – 24.9kg/m^2); overweight (25kg/m^2 – 29.9kg/m^2); and obesity (≥30kg/m^2). The categorization of the elderly followed the proposed by the Pan-American Health Organization (PAHO):[13] underweight (BMI<23kg/m2); adequate weight (BMI≥23 and <28kg/m^2); pre-obesity (BMI>28 and <30kg/m^2); and obesity (BMI≥30kg/m2).

2) Conicity index (CI) – calculated with the data of weight, height, waist circumference, and a constant that results from the square root of the ratio between 4π (originated from the deduction of the perimeter of the circle of a cylinder) and the average human density of 1,050 kg/m^3. The description above has the following schematized formula: CI: WC/0.109X√Weight (Kg) /height (cm), with cut-off points of 1.25 for men and 1.18 and 1.22 for women up to 49 years and from 50 years of age onwards, respectively.[14]

3) Waist-to-hip ratio (WHR) – calculated by dividing the waist circumference (WC) by the hip circumference, attributing metabolic and cardiovascular risk values ≥ 0.90 for men and ≥ 0.85 for women.

4) Waist-to-height ratio (WHtR) – mathematically obtained by the quotient between waist circumference (cm) and height (cm). Due to the inexistence, until the present moment, of a national reference of cut-off points for the

WHtR, the 90 percentile (P) was considered, corresponding to 0.50 as the limit for excessive abdominal fat diagnosis in adults. With respect to the elderly, the 0.55 cut-off point proposed by Correa was used.[15]

Biochemical evalution and insulin resistance

The serum levels of fasting glycemia and plasma insulin were obtained from the medical records, considering a maximum three-month period. In the absence of these examinations, referrals were made for collection and analysis, which occurred in the first consultation.

Regarding the fasting glycemia levels, the criteria of the Brazilian Diabetes Society were adopted to stratify the normality or inflection[16]. According to the laboratory specifications, the insulin values were considered normal in the interval from 3 to 25 um/L. Insulin resistance was determined by the homeostasis model assessment: insulin resistance (HOMA-IR), obtained by the formula[17]: HOMA = [fasting insulinemia (mU/l) x fasting glycemia (mmol/l)] / 22.5. According to a prevalence study conducted with the Brazilian population, any value higher than 2.7 was considered to define insulin resistance.[18]

Statical analysis

The data were compiled in Microsoft Excel 2013 for the descriptive statistical design and their use in inference software programs. The continuous variables were tested in the inferential analysis regarding their normal distribution by the Kolmogorov-Smirnov normality test. Homoscedasticity was not reached, and the Mann-Whitney U test was applied to test the differences between the medians of the independent groups. Spearman's test was used to analyze the correlation between variables, being used for the variables with non-normal distribution, while Pearson's test was used for the variables with a normal distribution. All analyses were performed using the software SPSS, version 23.0 (SPSS Inc., Chicago, IL, USA). Two-tailed P values <0.05 were considered statistically significant

RESULTADOS

One hundred forty-one patients with non-alcoholic hepatic steatosis diagnosed via USG were pre-selected, of which one individual tested positive for HVB, one did not allow the completion of anthropometric measurements, and 64 did not present some of the biochemical examinations requested, resulting in a sample of 75 eligible adult individuals of both sexes. Of these, the female sex prevailed (85%). Regarding age, 44% of individuals had more than 60 years, but the middle-aged individuals, from 45 to 59 years, corresponded to 40% of the sample. Only 16% were considered young adults, that is, with less than 45 years.

Regarding the degree of steatosis in the sample, 36 (48%) individuals showed mild accumulation, followed by moderate (43%) and severe (9%).

Table 1. Anthropometric and biochemical profile of patients with non-alcoholic fatty liver disease. Recife-PE, 2017

Variable	N	%	Min-Max.
BMI (kg/m^2)			
Eutrophy	8	11	24.5-27.3
Overweight	14	19	24.9-29.9
Obesity	53	70	30.5-42.5

Table 1. Anthropometric and biochemical profile of patients with non-alcoholic fatty liver disease. Recife-PE, 2017

Variable	N	%	Min-Max.
WHtR (cm)			
Normal	0	0	-
High	75	100	0.53-0.92
WHR (cm)			
Normal	6	8	0.74-0.93
High	69	92	0.83-1.29
CI			
Normal	14	19	1.04-1.62
Altered	61	81	1.00-1.79
WC (cm)			
Normal	0	0	-
High	10	13	86.0-99.0
Very High	65	87	88.0-140
Fasting Glycemia (mg/dL)			
Normal	45	60	74-99
Altered	30	40	103-364
Fasting Insulinemia (mU/L)			
Normal	62	83	3.00-24.3
Altered	13	17	25.02-221.1
Insulin resistance (HOMA – IR)			
No	20	27	0.6-2.5
Yes	55	73	2.8-52.2

Legend: BMI: Body mass index; WHtR: Waist-to-height ratio; WHR: Waist-to-hip ratio; CI: Conicity index; WC: Waist circumference; HOMA – IR: Homeostasis model assessment: insulin resistance; Min-Max: Minimum-Maximum.

Table 1 summarizes the anthropometric and biochemical characteristics of the individuals with NAFLD. Obesity prevailed in the sample, as indicated by the anthropometric measurements evaluated, with abdominal fat excess being found in all studied individuals, of which 80% had very high WC values. According to the HOMA-IR, insulin resistance was high in the population, accounting for more than half of the individuals (73%).

Table 2. Association of insulin resistance with anthropometric and biochemical variables in individuals with non-alcoholic fatty liver disease. Recife-PE, 2017

Variable	Insulin resistance		p- value*
	Presence (N=55)	Absence (N=20)	
	Median (IQ)	Median (IQ)	
BMI (kg/m^2)	32.6**(29.5-37)**	32.15**(29.5-34)**	0.429
WHtR (cm)	0.67 **(0.0-0.0)**	0.65 **(0.0-0.0)**	0.004*
WHR (cm)	0.97**(0.0-1.0)**	0.93**(0.0-0.25)**	0.143

Table 2. Association of insulin resistance with anthropometric and biochemical variables in individuals with non-alcoholic fatty liver disease. Recife-PE, 2017

Variable	Insulin resistance		p- value*
	Presence (N=55)	Absence (N=20)	
	Median (IQ)	Median (IQ)	
CI	1.34(1.0-1.0)	1.29(1.0-1.0)	0.031*
WC (cm)	103.5(99.5-115)	102(87.7-103)	0.001*
HOMA - IR	4.6(3.0-6.5)	1.7(1.0-2.0)	<0.000*

Legend: BMI: Body mass index; WHtR: Waist-to-height ratio; WHR: Waist-to-hip ratio; CI: Conicity index; WC: Waist circumference; IQ: Interquartile range; *: Statistically significant values by the Mann-Whitney U test.

The association of insulin resistance with the anthropometric parameters can be observed in Table 2. Of the anthropometric indicators, WHtR (p=0.0048), CI (p=0.0310), and WC (p=0.0011) were statistically significant, with higher medians in the group with IR compared to the group without the manifestation. Regarding fasting glycemia (<0.0001) and insulin levels (<0.0001), the increasing trend was maintained, showing statistical significance in the groups with IR. The same was observed for the HOMA-IR (<0.0001), which was significantly higher in the group with the IR clinical condition.

Table 3. Correlation between anthropometric and biochemical indicators with insulin resistance according to the HOMA-IR in individuals with non-alcoholic fatty liver disease. Recife, Pernambuco, 2017

Indicators	r
BMI (kg/m^2)	0.1458
WHtR (cm)	0.1310
WHR (cm)	0.2310*
CI	0.0631
WC (cm)	0.2184*
Fasting glycemia	0.1785

Legend: BMI: Body mass index; WHtR: Waist-to-height ratio; WHR: Waist-to-hip ratio; CI: Conicity index; WC: Waist circumference. *: Statistically significant differences by Spearman's correlation test

Table 3 summarizes the strength of the association through the correlation between insulin resistance and anthropometric and biochemical markers. Significant positive correlations with IR were only reached for WC (p=0.05) and WHR (p=0.04). For the anthropometric measurements, it is highlighted that the value of R was not very much increased, evidencing that the relationship was not strong. It should be noted that the population of the study may have been small in order to assess such an effect, and a larger sample could provide better evidence.

DISCUSSION

NAFLD is one of the main health conditions throughout the world as 30% of the adult population and from 60% to 80% of diabetic and obese patients are affected by it.[19,20] It is a chronic progressive disease, and its progression usually takes years or even decades.[21] Still, evidence suggests that NAFLD is the main cause of hepatocellular carcinoma in the United States.[22] Allied to that, its importance as the second main event that causes liver transplantation is a reality.[23] Besides disorders of liver origin, it is also responsible for the increment in cases of DM2, metabolic syndrome, and cardiovascular events.[21]

IR has been recognized as fundamental in the development of non-alcoholic hepatic steatosis. In this perspective, it is known that the imbalance that results from insulin resistance in the lipid metabolism leads to fat accumulation in the liver due to the reduction in the oxidation of free fatty acids and/or increased hepatic lipogenesis, and/or reduction in the release of lipids to the circulation. Consequently, fat deposits in the hepatocytes increase insulin resistance, forming a vicious circle. Besides, hyperinsulinemia results from genetic predisposition, excess of free fatty acids, or exposure to high levels of the tumor necrosis factor-alpha (TNF-α), interleukin 6 (IL-6), and/or other mediators.[24]

In this study, the IR was numerically important, assuming high percentages (73.4%). A Brazilian study conducted in Rio de Janeiro found values of 65% for this manifestation and a mean of 4.4 in the HOMA-IR for obese individuals with NAFLD.[25] In our study, we found higher HOMA-IR values; however, in both studies, the cut-off point established for IR was overcome. Another national study, conducted in Porto Alegre, observed high HOMA-IR mean values of 5.5, corroborating our findings.[26] In turn, the study by Barros et al., which aimed to relate NAFLD with metabolic syndrome in morbidly obese patients, found 86.8% of abnormal HOMA-IR.[27] However, the referred study only approached morbidly obese patients, who knowingly present worse blood glucose homeostasis, a factor that may have contributed to such a high and different number from our sample, being more heterogeneous regarding the nutritional status.

In general, the persistence and relationship of IR and NAFLD are also observed in the international scenario. The Gastroenterology and Hepatology Divisions of Texas and Florida, USA, aiming at recognizing the determinant role of NAFLD, IR, and steatohepatitis on atherogenic dyslipidemia, found values of 4.9 in the HOMA-IR.[28] The same study also found normal insulin levels (14 μIU/ML) and high plasma blood glucose levels (142 mg/dL).[28] In our study, 40% of individuals showed altered blood glucose, while the mean of the groups with IR was 122 mg/dL.

Such an analogy between high values reinforces the IR and hyperglycemia entanglement, resembling our research to the above-mentioned international study. On the other hand, in the mentioned study, the mean insulin values remained within the normality range.[26] The same was observed in our research as most of our population remained within the range of insulinemic normality. Regarding the mean values, in both groups, both with and without IR, basal insulinemia was within the normality range, considering the populational median, although being significantly higher in the group with IR. This majoritarian "insulin normality" behavior was verified in other assays.[25,27] These results reinforce the criticality and caution when considering insulin levels in the context of NAFLD and IR as a diagnostic method and/or exclusive clinical monitoring.

Anthropometric measurements are low-cost, harmless, and easily applicable nutritional status indicators that have been employed as obesity indicators. The correlations between anthropometric markers and IR have been widely studied, highlighting them as non-invasive indicators for assessing the risk of IR, both in epidemiological research and clinical practice.[9]

Depending on the anthropometric measurement used, their results can reveal different severities of body fat accumulation, being important to distinguish between the degree of general fat and the degree of abdominal fat. As

obesity markers for central or abdominal fat, we can highlight the WC, CI, WHtR, and WHR. As for the general obesity markers, BMI stands out.

Centralized obesity is an important cardiovascular risk factor, besides interfering more with the glucose-insulin homeostasis than general obesity.[29] By analyzing the findings of this study, it is seen that, among the centralized obesity markers, WHtR and CI were significantly associated with the presence of insulin in the sample with NAFLD, while WC showed a statistical trend. On the other hand, the BMI, which indicates fat generalization, and the WHR showed no association. In turn, the WHR (r=0,2310; p=0,04) and WC (r=0,2184; p=0,05) showed a significant positive correlation with the HOMA-IR values.

A Brazilian study conducted in Minas Gerais, aiming to identify IR anthropometric markers in older men, found positive correlations for all anthropometric indices with the HOMA-IR.[30] These results diverge from our study, but it is worth mentioning that, in this Brazilian study, the population had no NAFLD diagnosis, revealing that, for this sample, some anthropometric parameters showed better association than others, which is not seen in patients without preexisting NAFLD.

The increased waist circumference was associated with the presence of IR and correlated with the HOMA-IR values. An Iranian study also confirmed the relationship between IR and WC, which was higher in individuals with the manifestation.[31] Such a result corroborates the findings of this study with respect to the association and correlation of IR with WC.

Still in the international scenario, a cross-sectional study conducted with Japanese men with an average age of 50 years also observed an association between WC and IR.[32] Likewise, a prospective Mexican study found a strong association of WC with IR and DM2.[33] Including this one, the studies converge, in general, regarding increased WC abnormalities and abnormal glycemic responses.

CI and WHtR have shown to be important tools to indicate cardiovascular risk. On the other hand, their use to identify IR is still very incipient. In our study, we observed that both indices were associated with IR, showing to be significantly increased in the individuals with the manifestation.[34,35]

A multicenter study conducted with seven European and two American populations compared CI and WHtR as cardiovascular health indicators. The study verified that insulinemia showed consistent correlation patterns with the CI.[34] Another national study showed a similar conclusion, in which the authors identified CI as a discriminator of glycemia and cardiovascular risk.[13] These findings disagree with the present study. On the other hand, in a study conducted in Greece with 280 healthy women from 18 to 24 years of age, the CI showed a very weak correlation (r = 0.13; p = 0.03) with fasting insulinemia.[35] The evidence is inconclusive regarding the use of the CI to assess IR in patients with NAFLD. There are few studies in this thematic field, hampering any suggestion. *A priori* and based on our findings, the CI is significantly higher in individuals with IR.

A Brazilian study with patients diagnosed with acute coronary syndrome found a negative correlation of WHtR with IR.[36] This finding is in double disagreement with our study, first because no significant correlation was found, and second because the type of correlation was positive. Although the WHtR is considered superior to BMI and WC, since it is influenced by sex and race, it may alter the results. This occurs because fat distribution varies with sex and race, minimizing the ability of the WHtR to discriminate IR. Since the studies that use WHtR to identify IR are scarce, there emerges a difficulty to either refute or not the hypothesis.

Some traditional anthropometric indicators may not correctly identify the metabolic risk associated with obesity, including obese patients.[37] This was observed with the BMI, which was neither associated with the IR nor correlated in the present study, considering that its greatest limitation lies in its correlation with total body fat as it

does not reflect body fat distribution.[38] Furthermore, there is a BMI trend to underestimate adiposity in the elderly and overestimate it in individuals with more lean mass, further impairing its discriminating power.[39]

In view of the exposed above, the strength of this study was to approach nutritional practice parameters in a group with growing NAFLD prevalence. Furthermore, it reveals that some parameters are more predictive than others in associating with IR, one of the factors in the development of the disease. As limitations, it is highlighted that the small sample may have been insufficient to test the associations with more evidence.

CONCLUSION

Anthropometric indicators are applicable tools in clinical practice and in the context of NAFLD. Excessive abdominal fat is related to IR, as observed by the associations of WHtR, CI and WC, significantly increased in the group with IR. Furthermore, central fat plays an important role.

The findings show a directly proportional connection of WC and WHR with the HOMA-IR. It is suggested that the anthropometric markers, specifically those that delimit central fat distribution, such as WC, WHR, and WHtR, play an important role in the monitoring of IR in individuals with NAFLD.

ACKNOWLEDGEMENTS

To the State Health Secretariat of Pernambuco (Secretaria Estadual de Saúde de Pernambuco) for their financial support.

REFERENCES

1. Wijarnpreecha K, Panjawatanan P, Thongprayoon C, Jaruvongvanich V, Ungprasert P. Sarcopenia and risk of nonalcoholic fatty liver disease: A meta-analysis. Jornal Oficial da Saudi Gastroenterology Association. 2018;24(1):12-7. https://doi.org/10.4103/sjg.SJG_237_17
2. Younossi ZM, Koenig AB, Abdelatif D, Fazel Y, Henry L3, Wymer M. Global epidemiology of nonalcoholic fatty liver disease-Meta-analytic assessment of prevalence, incidence, and outcomes. Hepatology. 2016;64:73-84.
3. Seki Y, Kakizaki S, Horiguchi N, Hashizume H, Tojima H, Yamazaki Y, Sato K, Kusano M, Yamada M, Kasama K. Prevalence of nonalcoholic steatohepatitis in Japanese patients with morbid obesity undergoing bariatric surgery. J Gastroenterol. 2016;51(3):281-9. https://doi.org/10.1007/s00535-015-1114-8
4. Watanabe S1, Hashimoto E, Ikejima K, Uto H, Ono M, Sumida Y, Seike M, Takei Y, Takehara T, Tokushige K, Nakajima A, Yoneda M, Saibara T, Shiota G, Sakaida I, Nakamuta M, Mizuta T, Tsubouchi H, Sugano K, Shimosegawa T. Evidence-based clinical practice guidelines for nonalcoholic fatty liver disease/nonalcoholic steatohepatitis. J Gastroenterol. 2015;50(4):364-77.https://doi.org/ 10.1007/s00535-015-1050-7
5. Tokushige K, Hashimoto E, Kodama K. Hepatocarcinogenesis in non-alcoholic fatty liver disease in Japan. J Gastroenterol Hepatol. 2013;28(4):88-92. https://doi.org: 10.1111/jgh.12239
6. Fruci B, Giuliano S, Mazza A, Malaguarnera R, Belfiore A.Nonalcoholic Fatty liver: a possible new target for type 2 diabetes prevention and treatment. Int J Mol Sci. 2013;14(11):22933-66. https://doi.org /10.3390/ijms141122933
7. Mavrogiannaki AN, Migdalis IN. Nonalcoholic Fatty liver disease, diabetes mellitus and cardiovascular disease: newer data. Int J Endocrino. 2013;2013(450639):1-8. http://dx.doi.org/10.1155/2013/450639
8. Targher G, Bertolini L, Poli F, Rodella S, Scala L, Tessari R, Zenari L, Falezza G. Nonalcoholic fatty liver disease and risk of future cardiovascular events among type 2 diabetic patients. Diabetes. 2005;54(12):3541-46.

9. Carneiro IBP, Sampaio HAC, Carioca AAF, Pinto FJM, Damasceno NRT.Antigos e novos indicadores antropométricos como preditores de resistência à insulina em adolescentes. Arq Bras Endocrinol Metab. 2014;58(8):838-43. http://dx.doi.org/10.1590/0004-2730000003296

10. Mussoi TD. Avaliação Nutricional na Prática Clínica: da gestação ao envelhecimento. Rio de Janeiro: Guanabara; 2014. p. 423.

11. World Health Organization. Obesity: preventing and managing the global epidemic. WHO; 1998.

12. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a World Health Organization Consultation. Geneva: World Health Organization; 2000. p. 256. WHO Obesity Technical Report Series, n. 284.

13. OPAS. Organização Pan-Americana. XXXVI Reunión del Comitê Asesor de Ivestigaciones en Salud – Encuestra Multicêntrica – Salud Beinestar y Envejecimeiento (SABE) en América Latina e el Caribe – Informe preliminar; 2002

14. Pitanga FJG, Lessa I. Sensibilidade e especificidade do índice de conicidade como discriminador do risco coronariano de adultos em Salvador, Brasil. Rev Bras Epidemiol. 2004;7(3):259-69. http://dx.doi.org/10.1590/S1415-790X2004000300004.

15. Correa MM, Thomasi E, Tume E, Oliveira ERA, Facchini LA. Razão cintura-estatura como marcador antropométrico de excesso de peso em idosos brasileiros. Cad. Saúde Pública. 2017;33(5):1-14. http://dx.doi.org/10.1590/0102-311x00195315.

16. Diretrizes Sociedade Brasileira de Diabetes (2019-2020). Rio de Janeiro: Clannad; 2019. p.491.

17. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. 1985;28(7):412-19

18. Geloneze B, Vasques AC, Stabe CF, Pareja JC, Rosado LE, Queiroz EC, Tambascia MA. HOMA1-IR and HOMA2-IR indexes in identifying insulin resistance and metabolic syndrome: Brazilian Metabolic Syndrome Study (BRAMS). Arquivos Brasileiros de Endocrinologia & Metabologia. 2009;53(2):281-87.

19. Ratziu V, Bellentani S, Cortez-Pinto H, Day C, Marchesini G. A position statement on NAFLD/NASH based on the EASL 2009 special conference. Journal of Hepatology. 2010;53(2):72-384. https://doi.org: 10.1016/j.jhep.2010.04.008

20. Younossi ZM, Stepanova M, Afendy M, Fang Y, Younossi Y, Mir H, Srishord M. Mudanças na prevalência das causas mais comuns de doenças crônicas do fígado nos Estados Unidos de 1988 a 2008. Clinical Gastroenterology and Hepatology. 2011;9(6):524-30. https:doi.org: 10.1016/j.cgh.2011.03.020

21. Dai H, Wang W, Chen R, Chen Z, Lu Y, Yuan H. Lipid accumulation product is a powerful tool to predict non-alcoholic fatty liver disease in Chinese adults. Nutrition & Metabolism.2018;14(49):1-9. https://doi.org: 10.1186/s12986-017-0206-2

22. Yu J, Shen J, Sun TT, Zhang X, Wong N. Obesity, insulin resistance, NASH and hepatocellula carcinoma. Semin Câncer Biol. 2013;23(6):483-91.https:doi.org:10.1016/j.semcancer.2013.07.003

23. Wong RJ, Aguilar M, Cheung R, Perumpail RB, Harrison SA, Younossi ZM, Ahmed A. Nonalcoholic steatohepatitis is the second leading etiology of liver disease among adults awaiting liver transplantation in the United States. Gastroenterology. 2015;148(3):547-55. https:doi.org: 10.1053/j.gastro.2014.11.039

24. Portela CLM, Melo MLP, Sampaio HAC. Aspectos fisiopatológicos e nutricionais da doença hepática gordurosa não-alcoólica (DHGNA). Rev Bras Nutr Clin. 2013;28(1):54-60.

25. Chaves VG, Souza DS, Pereira SE, Saboya CJ, Peres WAF. Associação entre doença hepática gordurosa não alcoólica e marcadores de lesão/função hepática com componentes da síndrome metabólica em indivíduos obesos classe III. Rev Assoc Med Bras. 2012;58(3):288-293. http://dx.doi.org/10.1590/S0104-42302012000300007

26. Leon LB, Becker SCC, Petry RC, Wink EF, Lantz F, Tovo CV. Doença hepática gordurosa não alcoólica em pacientes com índice de massa corporal normal: etiologia e fatores de risco associados em um hospital terciário. Revista da AMRIGS. 2014;58(1):44-48

27. De Barros F, Setúbal S, Martinho JM, Ferraz L, Gaudêncio A. Barros, F et al. Correlation of non-alcoholic fatty liver disease and features of metabolic syndrome in morbidly obese patients in the preoperative assessment for bariatric surgery. ABCD Arq Bras Cir Dig. 2016;29(4):260-63. https://doi.org:10.1590/0102-6720201600040011.

28. Bril F, Sninsky JJ, Baca AM, Superko HR, Portillo Sanchez P, Biernacki D, Maximos M, Lomonaco R, Orsak B, Suman A, Weber MH, McPhaul MJ, Cusi K. Hepatic Steatosis and Insulin Resistance, But Not Steatohepatitis, Promote Atherogenic Dyslipidemia in NAFLD. J Clin Endocrinol Metab. 2016;101(2):644 – 52. https:doi.org:10.1210/jc.2015-3111

29. Martins IS, Marinho SP. O potencial diagnóstico dos indicadores da obesidade centralizada. Rev Saúde Pública. 2003;37(6):760-767. http://dx.doi.org/10.1590/S0034-89102003000600011

30. Anunciação PM, Ribeiro RCL. Anthropometric indicators in identification of insulin resistance in elderly men. Mundo da Saúde. 2015;39(2):157-163.http://doi.org/10.15343/0104-7809.20153902157163

31. Zadeh-Vakili A, Teerã FR, Hosseinpanah F. Waist circumference and insulin resistance: a community based cross sectional study on reproductive aged Iranian women. Diabetologia e Síndrome Metabólica. 2011;3(18):2-6. https://doi.org/10.1186/1758-5996-3-18

32. Tabata S, Yoshimitsu S, Hamachi T, Abe H, Ohnaka K, Kono S. Waist circumference and insulin resistance: a cross-sectional study of Japanese men. BMC Endocrine Disorders. 2009;9(1):1-7. https://doi.org:10.1186/1472-6823-9-1.

33. Mamtani M, Kulkarni H, Dyer TD, Almasy L, Mahaney MC, Duggirala R, Comuzzie AG, Blangero J, Curran JE. Waist Circumference Independently Associates with the Risk of Insulin Resistance and Type 2 Diabetes in Mexican American Families. PLOS ONE. 2013;8(3):1-7. https://doi.org:10.1371/journal.pone.0059153.

34. Valdez R, Seidell JC, Ahn YI, Weiss KM. A new index of abdominal adiposity as na indicator of risk for cardiovascular disease. A cross-population study. IntJObesRel Met Disorders. 1993;17(2):77- 82.

35. Mantzoros CS, Evagelopoulou K, Georgiadis EI, Katsilambros N. Conicity index as a predictor of blood pressure levels, insulin and triglyceride concentrations of healthy premenopausal women. Norm Metab Res. 1996;28(1):32-4.

36. Marcadenti A, Oliveira VG, Bertoni VM, Wittke E, Dourado LP, Souza RB, Pinto TM, Filho PP, Leivas JASL. Resistência à Insulina e Indicadores Antropométricos em Pacientes com Síndrome Coronariana Aguda. Rev Bras Cardiol. 2013;26(4):259-66

37. Lemieux I, Drapeau V, Richard D, PHD13, Bergeron J, Marceau P, Biron S, Mauriège P. Waist girth does not predict metabolic complications in severely obese men. Diabetes Care. 2006;29(6):1417-9. https://doi.org/10.2337/dc06-0441

38. Son YJ, Kim J, Park HJ, Park SE, Park CY, Lee WY, Oh KW, Park SW, Rhee EJ. Association of Waist-Height Ratio with Diabetes Risk: A 4-Year Longitudinal Retrospective Study. Endocrinology and Metabolism. 2016;31(1):127-133. https://doi: 10.3803/EnM.2016.31.1.127

39. Antonini-Canterin F, Di Nora C, Poli S, Sparacino L, Cosei L, Ravasel A, AC Popescu, Popescu BA. Obesity, Cardiac Remodeling, and Metabolic Profile: Validation of a New Simple Index beyond Body Mass Index. Journal of Cardiovascular Echography.2018;28(1):18-25. https://doi.org:10.4103/jcecho.jcecho_63_17

Contributors

Silva EIG was responsible for the conception, design, collection, analysis, and data interpretation; Guedes SEM was responsible for data collection and analysis; Cunha BES responsible for data collection and analysis; Brito CA was responsible for the design, review, and final approval.

Conflict of Interests: The authors declare that no conflicting interests exist

Received: September 29, 2019
Accepted: November 19, 2020