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The worldwide metabolic syndrome prevalence in people living with HIV: a systematic review

Abstract

Metabolic alterations have been reported in people living with HIV (PLHIV), related to viral infection, side effects of antiretroviral therapy, genetic, environmental and/or sociodemographic factors. We aimed to draw a global picture of prevalence of Metabolic Syndrome (MetS) in PLHIV. We performed a systematic review based on the PRISMA Statement method. We selected studies that investigated epidemiological characteristics of PLHIV who developed MetS in 4 databases: PubMed, SciELO, LILACS and Science Direct, using descriptors: HIV; prevalence; metabolic syndrome; epidemiology; antiretroviral therapy, highly active. A total of 1117 articles were identified, including 98 in the final analysis. The prevalence of MetS ranged from 7.8 to 55.8% (Internacional Diabetes Federation - IDF) and 7.1 to 58% (National Cholesterol Education Program Adult Treatment Panel III - NCEP/ATP III), being higher in African women than in African men (IDF), whereas European women and women of unknown origin were lower than women from Asia, South and North America (NCEP/ATP III). There is a high prevalence of MetS in PLHIV. The importance of multidisciplinary follow-up and encouragement of lifestyle changes in PLHIV is emphasized.

Keywords: HIV, metabolic syndrome, prevalence, epidemiology, AIDS, systematic review, multidisciplinary

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Abbreviations: AHA/NHLBI, American Heart Association and National Institutes of Health National Heart, Lung, and Blood Institute; AIDS, Human Immunodeficiency Syndrome; AO, abdominal obesity; ART, antiretroviral therapy; ARV, Antiretroviral; ASCVD, American College of Cardiology/American Heart Association Atherosclerotic CVD; AZT, zidovudine; BMI, body mass index; CVD, cardiovascular disease; DM, diabetes mellitus; DM2, diabetes mellitus type 2; EGIR, European Group for the Study of Insulin Resistance; GLUT1, glucose transporter 1; GLUT4, glucose transporter 4; HbA1c, hemoglobin A1c; HDL, high-density lipoprotein; HDL-C, high-density lipoprotein cholesterol; HOMA, homeostatic model assessment; IDF, International Diabetes Federation; INI, integrase inhibitors I; NNTRs, non-nucleoside reverse transcriptase inhibitors; INTRs, nucleoside reverse transcriptase inhibitors; IR, insulin resistance; JIS, Joint Interim Statement; LDL, low-density lipoprotein; MetS, Metabolic Syndrome; NCEP/ATP III, National Cholesterol Education Program Adult Treatment Panel III; PI, protease inhibitors; PLHIV, people living with HIV; PRISMA Statement, Preferred Items for Reporting of Systematic reviews and Meta-analysis; SAH, systemic arterial hypertension; TC, total cholesterol; TDF, tenofovir; TG, triglycerides; VLDL, very-low-density lipoprotein; WHO, World Health Organization

Introduction

The Metabolic Syndrome (MetS) refers to an organic disorder, triggered by the simultaneous occurrence of interrelated conditions, known for their potential cardiovascular damage, such as insulin resistance (IR), obesity, dyslipidemia, and systemic arterial hypertension (SAH).[1] MetS still being associated with other diseases: cancer, mostly of the liver, colorectal, endometrium and pancreas,[2] osteoarthritis,[3] asthma,[4,5] and syndromes such as obstructive sleep apnea.[6]

In this context, complex and multifactorial metabolic alterations have been commonly reported in the population of people living with HIV (PLHIV).[7] In recent decades, the emergence of comorbidities such as IR, dyslipidemia[8] and lipodystrophy has been observed in this population, attributed partially or totally to the natural course of infection, possibly because of their chronic inflammatory state.[9] On the other hand, although the antiretroviral therapy (ART) has evolved a lot, its effects have still been the target of studies, because there are reports of the association of its use with the increase in the number of factors associated with MetS in PLHIV,[10] among them, diabetes mellitus (DM),[11]dyslipidemia and lipodystrophy.[8]

Moreover, the aging of PLHIV, brought with it an increased risk for metabolic disorders,[12] making PLHIV exposed to traditional risk factors for the development of MetS, whether biological such as genetic predisposition to coronary heart disease, hypertension,[1] and DM,[13] female gender, advanced age, and / or environmental, such as smoking and sedentary lifestyle.[7,14]

In this context, characteristic sociodemographic factors of a population may be related to these comorbidities, and therefore allow the identification of individuals who have a higher cardiovascular risk, playing a significant role as a marker of metabolic disorders.[7]

Despite the large volume of studies reporting the prevalence of MetS in PLHIV, data are isolated and, in some cases, conflicting. Therefore, the present study aims to draw a global picture of the prevalence of MetS in PLHIV, identifying regional variations based on a systematic review of the literature.

Literature survey

This systematic review was conducted according to the Preferred Items for Reporting of Systematic reviews and Meta-analysis (PRISMA Statement).[15] The search and selection of the studies were

done by three researchers independently, with disagreements regarding the inclusion of papers resolved through a consensus meeting.

The studies identified in the research were screened according to the pre-defined eligibility criteria, through initial reading of the title, followed by the abstract of the pre-selected studies, and finally, the full texts were obtained for reading in full, resulting in the selected studies.

The results were not influenced by the authors and/or institutions where the studies were conducted. This review was registered in the International Prospective Register of Systematic Reviews (CRD42021268822).

Eligibility criteria

Eligible studies were population-based research articles with samples of gender men and woman, regardless of the time and continent of their realization, which investigated the prevalence of MetS in PLHIV. No limits were set as to the language or year of publication of the study.

Articles were excluded from the review if they presented one or more of the following criteria: the sample consisted of individuals under 18 years of age and/or perinatally acquired the HIV virus; had some bias related to metabolic and/or hormonal disease that could interfere in the diagnosis of MetS; when it was not known which criteria were used for the diagnosis of MetS; incorrect use of established diagnostic criteria for MetS; when the study was a summary publication; did not analyze the variables of interest and/or presented data divergence.

Information sources

Searches were made in 4 databases: MEDLINE (via PubMed, identifying articles from 1966 to March 2022), SciELO (articles from 1997 to March 2022), LILACS (via BIREME interface, articles from 1982 to March 2022), and Science Direct (articles from 1997 to March 2022). With the searches performed from February 21 to March 06, 2022.

Search strategy

For PubMed, SciELO, LILACS and Science direct, the search strategy was composed of associations of Mesh health descriptors: HIV; prevalence; "metabolic syndrome"; epidemiology; "Antiretroviral Therapy, Highly Active". For the search in Science direct was used: HIV AND "metabolic syndrome", plus the application of the title and abstract filters, exclusively. Other filters of text, availability, study origin, publication date, and age were not used.

Data extraction

The process of data collection in each included study was carried out by the researchers, who read the articles, extracted, plotted, and reviewed the information using a shared spreadsheet, prepared specifically for this purpose, containing the following fields: study design (author, time frame, origin); sample (number of participants, age, gender, use of ART, Human Immunodeficiency Syndrome (AIDS)); and the prevalence of HVT, considered the primary variable of interest in this study. Divergences regarding the completion of the worksheet were resolved by consensus.

Data analysis

For data analysis, the results obtained were grouped and stratified by geographic region: North America, South America, Asia, Europe, Africa, and Oceania. The studies that did not report the origin or that their sample originated from different continents composed a separate group, called studies with sample of unknown origin.

The prevalence analysis was done according to gender, grouping the samples of gender men, gender women, and those with data from both genders together. We carried out a descriptive analysis of the prevalence variable by calculating the mean, standard deviation, maximum and minimum values.

For statistical analysis, the diagnostic criteria most frequently used in the studies were considered, namely: International Diabetes Federation (IDF) and National Cholesterol Education Program Adult Treatment Panel III (NCEP/ATPIII), in the latter, the papers that used the criteria of the American Heart Association and National Institutes of Health National Heart, Lung, and Blood Institute (AHA/NHLBI) were also considered, because they consider the same parameters and diagnostic conditions for MetS of the NCEP/ATP III, despite presenting different nomenclatures.

Data distribution was verified using the Shapiro-Wilk test. For comparison of prevalence between genders, the student's t-test was used for data with normal distribution and the Mann-Whitney test for data that did not meet normality assumptions. For comparison of prevalence between continents, we used the Kruskal-Wallis Test with Student-Newman-Keuls post-test. We used the statistical program BioEstat version 5.3.

Results

The studies included in this review were identified during the period February 21, 2022 to March 06, 2022. The search procedure resulted in the identification of 1117 articles in the four databases. After removal of duplicates, 492 articles were considered for title and abstract analysis. Among these, however, 155 met the eligibility criteria and their full texts were analyzed. After analysis, another 57 articles were excluded. Among these, five because they had some bias towards metabolic problems that could interfere in the diagnosis of MetS, twenty-two because it was not known which criteria were used for the diagnosis of MetS, six because of data divergence, nine because they did not analyze variables of interest, three because they were duplicates, seven because the full text could not be accessed, one because one component of MetS was not correctly used, and four because the sample consisted of children and adolescents. In the end, ninety-eight studies met the pre-established eligibility criteria and were therefore included in this review. The steps of the review with the quantification of the remaining articles in each step are described in the flowchart (Figure 1).

The ninety-eight studies selected for inclusion in this review were published in English (88 articles), Portuguese (3 articles), Spanish (5 articles), and French (2 articles). Of these, 26 were conducted in Africa, 9 in North America, 20 in South America, 9 in Asia, 20 in Europe, and 1 in Oceania. In twelve studies it was not possible to identify the ethnic origin of the sample and one article employed samples from countries on different continents (multicenter studies). The studies included in this review involved 73135 participants, all diagnosed with HIV. Different diagnostic criteria for MetS were used in the studies: NCEP/ATP III (10), IDF (9), AHA/NHLBI, Joint Interim Statement (JIS) (21), EGIR (8), WHO (7), and American College of Cardiology/American Heart Association Atherosclerotic CVD (ASCVD) (22). In the included studies, 2 used EGIR criteria, 4 JIS, 2 WHO, in 1 ASCVD, in 50 IDF and in 70 NCEP/ATP III, however, some studies used more than one criterion for diagnosis of MetS. The descriptive data of the included studies are shown in Table 1.

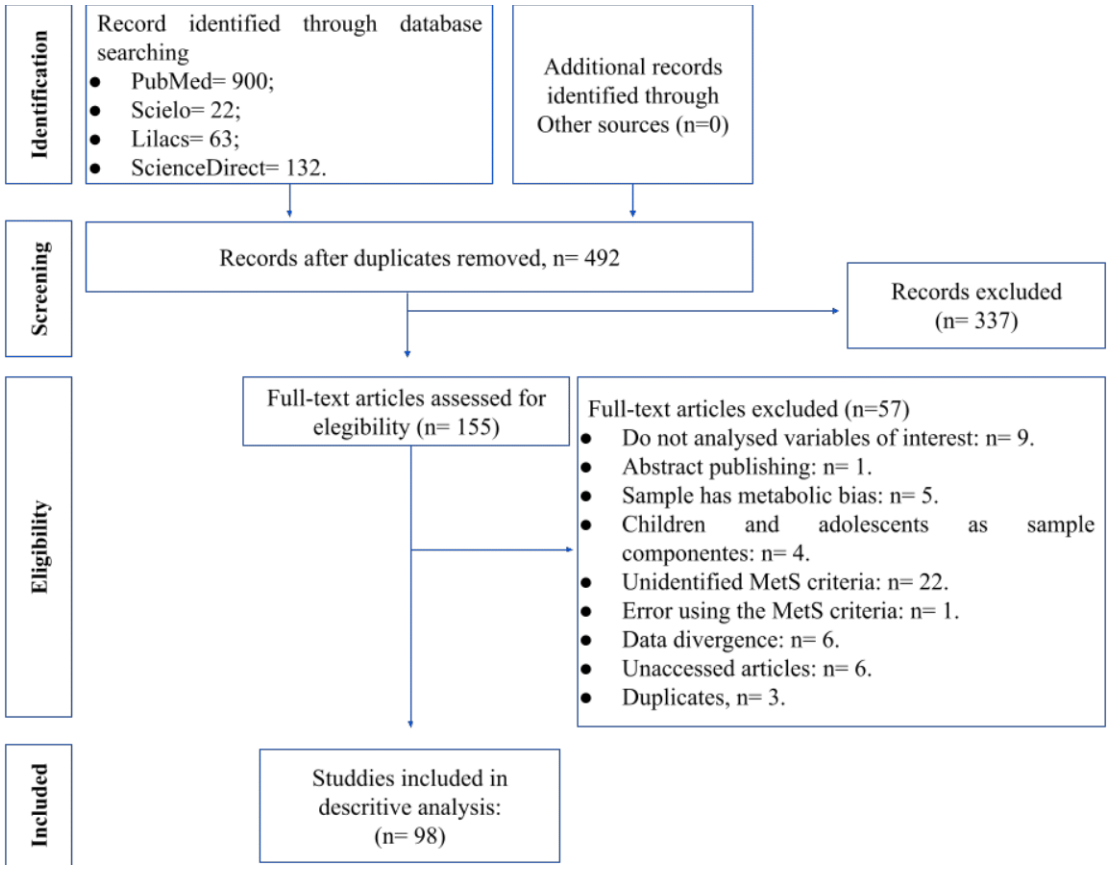

Figure 1 Review workflow.

Table 1 Distribution of studies included in the review according to diagnostic criteria

Continent	Total		IDF		NCEP/ATP III		JIS		ASCVD		EGIR		WHO	
	n	A	n	A	n	A	n	A	n	A	n	A	n	A
Africa	26	9234	21	7554	13	4990	4	1493	1	301			1	433
North America	9	7728	2	2120	8	5867								
South America	20	11844	10	4623	13	9921								
Asia	9	5505	4	2707	7	2982								
Europe	20	10642	8	4263	17	9328								
Oceania	1	66			1	66								
Unknown origin	13	27964	5	2309	11	27272					2	446	1	405

n: number of studies. A: sample size from the sum of the participants of the included studies. IDF: International Diabetes Federation. NCEP/ATP III: National Cholesterol Education Program Adult Treatment Panel III. JIS: Joint Interim Statement. ASCVD: American College of Cardiology/American Heart Association Atherosclerotic CVD. EGIR: European Group for the Study of Insulin Resistance. WHO: World Health Organization.

Considering the included studies that employed the IDF criteria, a total of 23, 413 PLHIV were obtained in 50 studies of samples of both genders, with 48 cross-sectional and 2 longitudinal studies (with baseline data). There was variability in the prevalence of MetS among the studies, with the minimum value of 7.8% in a study with sample of unknown origin and maximum value of 55.8% in a survey with sample from Europe. However, there was no statistical difference in the means between the continents. Specific data per geographic region are described in Table 2.

Considering the included studies that employed the NCEP/ATP III criteria, we obtained in 67 samples of both genders, totaling 58,538 PLHIV, of which 64 were cross-sectional studies, 3 longitudinal (with baseline data), 2 prospective cohorts (one with single data and one with baseline data), and 1 prospective observational (with more recent data). The prevalence of MetS ranged from 7.1% in Europe to 58.0% in Africa. However, as observed when the IDF criteria were applied, there was no statistical difference in the mean prevalence of MetS between the continents. Specific data per geographic region are described in Table 3.

Data were collected from 38 studies sampling gender men and 37 gender women according to the IDF criteria, while 29 studies sampling gender men and 28 gender women were obtained using the NCEP/ATP III criteria. The sample of gender women from Africa had a higher mean prevalence of MetS than gender men from the same continent when considering the diagnosis by the IDF criteria. In the other continents, no statistical difference was identified in the prevalence of MetS between gender men and women.

Comparative analysis of samples from gender men did not identify any statistical difference between the continents. On the other hand, lower prevalence of MetS was observed in gender European women and women of unknown origin when compared to those from North America, South America, and Asia in studies with diagnosis by NCEP/ATP III criteria. Specific data per geographic region according to gender are described in Table 4.

Table 2 Metabolic Syndrome prevalence by geographic region according to the IDF diagnostic criteria

Continent	Minimum	Maximum	Mean	Standard deviation
Africa	10,0	42,5	23,5	9,0
n= 7554				
North America	27,0	33,5	30,3	4,6
n= 2120				
South America	10,6	41,4	30,6	12,0
n= 4623				
Asia	19,1	41,4	30,6	10,0
n= 2707				
Europe	10,0	58,8	23,5	17,6
n= 4100				
Oceania	-	-	-	-
n= 0				
Unknown origin	7,8	43,2	20,4	13,6
n= 2309				

n: sample size from the sum of the participants of the included studies. Data from 49 of 50 included studies that used IDF to MetS diagnosis.

Table 3 Metabolic Syndrome prevalence by geographic region according to the NCEP/ATP III diagnostic criteria

Continent	Minimum	Maximum	Mean	Standard deviation
Africa	12,2	58,0	23,9	14,0
n= 4990				
North America	20,0	55,0	33,4	12,7
n= 4045				
South America	12,7	52,0	26,3	10,2
n= 9921				
Asia	19,7	26,7	23,0	2,9
n= 2982				
Europe	7,1	30,3	18,5	6,7
n= 9328				
Oceania	-	-	-	-
n= 0				
Unknown origin	8,5	52,2	22,4	14,6
n= 27272				

n: sample size from the sum of the participants of the included studies. Data from 67 of 70 included studies that used NCEP/ATP III to MetS diagnosis.

Table 4 Metabolic Syndrome prevalence by geographic region according to gender

Continent	NCEP/ATP III		IDF	
	Man	Woman	Man	Woman
	n= 15816	n= 9500	n= 7240	n= 5574
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Africa	19,7 ± 14,3	25,4 ± 16,9	14,4 ± 10,3	29,1 ± 11,1*
North America	30,3 ± 11,6	32,1 ± 17,4&	30,1 ± 0,1	34,9 ± 14,3
South America	22,4 ± 8,2	32,9 ± 14,9&	24,1 ± 13,9	32,4 ± 17,5
Asia	21,0 ± 5,8	35,4 ± 15,5&	26,7 ± 9,8	40,2 ± 6,5
Europe	20,3 ± 5,5	17,1 ± 3,1	26,0 ± #	
Oceania	29 ± #			
Unknown origin	19,6 ± 17,4	17,1 ± 15,6	17,7 ± 11,8	28,6 ± 18,2

n: sample size from the sum of the participants of the included studies. SD: standard deviation. NCEP/ATP III: National Cholesterol Education Program Adult Treatment Panel III. IDF: International Diabetes Federation.

It does not have data on the standard deviation, as these are data from a single study. *P<0,05 comparing Man and Woman on the same continente; Teste Mann-Whitney. & P<0,05 comparing to Europe and unknown origin sample; Teste de Kruskal-Wallis and Student-Newman-Keuls Post test.

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Discussion

The MetS results from the complex interaction between a set of factors, including: RI, obesity, dyslipidemia and SAH, consisting in an important risk indicator for the development of cardiovascular disease (CVD) and diabetes mellitus type 2 (DM2).[1] In PLHIV, multiple conditions contribute to its triggering, among them: HIV infection, which predisposes to chronic inflammation and immune activation; Antiretroviral (ARV), through metabolic toxicity; in addition to traditional risk factors, to which the entire population is exposed.[16] Thus, these aspects contribute to the variations in the prevalence data of MetS in this population.[17]

Regarding the isolated viral action on the genesis of MetS, the literature is limited since most countries start ART immediately after the diagnosis of HIV infection.[18] On the other hand, an association between HIV, chronic inflammation and immune dysfunction has been described, even in cases of viral suppression, triggering disturbances in lipid metabolism and endothelial dysfunction.[16] Corroborating such findings, HIV has also been reported to promote a chronic inflammatory state, potentiating glucose intolerance and in turn, IR.[9] Furthermore, it is hypothesized that the chronic inflammatory state induced by HIV predisposes to the development of DM.[16]

When untreated, HIV causes the depletion of memory T-CD4+ cells, causing immunodeficiency and evolving to AIDS.[19] Its pathophysiology runs with the activation of the innate and adaptive immune systems, generating a chronic low-grade inflammatory state, caused by pro-inflammatory mediators, among them Interleukin-6 and Tumor Necrosis Factor-α,[20] leading to vascular alterations, coagulation status, and organ damage.[19]

Its pro-atherogenic action occurs by the decrease of the arterio-protective function of hihg-density lipoprotrein (HDL), impaired due to inflammation, added to the increase of very-low-density lipoprotein (VLDL), which further increases the atherosclerotic risk.[21] In addition, it was observed the increase of small particles of HDL3b type, in view of the larger particles of HDL2a, in a population of untreated PLHIV,[22] indicating that the free cholesterol coming from these smaller particles is rapidly extracted by the liver, without esterification, a process that occurs in the already mature HDL.[23]

Moreover, it is proposed that HIV infection promotes mutations in 3 microRNAs: MiR-27, MiR-126 and MiR-1307, involved in lipid metabolism, anti-inflammatory and anti-atherogenic action, added to the development of DM, resulting in metabolic dysfunction and CVD, such as atherosclerosis.[22] In contrast, there was no significant difference between the average levels of triglycerides (TG), nor in the analysis of homeostatic model assessment (HOMA) indexes for the study of diabetes, although it was noted higher levels of hemoglobin A1c (HbA1c) in groups of PLHIV, when compared to the HIV-negative group.[22]

The TARV is effective in blocking the replication of HIV,[24] increasing life expectancy, resulting in the aging of this population.[25] Metabolic disorders are predominant in PLHIV,[26] derived from HIV infection itself, in addition to ART that emerges as a potent factor contributing to the emergence of these events.[27,28] However, some studies have concluded that the metabolic effects stem from the use of ART and not from HIV infection.[29,30]

Nowadays, the standard treatment for PLHIV is through the combination of at least three ARVs that act in at least two different molecular targets, among the main groups of ART are: protease inhibitors (PI), integrase inhibitors (INI), nucleoside reverse transcriptase inhibitors (INTRs) and non-nucleoside reverse transcriptase inhibitors (INNTRs).[31] In this review, it was observed that PIs, INTRs and INNRTs were the most frequently cited drugs regarding negative effects on metabolism.

PI use leads to alterations in metabolism[32] such as dyslipidemia,[33] fat redistribution[34,35,36] and IR, justified by inhibition of the activity of glucose transporters GLUT1 and GLUT4 at the plasma membrane.[14] In obese patients, hypertensive patients and/or patients with lipodystrophy, the risk of effects resulting from the use of PI increases.[37] Furthermore, some studies show that long-term PI use is associated with MetS in PLHIV.[35,38,39] In contradiction, one study stated that there is no such association.[40] However, it has been observed that ART leads to dyslipidemia characterized mainly by hypertriglyceridemia and decreased levels of HDL cholesterol,[41,42] which is a free cholesterol acceptor and has anti-inflammatory properties.[23]

One study observed that PI regimens combined with zidovudine (AZT) had higher prevalence of elevated TG compared to PI regimens combined with tenofovir (TDF).[43] Also comparing the drug groups, IP-based ART has been shown to be more likely to induce lipodystrophy compared to INNTRs-based ART.[44] INTRs have also been found to affect fatty acid oxidation in muscle[29] and can lead to the development of MetS.[36] Dolutegravir is an integrase ribbon transfer inhibitor, leads to increased abdominal obesity (AO), which in turn predisposes to the development of MetS, but the mechanisms justifying this relationship are still unknown.[45]

Several studies have concluded that the longer the duration of ART, the greater the risk for developing MetS.[26,46,47,48,49] In contrast, one study showed that there was no such association,[50] justified by differences in race and gender of the population. Studies evaluating the prevalence of MetS among ART-exposed and ART-virgin populations have found that MetS is more prevalent in the ART-exposed population.[51,52,53]

Moreover, ART has been associated with the development of hepatic steatosis because of weight gain in PLHIV,[54] in addition to the progressive increased risk of developing lipodystrophy,[55] among the INTRs, mainly AZT and stavudine[44]. Another study showed that ART may contribute to the development of exaggerated arterial remodeling, especially in PLHIV using INRTs and INNRTs.[56]

The main metabolic problems such as low HDL, hypertriglyceridemia[14] and OA[57] can be justified by risk factors associated with MetS that are modifiable, such as sedentary lifestyle,[7,57] overweight, poor diet, alcohol consumption and smoking.[58–61]

MetS is more frequent in PLHIV with overweight, obesity, or high abdominal circumference,[62,63] with obesity being more prevalent in females.[64] Individuals with high abdominal circumference have a higher prevalence of high total cholesterol (TC) and low-density lipoprotein (LDL).[62] One study showed that overweight patients have a fourfold increased risk for developing MetS,[65] however, another study found a lower prevalence of MetS in overweight or obese patients aged 60 to 75 years.[66] Evidencing that not only the behavioral factors, but also socio-demographic factors interfere in weight gain in PLHIV.[63]

Smoking is a prevalent risk factor among PLHIV[40] and has a significant association with MetS.[62,63] One study showed no association between alcohol consumption and MetS,[52] however, the use of alcoholic beverages has been indicated as a risk factor for the development of MetS in PLHIV.[7] Furthermore, family history of hypertension[58] and lack of formal education were factors associated with MetS.[57]

Thus, it is inferred the importance of prevention of diseases and health promotion, through multidisciplinary monitoring,[67] offering nutritional counseling for PLHIV[64,68,69] because the diet with low amounts of fat, leads to reduced body mass,[70] in addition to advice for modification of lifestyle,[13,59,68,71,72,73,74,75,76] such as: reducing alcohol consumption[48], smoking cessation,[40,64,72,73,77] encouraging regular exercise,[26,48,73,74,77,78] and also, modification of ART regimen when necessary.[64] This regular support contributes to a lower prevalence of MetS.[79] All these behavioral changes also reflect in the decrease of CVD.[80]

It was found that the prevalence in PLHIV has great variability in different samples with values ranging from 7.1% to 58%. However, there was a high prevalence of MetS in the study population when compared to the general population.[81]

In this review, it was noted that the prevalence of MetS was higher in African women than in African men. This may be associated with the longer time of HIV diagnosis.[82] In addition, it is noted that women have higher mean waist circumference[78] and lower HDL levels.[78,83] AO, CT/HDL-C ratio ≥3.0 and specific ART regimens was associated with MetS in African women and not in men.[83]

It was noted that women from Europe and of unknown origin had a lower prevalence of MetS than women from South America, North America and Asia. The picture of MetS was mainly driven by high TC, TG and the presence of AO[69,84,85] and low HDL levels,[84] higher body mass index (BMI) and aging[86] may also be related to the increased prevalence of AO, abnormal HDL-C and PI use[46,86] in South American women. In North American women, the association between MetS and PI use has conflicting data[71,87], and it is not possible to establish a causal relationship between these variables. Furthermore, HIV viral load itself, BMI, age, smoking and specific ARVs were associated with MetS.[71]

Ethnicity can influence MetS, white or Hispanic women had lower HDL and higher TG levels compared to African American women,[71] Hispanic women had a higher prevalence of MetS compared to men, and OA was the factor influencing this difference.[88]

The studies available in the literature are scarce for certain geographical regions, limiting the joint analysis of the worldwide prevalence of MetS. Moreover, some studies that addressed its prevalence in the same continent showed variable results, resulting in high standard deviation.

Conclusion

The studies available in the literature are scarce for certain geographical regions, limiting the joint analysis of the worldwide prevalence of MetS. Moreover, some studies that addressed its prevalence in the same continent showed variable results, resulting in high standard deviation.

In summary, the studies available in the literature reveal that the prevalence of MetS in PLHIV has high numbers. The prevalence of MetS ranged from 7.8 to 55.8% (IDF) and 7.1 to 58% (NCEP/ATP III). The prevalence of MetS in Africa was higher in gender women than men (IDF) and European women and women of unidentified origin had a lower prevalence than women from Asia, South and North America (NCEP/ATP III).

The following factors were identified as being associated with the prevalence of MetS in PLHIV: female gender, advanced age, use of specific ARVs, longer duration of ARV use, longer duration of HIV infection, lipodystrophy, family history of DM, high carbohydrate intake, physical inactivity, lower level of education, and advanced HIV disease. Thus, the importance of multidisciplinary monitoring of PLHIV is emphasized, in addition to encouraging changes in lifestyle of this population, especially the regular practice of physical exercise.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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