HIV/AIDS - Research and Palliative Care

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REVIEW

Biological Depiction of Lipodystrophy and Its Associated Challenges Among HIV AIDS Patients: Literature Review

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Abstract: Lipodystrophy syndrome is a medical condition characterized by the absence of adipose tissue without any underlying starvation or macromolecule breakdown. In HIV AIDS patients, the use of highly active antiretroviral therapy (HAART) can lead to an acquired form of lipodystrophy, with a prevalence ranging from 10% to 83% among HIV AIDS patients. It was aimed to review the current understanding of biological depiction and challenges related to lipodystrophy in AIDS patients. Relevant articles published in the English language were searched in PubMed, Google Scholar, and Google. Keywords used for the search were: lipodystrophy, lipodystrophy and HIV, ART and lipodystrophy, HIV treatment, metabolic syndrome and HIV. Articles with full abstract information were read for those that met the objective criteria of the review, then full text of the articles was accessed and used. It was revealed by the literature that patients who developed lipodystrophy are characterized by insulin abnormality, obesity, diabetes mellitus, dyslipidemia, fatty liver disease, and ovarian dysfunction. Anthropometric measurements have been known to change significantly with lipodystrophy. HIV patients suffering from hepatitis C virus, hepatitis B virus, who take a protease inhibitor, are changing treatment or duration of treatment, and are women are the common risk factors for lipodystrophy. The metabolic syndrome seen in HIV patients associated with lipodystrophy can further be complicated to different adverse health effects and can result in increased morbidity and mortality rate if not treated. Existing studies have successfully identified several challenges faced by HIV AIDS patients due to lipodystrophy, including low self-esteem, compromised quality of life, and poor treatment adherence. However, it is crucial to acknowledge that there may be numerous other challenges that have yet to be discovered, emphasizing the need for further studies. It is recommended that managing dyslipidemia, treating diabetes mellitus, modifying lifestyle, and improving the anthropometric measurements have crucial roles to halt further complications associated with lipodystrophy.

Keywords: lipodystrophy, HIV, highly active antiretroviral therapy, dyslipidemia

Introduction

Lipodystrophy syndrome is a collection of disorders manifested as a lack of adipose tissue in the absence of starvation and breakdown of macromolecules. Severe forms of metabolic syndrome can be linked to these disorders because abnormal fat deposition prevents fat from being stored in the appropriate subcutaneous depots.[1]

Lipodystrophy was first described by Carr et al in 1998[2] among acquired immune deficiency syndrome (AIDS) patients who were taking highly active antiretroviral therapy (HAART) for a prolonged time. Those HIV-infected patients on HAART develop an acquired type of lipodystrophy syndrome (HALS); these types are characteristically similar to the one seen in obesity.[3]

A distressing morphologic change in body habitus is evidenced by the accumulation of central fat (lipohypertrophy) as well as an increase in waist to hip ratio, buffalo hump, enlarged breast, arm fat accumulation, and multiple lipomas. Lipodystrophy may also manifest as lipoatrophy of the face, abdomen, arms, legs, or buttocks that results in sunken cheeks, exaggerated muscles, bones, arteries and veins. It occurs most often in patients responding to HAART.[2,4]

Different studies report about 11% to 83% of HIV AIDS patients have developed lipodystrophy due to the HAART they use.[4]

Received: 21 November 2023
Accepted: 8 March 2024
Published: 3 April 2024

The increased risk of lipodystrophy is common in patients who take NRTIs and protease inhibitors.[5] The proposed pathogenesis of lipodystrophy for protease inhibitors and nucleoside reverse transcriptase inhibitors (NRTI) is through halting lipid metabolism and causing mitochondrial toxicity.[6]

Lipodystrophy patients experience increased distress as a result of the cosmetic effects as well as a perception that the obvious facial and extremity wasting represents a disease progression and disclosure of HIV status[2] and it also negatively affects the self-esteem of people living with HIV (PLHI), this makes adherence to ART challenging and can result in a sedentary life style.[7,8]

Several factors may contribute to lipodystrophy, including sex difference, intravenous drug use, age, and the period of antiretroviral therapy usage. Duration of indinavir treatment may further contribute to lipodystrophy with central obesity.[6] Female gender, co-infection with hepatitis C, HIV infection status before HAART initiation, NRTI, and protease inhibitors can be risk factors of the condition.[9]

Method

Relevant articles published in the English-language were searched for in PubMed, Google Scholar and Google. Keywords used for the search were: lipodystrophy, lipodystrophy and HIV, ART and lipodystrophy, HIV treatment, metabolic syndrome and HIV. Articles which contained full abstract information were read; when they met the objective criteria of the review, then the full text of the articles was accessed and used.

Forms of Lipodystrophy Syndromes

Lipodystrophy is a condition that is characterized by body shape abnormalities caused by changes in body fat distribution. It comprises three forms: lipoatrophy, lipohypertrophy and a mixed pattern of both conditions.[10] Lipoatrophy is defined as the loss of subcutaneous fat, which is most noticeable on the face, buttocks, and extremities.[11] Lipohypertrophy refers to the accumulation of fat in certain body regions, including the abdomen, back of the neck (buffalo hump), breasts, and multiple lipomas. See images in Leow et al.[12]

HIV AIDS patients who have lipodystrophy are characterized by abnormalities in their body composition, metabolic substance levels, anthropometric measurements, and endocrine metabolic levels.[8,13,14] Patients who have developed HIV-associated lipodystrophy syndrome (HALS), may have complications like cardiovascular disease, dyslipidemia, neurological disorders, kidney and liver diseases, bone disorders, and diabetes mellitus type 2; health problems related to abnormality in fat redistribution and metabolic substance level disturbance.[13,15,16]

Epidemiology

There is no standardized criteria to diagnose lipodystrophy with AIDS disease; therefore, the epidemiological characteristics like prevalence, risk factors, incidence, responses and severity vary significantly from report to report. The prevalence of lipodystrophy varies from 10% to 80% in AIDS patients. The wide variation may also be due to differences in geographical location, age, genetic makeup, lifestyle standard, and methodological approaches.[14]

Different cross-sectional studies across the world reported the prevalence of lipodystrophy varies as 44%, 32.4%, 69.2%, 30%, and 16.3%[2,9,17–19] respectively in all age groups of HIV infected patients (Table 1).

Pathophysiology

If an antiretroviral is used to treat HIV AIDS, it contributes to lipodystrophy in AIDS patients and the mechanisms are not fully understood.[34]

HIV-associated lipodystrophy syndrome (HALS) is highly associated with the use of protease inhibitors (PI) and nucleoside reverse transcriptase inhibitors (NRTIs). The mechanisms are: via mitochondrial toxicity that may be caused by abnormally proliferated mitochondria, the structure and DNA makeup of mitochondria. Secondly, via adipocyte cell differentiation disturbance through down regulation of adipocyte forming transcription factors or genes like C/EBPA (a gene code for enhancer-binding protein alpha) and peroxisome proliferator-activated receptor gamma (PPARγ). Thirdly, via decreased secretion and release of adiponectin from adipose tissue. Moreover, HAART can increase macrophage

Table 1 Studies Finding Showing Biological Depictions and Challenges Related to Lipodystrophy in AIDS Patients

Type of the Study	Country	Conducted by	Main Findings
Prevalence and risk actors			
Cross-sectional	Serbia	Dragovi G et al, 2014[9]	The prevalence of lipodystrophy was 69.2%, NRTIs and protease were at high risk for lipodystrophy.
Cross-sectional	Brazil	Maria T et al, 2017[20]	The prevalence of lipodystrophy was 50.8%, and lipodystrophy was associated with excess weight and predisposes to the development of metabolic syndrome.
Cross-sectional	Nigeria	Iwuala SO et al, 2015[21]	The prevalence of lipodystrophy was 26%, and Male gender and HAART use were the factors associated with lipoatrophy.
Cross-sectional	India	Kalyanasundaram AP et al, 2012[22]	Among the patients on ART, the prevalence of lipodystrophy was 60.7%.
HAART regimen and lipodystrophy			
Prospective Cohort	Thailand	Aurpibul L et al, 2012[23]	Substitution of stavudine with zidovudine resulted in decreased severity or resolution of lipodystrophy among HIV-infected children and adolescents.
Cross-sectional, comparative, descriptive study	Brazil	Tsuda LC et al, 2012[24]	Reported zidovudine, lamivudine and efavirenz seemed to protect against lipodystrophy syndrome.
Systematic review	Low economic countries	Finkelstein JL et al, 2015[11]	Nevirapine was associated with a 50% lower odds of lipoatrophy (OR 0.50, 95% CI: 0.26–0.95, <0.001).
Cross-sectional	India	Kalyanasundaram AP et al, 2012[22]	Lipodystrophy was reported in 62.1% of patients on ZDV regimens and 58.8% of patients on d4T regimens. There was no significant difference in the prevalence of lipodystrophy and type of ART in the study population.
Randomization trial	Uganda and Zimbabwe	Bwakura-dangarembizi M et al, 2015[25]	Long-term zidovudine-based ART is associated with similar body circumferences and skinfold thicknesses to abacavir-based ART with low rates of lipid abnormalities and clinical lipodystrophy.
Lipodystrophy related complication and modification of the syndrome			
Cohort	Switzerland	Bouatou Y et al, 2 018[26]	About 24.9% of HIV patients on follow-up developed lipodystrophy during and is independently associated with chronic kidney disease (CKD) after adjustment for previously reported risk factors.
Cross-sectional	Democratic republic of Congo	Tshamala HK et al, 2019[19]	Lipohypertrophy, hypercholesterolemia, and lactic acidosis emerge as a frequent metabolic disorders in children and adolescents due to ARV therapy.
Cross-sectional	Brazil	Beraldo RA et al, 2017[27]	Lifestyle changes with nutritional follow-up, regular physical exercise, and a change in the therapeutic regimen may contribute to improve the metabolic profile and consequently reduce the cardiovascular risk of AIDS patients.
Cohort	USA	Safar Zadeh E et al, 2013[28]	Leptin replacement therapy ameliorated both the metabolic and hepatic abnormalities of lipodystrophy. Improvements in non-alcoholic steatohepatitis (NASH) score presumably represents stabilization or improvement of the course of the disease
Review		Nzuza S et al, 2017[29]	If lipodystrophy is not carefully managed, it may ultimately predispose a significant number of patients to increased risks of metabolic syndrome, diabetes and cardiovascular diseases.
Cross-sectional	Israel	Tsiodras S et al, 2019[30]	Adherence to a Mediterranean dietary pattern was favorably related to cardiovascular risk factors in HIV-positive patients with fat redistribution.

(*Continued*)

Table 1 (Continued).

Type of the Study	Country	Conducted by	Main Findings
Challenges related to lipodystrophy			
Review		Nzuza S et al, 2017[29]	Lipodystrophy related cosmetically distressing and socially stigmatizing for many patients leading to decreased adherence to antiretroviral therapy.
Cross-sectional and comparative	Brazil	Siqueira LR et al, 2021[7]	Lipodystrophy negatively affects the self-esteem of HIV infected people and this made it difficult to adhere to ART.
Cross-sectional	Burkina Faso	Guira O et al, 2014[31]	Facial lipoatrophy contributes more to stigma
Cross-sectional	Spain	Méndez ES et al, 2015[32]	About 27% of participants, who feared lipodystrophy, had poor adherence to treatment
Single-site cross-sectional	Switzerland	Verolet CM et al, 2015[33]	Lipodystrophy was associated with a poor quality of life among HIV AIDS patients on HAART.

recruitment, inhibit glucose delivery, impair insulin signal transmission, and generate reactive oxygen species, as well as enhance the formation of interleukin 6 (IL6) and tumor necrosis factor (TNF).[34,35]

The other proposed mechanisms are: impairment of adipocyte differentiation and drug-induced lipodystrophy also leads to an increase in lipolysis. Increased free fatty acid (FFAS) in blood, increased intracellular FFAS, increased ectopic FFAS deposition in different organs like visceral, pancreas skeletal muscle, and liver could be due to lipolysis that happens in subcutaneous tissue.[34] These are the ways in which metabolic substance de-arrangement may happen.

Adipose tissue distribution may be directly affected by HIV-1 viral proteins. Researchers have shown that HIV-1 viral protein R inhibits gene transcription factor PPARγ, which can cause inhibition of adipocyte differentiation in vivo.[34]

Anthropometric Characteristics

Anthropometric parameters of HIV AIDS patients who were on HAART are reported by different works of literature. A report from Kenya in 2013 showed that increased abdominal girth was evident in 40.4% of the patients of whom 24% had isolated abdominal fat accumulation.[2] Another study reported lipodystrophy in HIV AIDS patients was characterized by increased triceps, subscapular and supra-glacial skin folds, and mid-upper arm and leg circumferences in body appearance.[18]

According to research conducted in Thailand, substitution of stavudine (d4T) with zidovudine (ZDV) was associated with an increase in weight-for-age *z* score of children at the time of substitution from −0.91 (SD, 1.0) to −0.76 (SD, 1.1) at 96 weeks (P =0.02), whereas height-for-age *z* score did not change.[23] However, treatment with efavirenz and nevirapine-containing regimens were not anthropometrically differently from the control group in that study.

Similarly, another report from Brazil on patients using antiretroviral therapy showed that 34% of overweight and 20% of obesity were observed.[36] In another study, lipodystrophy was reported as 18.1% in HIV patients who were underweight compared to 5.5% in HIV-negative controls. In the same report, 3.5% of HIV AIDS patients had severe forms of malnutrition and it was statistically significant (P = 0.00). Another finding of the report was that being male or female resulted in different patterns of lipodystrophy, but prevalence in lipodystrophy and HAART regimen were not shown as significantly associated.[22]

Moreover, a study conducted at a pediatric HIV outpatient clinic in London, UK, showed about 27.5% patients had BMI ≥91st percentile, 10.0% ≥98th percentile (BMI), 2.5% had a waist circumference ≥90th percentile, 2.5% had a waist hip ratio ≥90th percentile, 22.5% had ≤10th percentile for hip circumference, 37.5% had ≤10th mid-upper arm circumference and 55.0% had at least one abnormal anthropometric measurement, excluding BMI.[37]

Conversely, other studies did not observe any differences in body habitus like waist/hip circumference ratio, hip circumference, BMI, and waist circumference between HIV infected and non-HIV infected patients on treatment.[8]

Risk Factors

Demographic, anthropometric, and behavioral factors associated with lipodystrophy were reported differently by different literature.[3,6,11]

According to a study conducted in Serbia, it was determined that 69.2% of the patients with lipodystrophy, along with HIV also had hepatitis C infection (HCV) and 7.9% were co-infected with hepatitis B virus (HBV).[9] Additionally, several other studies demonstrated the association between HCV co-infection with HIV and lipodystrophy.[9] In contrast, some other studies did not find a significant difference in the proportion of HCV infection between HIV and non-HIV infected groups.[3]

According to the Da Silva et al, report, women with HIV AIDS had a 1.87 relative hazard risk of having any kind of lipodystrophy when compared to men.[6] In contrast, another study did not show the risk of having lipodystrophy among HIV AIDS patients on treatment and those who were new to treatment was any different according to their gender and age.[38]

Research conducted in Thailand consisting of 247 HIV-infected adults showed that facial atrophy and abnormally enlarged female breasts were observed in 50% and 42% of patients who were on PI respectively compared to non-PI ART. A study conducted in India has revealed that transitioning HIV patients from NNRTIs to PI upon treatment failure leads to a significant increase in T-cell count. This increase in T-cells has been found to be associated with a 10% annual development of lipodystrophy in these patients. Consistently, using PI treatment among Brazil AIDS patients, was associated with increased self-reported lipodystrophy.[6]

A similar finding from another study showed that stavudine had about 2.8 to 7.8 greater risk of being associated with lipodystrophy in HIV AIDS when compared to other anti-retroviral treatments.[11] Additionally, treatment duration of six month by indinavir was also believed to contribute to the occurrence of a 1.26 greater rate of lipodystrophy with central obesity.[6]

Characterization of Lipodystrophy in Terms of Laboratory Parameters

As a result of lipodystrophy, metabolic abnormalities such as insulin resistance, steatosis, hypertriglyceridemia and diabetes mellitus often occur in conjunction with the severity of the comorbidities correlated with the level of adiposity.[34]

A study from Sergipe, Brazil in 2017 showed metabolic syndrome (MS) (mainly lipid and glucose abnormalities) was identified among 59.3% of patients diagnosed with lipodystrophy.[20] Similarly, Beraldo et al reported the prevalence of hyperglycemia was 24.8% in HIV AIDS patients.[27]

A report from Barcelona, Spain showed that AIDS patients who had lipodystrophy, also had increased CD4+ lymphocyte, decreased viral load, and increased triglycerides and cholesterol levels compared with those without lipodystrophy. Furthermore, There was an increased risk of lipodystrophy in patients with a high triglyceride level who had started HAART.[6]

A cross-sectional study conducted in Melbourne, Australia involved one hundred HIV-positive patients; a multivariate analysis of low-density lipoprotein cholesterol (OR, 2.65; CI, 1.4–4.9) showed an increased risk and current tenofovir or abacavir use with reduced risk of lipodystrophy (OR, 0.096; CI, 0.011–0.83).[39]

Many other studies showed that lipid parameters abnormally change in HIV-infected individuals. For example, hypercholesterolemia in children on ARV therapy was seen in 7.5%, and 33.3% of two different studies[15,19] respectively; hypertriglyceridemia in children on ARV therapy was seen in 16.2% and 7% of children on antiretroviral therapy-naive;[19] hypertriglyceridemia and reduced HDL were in 55.7% and 25.9%[15,27] of people living with HIV/AIDS respectively.

On the other hand, there were other studies that indicated there were no significant differences in blood lipid parameters, such as HDL-C, total cholesterol, LDL-C, triglyceride, and insulin levels, between individuals with AIDS and ART-related lipodystrophy and those without this condition.[3,17]

Complications

There is a severe form of the metabolic syndrome in lipodystrophic patients, which consists of dyslipidemia, insulin resistance, diabetes, and ovarian dysfunction.[40]

Patients with lipodystrophy have insufficient subcutaneous adipose tissue storage capacity, and severe insulin resistance (IR) is also observed, often manifested as acanthosis nigricans, type 2 diabetes mellitus (T2DM), hyperlipidemia, and nonalcoholic fatty liver disease (NAFLD).[41]

Heart problems were reported in 30.4% of patients with lipodystrophy by the international chart review study and patients with insulin resistance, diabetes, and dyslipidemia may be predisposed to atherosclerotic cardiovascular disease (ASCD).[42] Similarly, according to a 7-year surveillance study including patients around the world, darunavir combined with ritonavir increased the risk of cardiovascular disease (CVD) by 1.59%.[43]

As demonstrated in the replacement therapy of leptin, the complication manifested as NASH was observed in 86% of HIV patients who had the genetical and acquired form of lipodystrophy, but the prevalence of the complication was reduced to 33% upon leptin replacement therapy on average over 25.8 ± 3.7 months ($p = 0.0003$).[28]

Current Treatment of Lipodystrophy

Effective treatment options are available to address the body appearance disturbances caused by lipodystrophy in HIV patients. These interventions not only help in resolving the physical changes but also play a crucial role in boosting the patients' self-esteem and overall satisfaction with the treatment. Furthermore, the utilization of appropriate treatment methods can effectively prevent the occurrence of complications associated with lipodystrophy.[35]

Lifestyle Modification

Diet and Nutritional Modification Therapy

There is currently no universally accepted nutritional guideline for lipodystrophy syndrome. However, research has indicated that individuals with HIV-associated lipodystrophy syndrome (HALS) may find the Mediterranean diet beneficial. This dietary approach emphasizes the consumption of a variety of vegetables, dairy products, saturated fats, fruits, whole grain cereals, red meat, and fish.[34]

To attain normalized blood lipid levels, reduced central obesity, corrected body posture, and increased muscle strength, it is advisable to engage in a combination of physical exercise that focus on the cardiovascular system and muscular strengthening activities.[35]

Managing Underlying Diabetes Mellitus

Metformin

Metformin is a pharmaceutical drug employed in the management of type 2 diabetes mellitus; however, its efficacy does not extend to the treatment of lipodystrophy. A considerable number of individuals afflicted with lipodystrophy also experience diabetes mellitus, leading to the prescription of this medication as a preventive measure against the exacerbation of lipodystrophy, which can be intensified by the presence of diabetes mellitus.[34]

This medication has been found to have a positive impact on patients with insulin resistance, leading to a decrease in BMI, blood pressure, and blood lipid levels. Additionally, it can improve insulin action resistance in HIV patients with lipodystrophy.[35,44]

Other Medications for Diabetes Mellitus

Despite not being specifically intended for the treatment of lipodystrophy, rosiglitazone and pioglitazone (thiazolidinedione) are commonly prescribed to manage type 2 diabetes mellitus and mitigate the associated complications of lipodystrophy.[34]

Management of Dyslipidemia

Statins

Studies have indicated that the administration of pravastatin and rosuvastatin can lead to a reduction in both total and LDL cholesterol levels, while also potentially promoting an increase in subcutaneous adipose tissue in the extremities.[34]

In a combined analysis of two research studies, tesamorelin demonstrated a significant reduction of visceral adipose tissue (VAT) in individuals with abdominal obesity caused by HIV infection. The treatment resulted in a 15.4% decrease in VAT, while also leading to an increase in insulin-like growth factor one (IGF-1) levels within the normal physiological range. Furthermore, tesamorelin exhibited the ability to lower triglyceride levels and reduce the ratio of total cholesterol to HDL cholesterol in comparison to the placebo group.[45]

Fibrates, nicotinic acid, ezetimibe are also used for the treatment of blood lipid abnormalities in HALS.[34]

Leptin Replacement Therapy

Metreleptin, a synthetic form of leptin, is prescribed as a supplementary treatment alongside dietary modifications to address the complications arising from leptin deficiency in individuals diagnosed with congenital generalized lipodystrophy (CGL) and acquired generalized lipodystrophy (AGL). Diker-Cohen et al reported, in a cohort study, the effectiveness of metreleptin was found to be more pronounced in patients with higher baseline metabolic thresholds, including baseline HbA1c levels above 7.0% or 8.0%, triglycerides exceeding 300 or 500 mg/dL, and leptin levels below 4 ng/mL.[46]

Growth Hormone and Growth Hormone-Releasing Factor

Growth hormone (GH)-releasing factor (GHRF) has demonstrated its ability to reinstate the natural regulation of growth hormone (GH) secretion, upholds the regular negative influence of insulin-like growth factor-1 (IGF1) on GH release, and restricts the adverse effects associated with GH and lipohypertrophy in PLWH.[45]

Transplantation

Adipose tissue transplantation has been suggested as an alternative treatment for metabolic abnormalities in lipodystrophy. The process involves isolating and culturing pre-adipocytes, followed by repopulating and transplanting adipocytes. However, despite its intriguing concept, this approach has not been extensively studied, and therefore, the metabolic effects of adipose tissue transplantation in lipodystrophy remain largely unknown. In HIV patients with facial lipoatrophy, autologous fat transfer combined with dermal fillers has been tested primarily for aesthetic purposes, yielding promising results. Additionally, it is worth considering that there have been reported cases where hematopoietic stem cell transplantation, used to treat leukemia or neuroblastoma, led to abnormal distribution patterns of adipose tissue resembling APL later in life. This emerging form of lipodystrophy may offer valuable insights into the genetic and pathophysiological processes underlying lipodystrophy.[41]

Surgical Treatment

Patients who have a chief complaint related to cervicodorsal lipohypertrophy are evaluated for surgery. Excisional lipectomy is the recommended primary treatment due to the limitations of liposuction alone. Liposuction can be used for improved contouring and in subsequent procedures. Although there is a slightly increased risk of complications, adjunctive techniques like quilting sutures and drain placement may be utilized alongside excisional lipectomy.[5]

Conclusions

Both the HIV virus and the combined antiretroviral therapy used in HIV-infected patients can contribute to the occurrence of lipodystrophy. This metabolic syndrome presents in a severe form, with insulin resistance, ovarian dysfunction, diabetes, and dyslipidemia, being prominent features. These abnormalities can further be complicated to different adverse health states, and can result in increased morbidity and mortality rates if not treated. Different findings associate socio-economic, underlying disease state, treatment regimen, and change in regimen with different forms of lipodystrophy. Any form of lipodystrophy is characterized by different altered laboratory parameters like blood glucose, triglyceride, total cholesterol, LDL-C, CD4 lymphocyte, HDL-C count, viral load and altered anthropometric value. To date, the exact cause of lipodystrophy in HIV AIDS patients remains uncertain, despite numerous studies conducted on the subject. Therefore, it is imperative to conduct additional research that can provide a clear etiological identification and shed light on the precise cause. Existing studies have successfully identified several challenges faced by HIV AIDS patients due to lipodystrophy, including low self-esteem, compromised quality of life, and poor treatment adherence. However, it is crucial to acknowledge that there may be numerous other challenges that have yet to be discovered, emphasizing the need for further studies.

Recommendation

Even if it is helpful to treat HIV patients with cART, the effect of the drug and the virus itself have huge health impacts on the patients' health status. Lipodystrophy that happened due to these drugs has disgusting features on the

patients which affect both physiological and psychological appearance of the patients. Therefore it is recommended to halt further complications that are associated with this state through management of dyslipidemia, treating diabetes mellitus, life style modification to reduce risk factors and improve the anthropometric measurements.

Abbreviations

AC, abdominal circumference; AIDS, Acquired Immune Deficiency Syndrome; BMI, body mass index; $CD4^+$, cluster of differentiation four, CI, confidence interval; GH, growth hormone; HAART, highly active antiretroviral treatment; HAZ, height for-age z-score; HCV, hepatitis C virus; HIV, human immune virus; MS, metabolic syndrome; NRTI, nucleoside reverse transcriptase inhibitors; OR, odds ratio; PLWH, people living with HIV; PPARγ, peroxisome proliferator activated receptor gamma; VAT, visceral adipose tissue.

Data Sharing Statement

All the literature used to prepare this manuscript can be available upon request.

Funding

No funding was used in this review.

Disclosure

The author reports no conflicts of interest in this work.

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