Chapter 12
Nutrition and Physical Exercise in Older Patients with HIV

Chiara Mussi

Key Points

- Both nutrition and physical exercise have a crucial role in determining the outcomes of patients infected with human immunodeficiency virus (HIV).
- Since malnutrition is considered a geriatric syndrome, the management approach must be multifactorial to succeed.
- There are many methods to describe malnutrition, but in patients with HIV the Mini Nutritional Assessment (MNA) and Subjective Global Assessment (SGA) are widely used.
- As far as intervention is concerned, WHO recommendations are the most commonly followed guidelines.

C. Mussi, MD, PhD
Centro di Valutazione e Ricerca Gerontologica,
University of Modena and Reggio Emilia, Modena, Italy
e-mail: chiara.mussi@unimore.it

G. Guaraldi et al. (eds.), *Managing the Older Adult Patient with HIV*, DOI 10.1007/978-3-319-20131-3_12,

- Sarcopenic obesity is an expression of malnutrition that is particularly frequent and characteristic of older patients with HIV.
- Physical exercise is important for everybody, but especially in patients with HIV:
  - enhances muscle strength and prevents sarcopenia;
  - improves outcomes of frequent non-HIV, age-related chronic conditions; and
  - reduces markers of chronic inflammation.
- Resistance exercises enhance strength and aerobic exercises improve outcomes.
- Mixed protocols are more complex, but more complete in terms of results.

12.1 Overview

Nutrition and physical exercise have a central and crucial role in influencing outcomes in older patients with HIV (Fig. 12.1) [1]. Emerging data shows that both nutrition and physical exercise can impact viral replication and the immune system in HIV. Optimal nutrition is an important adjunct in the clinical care of patients with HIV. Nutritional interventions may improve symptom management, the quality and span of life, support the effectiveness of medications, and improve the resistance of the patient to infections and other disease complications by altering immunity. Moreover, malnutrition can be considered a geriatric syndrome (for the definition, see Chapter 7), so the management has to be multifactorial.

The management of nutrition in older patients with HIV can be divided into assessment of risk of malnutrition (tools to define nutritional status) and intervention (asymptomatic and symptomatic phases of HIV infection).

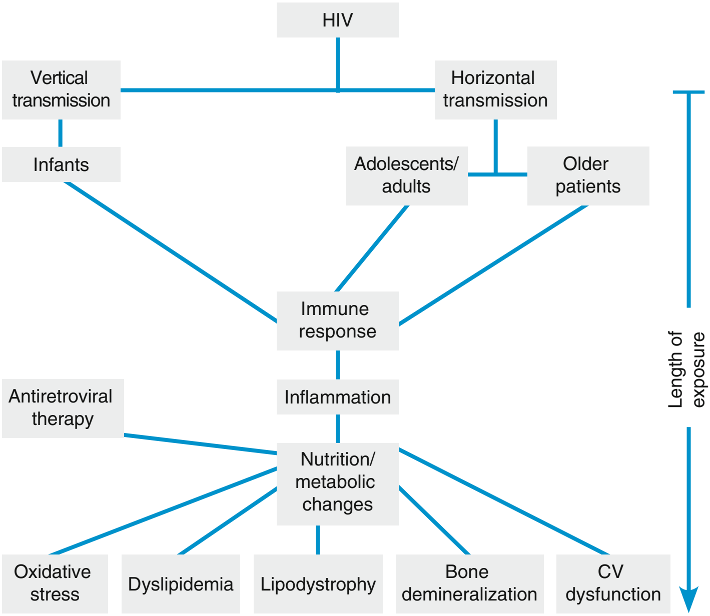

FIGURE 12.1 The central role of nutrition in the evolution of HIV [1]. *ART* antiretroviral therapy, *CV* cardiovascular (Reproduced with permission from © Dove Medical Press Ltd)

12.2 Assessment of Risk of Malnutrition

Screening for malnutrition at an early stage allows the intervention to be most successful. History, physical examination, and anthropometric measurements are essential parts of any nutritional evaluation. Incorporating biochemical measurements in the routine nutritional assessment provides an often-needed objective dimension, nevertheless, interpreting these measurements must take into consideration the normal biological changes seen with aging and the simultaneous presence of HIV infection.

12.2.1 Anthropometric Evaluation

The physical examination should determine general body habitus, body weight and height, and the presence of any sign of nutritional deficiency in the skin, hair, nail, eyes, mouth, or muscles. The body mass index (BMI) is a useful measurement for assessing nutritional status and can be calculated using the formula (BMI = weight (kg)/[height (m)]^2). The association between BMI and mortality in older adults follows a J-shaped curve, unlike the U-shaped curve relationship in younger adults. Data from several studies of individuals aged 60–90 years indicate the lowest mortality occurred at progressively increasing body weight, and higher mortality occurred with lower body weight [2]. BMI, however, may not be as informative in the elderly as it is at younger ages. There is little documentation relating BMI to direct measurements of body composition in the elderly, especially at very old ages or in non-Caucasian ethnic groups. In addition, stature often cannot be measured accurately in the elderly individuals because of increased prevalence of spinal curvatures, which is reported to be as high as 30 %. For such individuals, the estimation of stature from knee height is probably the best method for providing this information [3]. The anthropometric evaluation includes measurements of arm circumference, mid-arm muscle area, calf circumference, triceps skin-fold, and subscapular skin-fold thickness. Calf circumference has been recommended as a more sensitive measure of the loss of muscle mass in the elderly than arm circumference and mid-arm muscle area [4]. Skin-fold thickness is frequently used to assess body fat stores, nevertheless, the accuracy of this technique in nutritional evaluation is hampered by the unpredictable response of subcutaneous fat to undernutrition and the absence of a definite correlation between skin-fold thickness and total body fat in older men, especially in patients with HIV.

12.2.2 Biochemical Profile

Serum albumin, total cholesterol, total lymphocyte count, and proteins with a shorter half-life than albumin (eg, prealbumin, retinol binding proteins, and leptin) are frequently used to assess malnutrition in older patients without HIV infection. However, specificity as markers of malnutrition in patients with HIV is lost.

Serum albumin level is the most frequently utilized biochemical marker for malnutrition in older patients. Albumin levels less than 3.5 mg/dL are strongly suggestive of malnutrition and levels less than 3.2 mg/dL are excellent predictors of mortality and morbidity in the elderly [5]. Nevertheless, in patients with HIV this biochemical parameter is not as useful as in non-infected older patients, since it does not consistently predict malnutrition outcomes. This suggests that albumin may measure end stage disease as well as malnutrition and should not be used as a proxy for nutritional status without further study of its association with validated measures [6].

12.2.3 Screening Tools

In literature there are many screening tools to evaluate malnutrition in elderly patients, but they are not validated in the HIV population. The two tests proposed are widely used in both older patients with and without HIV.

The Mini-Nutritional Assessment (MNA®) (Fig. 12.2) [7] evaluates the risk of malnutrition in elderly people. It is considered one of the most complete screening tools for malnutrition, since it involves anthropometric measurements, global assessment, dietary questionnaire, and a subjective assessment. It enables a patient to be categorized as normal (adequate nutrition), borderline (at risk of malnutrition), or malnourished. Ruiz et al. [8] suggest that the MNA® can be

Mini Nutritional Assessment
MNA®

Nestlé NutritionInstitute

Last name: First name:

Sex: Age: Weight, kg: Height, cm: Date:

Complete the screen by filling in the boxes with the appropriate numbers.
Add the numbers for the screen. If score is 11 or less, continue with the assessment to gain a Malnutrition Indicator Score.

Screening

A Has food intake declined over the past 3 months due to loss of appetite,digestive problems, chewing or swallowing difficulties?
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake ☐

B Weight loss during the last 3 months
0 = weight loss greater than 3kg (6.6lbs)
1 = does not know
2 = weight loss between 1 and 3kg (2.2 and 6.6 lbs)
3 = no weight loss ☐

C Mobility
0 = bed or chairbound
1 = able to get out of bed / chair but does not go out
2 = goes out ☐

D Has suffered psychological stress or acute disease in the past 3 months?
0 = yes 2 = no ☐

E Neuropsychological problems
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems ☐

F Body Mass Index (BMI) = weight in kg/ (height in m)^2
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater ☐

Screening score (subtotal max. 14 points) ☐☐

12-14 points:	Normal nutritional status
8-11 points:	At risk of malnutrition
0-7 points:	Malnourished

For a more in-depth assessment, continue with questions G-R

Assessment

G Lives independently (not in nursing home or hospital)
1 = yes 0 = no ☐

H Takes more than 3 prescription drugs per day
0 = yes 1 = no ☐

I Pressure sores or skin ulcers
0 = yes 1 = no ☐

J How many full meals does the patient eat daily?
0 = 1 meal
1 = 2 meals
2 = 3 meals ☐

K Selected consumption markers for protein intake
- At least one serving of dairy products (milk, cheese, yoghurt) per day yes ☐ no ☐
- Two or more servings of legumes or eggs per week yes ☐ no ☐
- Meat, fish or poultry every day yes ☐ no ☐

0.0 = if 0 or 1 yes
0.5 = if 2 yes
1.0 = if 3 yes ☐.☐

L Consumes two or more servings of fruit or vegetables per day?
0 = no 1 = yes ☐

M How much fluid (water, juice, coffee, tea, milk...) is consumed per day?
0.0 = less than 3 cups
0.5 = 3 to 5 cups
1.0 = more than 5 cups ☐.☐

N Mode of feeding
0 = unable to eat without assistance
1 = self-fed with some difficulty
2 = self-fed without any problem ☐

O Self view of nutritional status
0 = views self as being malnourished
1 = is uncertain of nutritional state
2 = views self as having no nutritional problem ☐

P In comparison with other people of the same age, how does the patient consider his / her health status?
0.0 = not as good
0.5 = does not know
1.0 = as good
2.0 = better ☐.☐

Q Mid-arm circumference (MAC) in cm
0.0 = MAC less than 21
0.5 = MAC 21 to 22
1.0 = MAC greater than 22 ☐.☐

R Calf circumference (CC) in cm
0 = CC less than 31
1 = CC 31 or greater ☐

Assessment (max. 16 points) ☐☐.☐
Screening score ☐☐.☐
Total Assessment (max. 30 points) ☐☐.☐

Malnutrition Indicator Score

24 to 30 points	☐	Normal nutritional status
17 to 23.5 points	☐	At risk of malnutrition
Less than 17 points	☐	Malnourished

References
1. Vellas B, Villars H, Abellan G, *et al.* Overview of the MNA® - Its History and Challenges. *J Nutr Health Aging.* 2006;**10**:456-465.
2. Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for Undernutrition in Geriatric Practice: Developing the Short-Form Mini Nutritional Assessment (MNA-SF). *J. Geront.* 2001;**56A**: M366-377
3. Guigoz Y. The Mini-Nutritional Assessment (MNA®) Review of the Literature -What does it tell us? *J Nutr Health Aging.* 2006; **10**:466-487.

For more information: www.mna-elderly.com

FIGURE 12.2 The mini-nutritional assessment [7] (Reproduced with permission from © Nestlé and ® société des Produits Nestlé) used as a unique nutritional screening test that contains a combination of objective and subjective measures (including BMI, weight loss, dietary history, etc), since it is able to detect nutritional problems in elderly patients infected with HIV [8].

The SGA [9] does not use laboratory criteria but relies heavily on functional capacity and physical signs of malnutrition. Specifically, it combines information from the history of the patient (such as weight loss, dietary intake, functional status), physical examination (such as muscle and fat distribution, edema), and the clinician's judgement. As such, it is highly dependent on the screening clinician for accuracy. On initial validation, its ability to predict infection as a complication of malnutrition was compared to six other independent methods (including albumin and anthropometric measures). The SGA was found to be 82 % sensitive and 72 % specific, and out-performed all six methods [10]. Published literature demonstrates SGA as a valid tool for the nutritional diagnosis of hospitalized clinical and surgical patients, and point to a potential superiority of nutritional screening methods in the early detection of malnutrition [11].

12.3 Intervention

An effective intervention to prevent or cure malnutrition should be multifactorial, since malnutrition is considered a geriatric syndrome.

Mc Dermott et al. [12] described a customized nutrition intervention that produces changes in energy intake, maintenance of appropriate protein intake, and the reversal of unintentional weight loss over 5 to 15 months. Sustained improvements occurred across a socioeconomically diverse population, despite persistent disease- and medication-associated side effects. The intervention format consisted of weekly, customized, one-on-one counseling in a supportive environment, and an oral caloric supplement (480 kcal/day, with 30 g protein). Sessions were conducted with a nutritionist using an interactive, action-oriented learning approach. A strong nutrition foundation that incorporated the concept of 'food as medicine' was accompanied by effective behavioral strategies, with problem solving and crisis management techniques defined by and specific to the needs of the patient. Twelve weekly sessions allowed sufficient time to introduce concepts, refine coping skills, and address a diverse array of issues bearing on nutritional status. Changing lifestyle habits requires commitment and substantial investment on the part of the individual and the medical team. By understanding the relationship of food choices, weight stability, and health status, the intervention fostered patient empowerment and provided an effective, sustainable treatment strategy for the reversal of HIV-associated wasting, regardless of adjunct therapies [12].

The effects of HIV infection on nutritional status and needs vary according to the stage of the disease. WHO recommendations are different for the two distinct phases of HIV infection: asymptomatic and symptomatic [13].

During the asymptomatic phase, energy requirements increase by 10 % over the level of energy intake recommended for healthy, non-HIV-infected people of the same age, sex, and physical activity level. For example, the energy requirements of a 35-year-old moderately active male with asymptomatic HIV are 3,152 kcal/day, compared with 2,865 kcal/day for a 35-year-old moderately active male who is not infected with HIV (2865 + 287 [10 %] = 3,152). The energy requirements of a 35-year-old moderately active female with asymptomatic HIV are 2,360 kcal/day, compared with 2,145 kcal/day for a 35-year-old moderately active female who is not infected with HIV (2,145 + 215 [10 %] = 2,360).

During the symptomatic phase, energy requirements of patients with HIV increase by 20–30 % over the level of energy intake recommended for healthy, non-HIV-infected people of the same age, sex, and physical activity level. The range in the requirement reflects the fact that people with more frequent and more severe symptoms need up to 30 % more energy. For example, the energy requirement of a 35-year-old moderately active male with HIV is 3,438 kcal/day (2,865 + 573 [20 %] = 3,438) during the early symptomatic stage and 3,734 kcal/day (2,865 + 860 [30 %] = 3,725) during the late symptomatic stage. The energy requirement of a 35-year-old moderately active female with HIV is 3,438 kcal/day (2,145 + 429 [20 %] = 2,574) during the early symptomatic stage and 3,734 kcal/day (2,145 + 644 [30 %] = 2,789) during the late symptomatic stage.

Data are not sufficient to recommend an increase in protein or micronutrients for patients with HIV. The WHO recommends for people to get 12–15 % of energy from protein and take micronutrients at one recommended daily allowance (RDA). However, people with pre-existing or concurrent protein and micronutrient deficiencies may require higher intake. These recommendations are for all patients with HIV, whether they are taking antiretroviral (ARV) drugs or not [13].

Many years ago the Nutritional Pyramid was created to visually describe the nutritional needs of the general population. Since the introduction of the Nutritional Pyramid new models have been built; in 2007 the Modified MyPyramid for Older Adults was created by the Cardiovascular Nutrition Laboratory at Tufts University. The revised pyramid emphasized exercise, getting enough fluids, taking vitamins, and eating frozen or canned fruits and vegetables along with fresh. In 2011 the MyPlate for Older Adults (Fig. 12.3) was introduced and corresponds to the government's food group symbol, MyPlate.

12.4 Sarcopenic Obesity

The aging process is characterized by changes in the body composition, with a decrease in muscle mass and an increase in fat mass, particularly visceral fat. Sarcopenia is an important cause of frailty, disability, and loss of independence in older adults. Concurrently, there is an increased prevalence of obesity in the aging population. These age-related changes in the body composition determine a combination of excess weight and reduced muscle mass or strength, recently defined as sarcopenic obesity [15, 16].

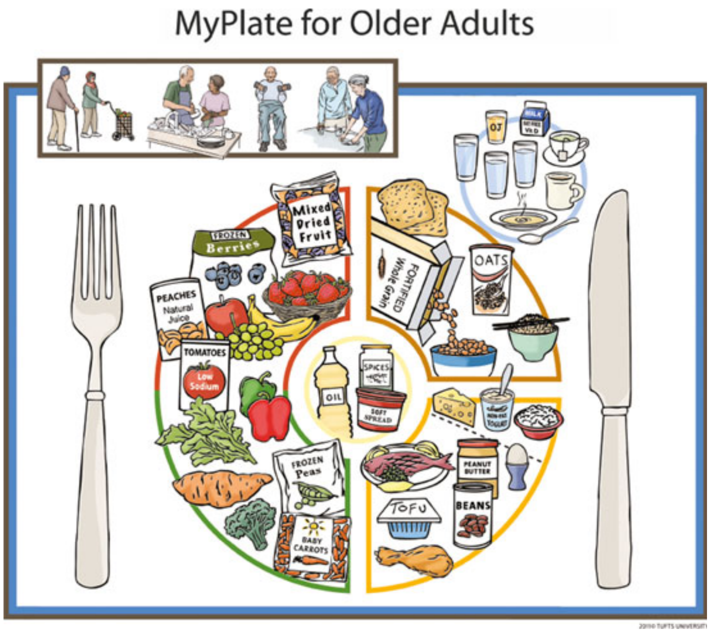

FIGURE 12.3 MyPlate for older adults places emphasis on the importance of physical exercise, foods that contain high levels of vitamins and minerals, a variety of fruits and vegetables, enriched or fortified whole grains, a range of protein, alternatives to salt (such as herbs and spices), and oils low in *trans* fat [14] (Reproduced with permission from © 2011 Tufts University)

Due to the loss of skeletal muscle, the basal metabolic rate declines [17]. There is also a decreased intensity and duration of physical activity as well as decreased postprandial energy expenditure due to a decreased fat oxidation, accounting for the decreased energy expenditure seen with aging.

Medical complications of obesity in the elderly are mainly concentrated around the metabolic syndrome (glucose intolerance, hypertension, dyslipidaemia, and cardiovascular disease). Elderly people who are obese are also likely to have functional limitations because of decreased muscle mass and strength, increase in joint dysfunction, disabilities of activities of daily living, frailty, chronic pain, and impaired quality of life [18]. A study by Baumgartner [19] observed that men and women older than 60 years of age with sarcopenic obesity showed, respectively, an 8- and 11-fold higher risk of having three or more physical disabilities. More importantly, it was observed that the association with functional status impairment was stronger for sarcopenic obesity than for either obesity or sarcopenia alone. Obesity is an important risk for frailty either through increased levels of inflammatory markers or through sarcopenia. Sarcopenic obesity appears to be linked with the upregulation of tumor necrosis factor (TNF)-α, interleukin (IL)-6, leptin, and myostatin and the downregulation of adiponectin and IL-15 [20]. Multiple combined exercise and mild calorie restriction markedly attenuate the symptoms of sarcopenic obesity.

12.5 Physical Exercise

Regular exercise and physical activity are important to the physical and mental health of almost everyone, including older adults. Being physically active can help with staying independent, and regular physical activity over long periods of time can produce long-term health benefits. Hence, health experts say that older adults should be active every day to maintain their health. In addition, regular exercise and physical activity can reduce the risk of developing some diseases and disabilities that occur as people grow older. In some cases, exercise is an effective treatment for many chronic conditions. For example, studies show that people with arthritis, heart disease, or diabetes benefit from regular exercise. Exercise also helps people with high blood pressure, balance problems, or difficulty walking. In the United States, the Go4Life® is the National Institute on Aging's national campaign to help older people fit exercise and physical activity into daily life (www.nia.nih.gov/Go4Life). Patients and physicians can find practical guidelines to start or improve physical exercise [21]. Patients with HIV represent a specific population that could benefit more than other groups from physical exercise, since exercise prevents sarcopenia and enhances muscle power, improves the outcomes in frequently associated non–HIV diseases (eg, diabetes and hypertension), and reduces chronic inflammation.

Many datasets indicate that individuals with HIV maintain a low level of chronic immune activation and inflammation even in the presence of effective antiretroviral therapy (ART). This residual immune activation seems to be associated with accelerated or accentuated aging and an increased incidence of non-AIDS-defining illnesses. Several published studies suggest that physical activity is a beneficial non-pharmacological intervention to reduce chronic inflammation: increasing evidence suggests that the introduction of regular physical exercise in the clinical management of individuals with HIV may have a significant positive impact in reducing some of the long-term complications of both infection and ART (Fig. 12.4) [22].

In older individuals with HIV infection, as well as those with other chronic diseases, it is important to improve muscle mass to preserve muscle tropism and functional status. Sakkas et al. [23] conducted a randomized double-blind, placebo-controlled study to evaluate the effect of creatine supplementation on muscle size, strength, and function in individuals with HIV. All subjects underwent three times-weekly supervised resistance exercise beginning at week 2 until week 14, while continuing on the assigned study medication. It was found that after 14 weeks, 1-repetition maximum strength increased in all muscle groups and that the magnitude of this increase was not greater with creatine supplementation. It was concluded that progressive resistance training is important in preventing and reversing muscle weakness and the administration of creatine may have a beneficial aesthetic impact but does not improve physical functional capacity. This last result is important, since in elderly patients with HIV renal function is not always preserved, so the use of protein surplus is not safe. Nevertheless, research has indicated that increased dietary protein intake (up to 1.6 g protein/kg/day) may enhance the hypertrophic response

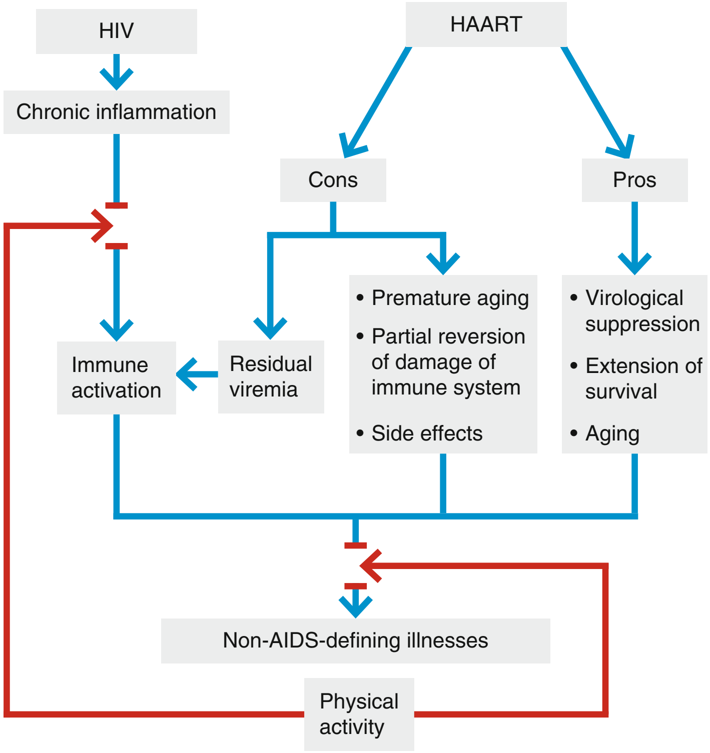

FIGURE 12.4 Potential benefits of physical activity on chronic HIV infection. *HAART* highly active antiretroviral therapy (Adapted from d'Ettorre et al. [22])

to resistance exercise [24]. It has also been demonstrated that in very old men and women the use of a protein-calorie supplement was associated with greater strength and muscle mass gains than the use of placebo.

Moderate physical activity can improve many immune parameters, reduce the risk of acute infection, and combat metabolic abnormalities. As people with HIV age, alternative therapies such as nutrition and physical activity may complement medical management.

12.5.1 Resistance Training

Despite the significant benefits associated with highly active antiretroviral therapy (HAART), HIV infection and its therapy have been associated with the development of several metabolic complications: increased central adiposity, peripheral lipoatrophy, peripheral insulin resistance, diabetes, dyslipidemia and hypertriglyceridemia, osteoporosis, and osteopenia [25]. These complications may predispose patients to a premature risk of metabolic and cardiovascular diseases. In addition, aging predisposes patients to the same biological effects, and one could expect that aging could act as a potentiator of those HIV infection- and HAART-related alterations. On the other hand, resistance training improves many of those alterations [26].

Souza et al. [27] demonstrated that a substantial strength increase related to all exercises in every patient who completed the proposed training program (progressive resistance exercises) regardless of their age, gender, baseline HIV infection stage, or the presence of any HIV/AIDS-associated morbidity.

A regular resistance exercise program has been shown to improve lean body mass and strength in patients with HIV; such exercise reduces serum triglyceride levels with and without anabolic therapies. Promoting regular fitness may minimize muscle wasting and normalize blood lipids without requiring the addition of pharmacologic therapies to patients already receiving complicated medical regimens.

12.5.2 Aerobic Training

In a recent Cochrane review, O'Brien et al. [28] demonstrated that aerobic exercise appeared to be safe and beneficial for adults living with HIV, nevertheless, these findings were limited by small sample sizes and large withdrawal rates considered in the meta-analysis.

In a study by Smith et al. [29] it was concluded that 12 weeks supervised aerobic exercise training safely decreases fatigue, weight, BMI, subcutaneous fat, and abdominal girth (central fat) in individuals with HIV-1 infection, while it did not appear to have an effect on dyspnea.

12.5.3 Mixed Protocols

Yahiaoui et al. [30] demonstrated good results with a combined protocol consisting of a mix of endurance and resistance exercises three times per week for at least 6 weeks to improve cardiovascular, metabolic, and muscle function. Stretching, before and after exercising, is also recommended to prevent injuries [30].

12.6 Conclusion

Extensive literature demonstrates that nutrition and physical exercise are probably the most important non-pharmacologic strategies to improve outcomes in older patients with HIV. The multifactorial nature of malnutrition and the complexity of interventions underline the importance of the multidimensional geriatric evaluation and effective interdisciplinary team work.

References

1. Somarriba G, Neri D, Schaefer N, Miller TL. The effect of aging, nutrition, and exercise during HIV infection. HIV AIDS (Auckl). 2010;2:191–201.
2. Kamel HK, Iqbal MA. Body mass index and mortality among hospitalized elderly patients. Arch Intern Med. 2001;161:1459–60.
3. Chumlea WC, Guo S. Equations for predicting stature in white and black elderly individuals. J Gerontol. 1992;47:M197–203.
4. Pearson MB, Bassey EJ, Bendall MJ. The effects of age on muscle strength and anthropometric indices within a group of elderly men and women. Age Ageing. 1985;14:230–4.

5. Corti MC, Guralnik JM, Salive ME, Sorkin JD. Serum albumin level and physical disability as predictors of mortality in older persons. JAMA. 1994;272:1036–42.
6. Dusingize JC, Hoover DR, Shi Q, et al. Association of serum albumin with markers of nutritional status among HIV-infected and uninfected Rwandan women. PLoS One. 2012;7, e35079.
7. Nestle Nutrition Institute. MNA® Mini Nutritional Assessment. Available at www.mna-elderly.com. 2015. Accessed 17 Nov 2015.
8. Ruiz M, Kamerman LA. Nutritional screening tools for HIV-infected patients: implications for elderly patients. J Int Assoc Physicians AIDS Care. 2010;9:362–7.
9. The Subjective Global Assessment. A highly reliable nutritional assessment tool. Available at www.subjectiveglobalassessment.com. 2012. Accessed 20 Nov 2015.
10. Detsky AS, Baker JP, Mendelson RA, Wolman SL, Wesson DE, Jeejeebhoy KN. Evaluating the accuracy of nutritional assessment techniques applied to hospitalized patients: methodology and comparisons. JPEN J Parenter Enteral Nutr. 1984;8:153–9.
11. da Fink Silva J, Daniel de Mello P, Daniel de Mello E. Subjective global assessment of nutritional status A systematic review of the literature. Clin Nutr. 2015;34:785–92.
12. McDermott AY, Shevitz A, Must A, Harris S, Roubenoff R, Gorbach S. Nutrition treatment for HIV wasting: a prescription for food as Medicine. Nutr Clin Pract. 2003;18:86–94.
13. World Health Organization. Nutrient requirements for people living with HIV/AIDS. Report of a technical consultation; 13–15 May 2003, Geneva.
14. Tufts University. Gerald J and Dorothy R Friedman School of Nutrition Science and Policy. My plate for older adults. Available at http://www.nutrition.tufts.edu/research/myplate-older-adults. 2015. Accessed 20 Nov 2015.
15. Marcell TJ. Sarcopenia: causes, consequences, and preventions. J Gerontol A Biol Sci Med Sci. 2003;58:M911–6.
16. Thomas DR. Loss of skeletal muscle mass in aging: examining the relationship of starvation, sarcopenia and cachexia. Clin Nutr. 2007;26:389–99.
17. Lauretani F, Russo CR, Bandinelli S, et al. Age-associated changes in skeletal muscles and their effect on mobility: an operational diagnosis of sarcopenia. J Appl Physiol. 2003;95:1851–60.
18. Campbell MJ, McComas AJ, Petito F. Physiological changes in ageing muscles. J Neurol Neurosurg Psychiatry. 1973;36:174–82.

19. Baumgartner RN. Body composition in healthy aging. Ann N Y Acad Sci. 2000;904:437–48.
20. Ferrucci L, Harris TB, Guralnik JM, et al. Serum IL-6 level and the development of disability in older persons. J Am Geriatr Soc. 1999;47:639–46.
21. National Institute on Aging. Exercise and physical activity: your everyday guide from the National Institute on Aging. Available at www.nia.nih.gov/health/publication/exercise-physical-activity/introduction. 2015. Accessed 17 Aug 2015.
22. d'Ettorre G, Ceccarelli C, Giustini N, Mastroianni CM, Silvestri G, Vullo V. Taming HIV-related inflammation with physical activity: a matter of timing. AIDS Res Hum Retroviruses. 2014;30:936–44.
23. Sakkas GK, Mulligan K, Dasilva M, et al. Creatine fails to augment the benefits from resistance training in patients with HIV infection: a randomized, double-blind, placebo-controlled study. PLoS One. 2009;4, e4605.
24. Evans WJ. Protein nutrition and resistance exercise. Can J Appl Physiol. 2001;26:S141–52.
25. Malita FM, Karelis AD, Toma E, Rabasa-Lhoret R. Effects of different types of exercise on body composition and fat distribution in HIV-infected patients: a brief review. Can J Appl Physiol. 2005;30:233–45.
26. Hunter GR, McCarthy JP, Bamman MM. Effects of resistance training on older adults. Sports Med. 2004;34:329–48.
27. Souza PM, Jacob-Filho W, Santarém JM, Silva AR, Li HY, Burattini MN. Progressive resistance training in elderly HIV-positive patients: does it work? Clinics. 2008;63:619–24.
28. O'Brien K, Nixon S, Tynan AM, Glazier R. Aerobic exercise interventions for adults living with HIV/AIDS. Cochrane Database Syst Rev. 2010;4, CD001796.
29. Smith BA, Neidig JL, Nickel JT, Mitchell GL, Para MF, Fass RJ. Aerobic exercise: effects on parameters related to fatigue, dyspnea, weight and body composition in HIV-infected adults. AIDS. 2001;15:693–701.
30. Yahiaoui A, McGough EL, Voss JG. Development of evidence-based exercise recommendations for older HIV-infected patients. J Assoc Nurses AIDS Care. 2012;23:204–19.