

High prevalence of malnutrition and sarcopenia in patients with NTM pulmonary disease: results from an Italian prospective multicentre study

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TITLE

High Prevalence of Malnutrition and Sarcopenia in patients with NTM pulmonary disease: results from an Italian prospective multicentre study

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Declarations

Ethics approval

This study received Ethics Committee approval (#259, ASST Monza, 17 March 2022)

Consent for publication

All patients provided written informed consent at the time of enrolment

Availability of data and materials

Individual participant data referring to this article (i.e. text, tables and figures) will be made available upon reasonable request. Proposals should be directed to paola.faverio@unimib.it

Conflicts of interest of every author.

The authors declare not to have any conflicts of interest that may be considered to influence directly or indirectly the content of the manuscript.

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Authors' contributions

SA and PF are the guarantors of this research. PF, AF, SC, and MS were responsible for study concept and design. PF, AF, GT, FG, SC, FV, RM, VC, FB, LP, FDS, JM, SG, IG, MTA, GB, GC, GF, ET, AG, AB, RDM, GC, AR, MF, LM, AC, SC, LGM, FL, LC, FB, GS, AG, MS, and SA contributed to patient

recruitment, follow-up and contributed to data acquisition. PF, SC and GT performed data analysis. PF, AF, SC and GT contributed to the drafting of this manuscript. PF, AF, GT, FG, SC, FV, RM, VC, FB, LP, FDS, JM, SG, IG, MTA, GB, GC, GF, ET, AG, AB, RDM, GC, AR, MF, LM, AC, SC, LGM, FL, LC, FB, GS, AG, MS, and SA read and approved the final manuscript.

Statement of Ethics

Our research complies with the guidelines for human studies and was conducted ethically in accordance with the World Medical Association Declaration of Helsinki.

Artificial intelligence involvement.

Artificial intelligence (AI) was not used for the conduct and the writing of this study. AI tools (ChatGPT) were utilized only for linguistic and grammatical revision of the text.

Abstract

Background: NTM pulmonary disease (NTM-PD) is frequently associated with low body mass index and weight loss, yet comprehensive nutritional evaluation at diagnosis remains limited.

Methods: we conducted a multicenter observational study across eight Italian referral centers to assess nutritional status and physical performance in newly diagnosed NTM-PD patients. Assessments included anthropometry, nutritional and physical activity questionnaires, bioelectrical impedance analysis, handgrip strength, gait speed, and pulmonary function tests in order to identify nutritional phenotypes and sarcopenia according to EWGSOP2 definition.

Results: 69 patients (77% female, mean age 69 years) were enrolled. The majority had Mycobacterium avium complex infection (74%), and 29% had a cavitary disease. Lung function impairment was generally mild. However, physical performance was frequently reduced: 36% showed impaired gait speed and 45% reduced handgrip strength. Nutritional evaluation revealed

a high burden of undernutrition: over 20% of participants were underweight, up to 40% were at risk of malnutrition or overtly malnourished according to screening tools and more than 20% already exhibited a malnourished phenotype. Sarcopenia was identified in 29% of subjects. Cavitory disease was associated with worse nutritional status and higher prevalence of severe sarcopenia. Overall, more than half of participants required nutritional intervention.

Conclusion: Patients with NTM-PD at diagnosis show a high prevalence of impaired nutritional status (40% at risk of malnutrition or malnourished and requiring a nutritional intervention) and physical performance. Sarcopenia is also highly prevalent (29%) highlighting the need for dietary and physical interventions.

Introduction

Nontuberculous mycobacterial (NTM) pulmonary disease (PD) is a chronic infectious condition frequently associated with low body mass index (BMI) and weight loss.(1) Altered nutritional status may contribute to the development of NTM-PD and not merely reflect disease progression and poor outcome. It has also been hypothesized that patients with NTM-PD exhibit a distinct body morphotype compared with the general population, characterized by a taller, leaner body habitus and smaller anthropometric measurements, such as reduced waist circumference.(2) Several observational studies, conducted mainly in Japan and South Korea, have demonstrated that low body weight —particularly a BMI <18.5 kg/m²— low fat mass, reduced skeletal muscle mass and lower total serum protein are associated with worse radiological scores, clinical deterioration, NTM persistence in sputum or unfavorable outcomes not only at diagnosis but also during the course of the disease.(3-8) The only prognostic score currently validated for NTM-PD, the BACES score —a predictive model for all-cause mortality in NTM-PD— includes low BMI and identifies it as an independent predictor of mortality, together with age ≥ 65 years, presence

of cavitary disease, elevated erythrocyte sedimentation rate, and male sex.(9)

A recently published study conducted on the NTM-KOREA cohort highlighted the significant impact of nutritional status on disease course and management: preliminary longitudinal data suggested that malnutrition may negatively affect symptomatic improvement and treatment adherence.(10) A South Korean study assessing nutritional status using nutritional questionnaires and bioelectrical impedance analysis (BIA) reported a prevalence of sarcopenia of 20% and adipopenia of 36%, indicating that low fat-free mass (FFM) and reduced fat mass are also common features in patients with NTM-PD.(11) Sarcopenia may affect physical performance and cough efficacy, thereby reducing airway clearance and perpetuating the vicious cycle of infection.

To date, only one retrospective study conducted in Japan evaluated the role of nutritional intervention in NTM-PD.(12) *Noma et al.* reported that, among 16 patients who received three months of dietitian-guided registered nutritional counseling, the total energy sufficiency ratio increased, though significant weight gain was not achieved and data on NTM-PD outcome were not available.

Despite this growing body of evidence, no studies have comprehensively evaluated nutritional status or the role of nutritional interventions in Caucasian patients with NTM-PD at the time of diagnosis.

This study aims to perform a full physical performance and nutritional evaluation in patients with a new diagnosis of NTM-PD before starting antibiotic therapy stratified according to disease severity.

Materials and Methods

An observational prospective, multicentre study recruited consecutive patients with NTM-PD prior to antibiotic exposure, over a 3-year period (April 2022–April 2025) from outpatient specialist clinics of eight hospitals

in Italy. The study was approved by the Ethics Committee (#259, ASST Monza, 17 March 2022) and registered on ClinicalTrials.gov (NCT05376280 – NutrNTM study).

Participants were eligible if they were ≥ 18 years old, had a new NTM-PD diagnosis based on 2020 European Respiratory Society (ERS) guidelines,(13) and provided written informed consent. Exclusion criteria were: severe renal failure (glomerular filtration rate < 30 mL/min), New York Heart Association (NYHA) class IV heart failure, severe liver failure (Child-Pugh class C), active solid or hematological malignancy, current or recent (within the previous 6 months) antimycobacterial therapy, severe immunosuppression, inability to walk, need for oxygen therapy at rest, or participation in other interventional clinical trials. All participants provided written informed consent at enrolment. The study was reported in accordance with the STROBE guidelines.(14).

The study protocol included a specialist (T1) and a nutritional visit (T2, within one month of T1). At T1 medical history, oxygen saturation, and pulmonary function tests (PFTs) were collected; ii) at T2 anthropometric measurements, questionnaires assessing nutritional status and risk of eating disorders (Malnutrition Universal Screening Tool [MUST], Mini Nutritional Assessment [MNA], Eating Attitudes Test-26 [EAT-26]), physical activity assessment (International Physical Activity Questionnaire [IPAQ]), bioelectrical impedance analysis (BIA), handgrip dynamometry, and the 4-meter gait speed test were carried out. Information regarding initiation of antimycobacterial treatment and therapeutic agents versus a “watchful waiting” approach, as well as “good clinical practice” nutritional recommendations provided by nutritionists, was also collected.

Procedures

PFTs measurements were performed according to ATS/ERS standardisation using a dry spirometer.(15,16) Patients were categorized into normal PFTs, obstructive (defined as $FEV1/FVC < 0.7$ with a concomitant reduction of $FEV1 < 80\%$ predicted)) or restrictive pattern (defined as having a $FEV1/FVC \geq 0.7$ and a $FVC < 80\%$ predicted).

Anthropometric assessment included body weight, height, waist, mid-upper arm and calf circumferences. Body mass index (BMI) and percentage body weight loss over the prior 6 months were calculated.

Muscle strength was assessed by handgrip strength of both dominant and non-dominant hands using a handheld dynamometer. Measurements were repeated three times for each side, and the highest value was recorded.(17) Physical performance was evaluated using the 4-meter gait speed test conducted along a 4-meter corridor.

BIA was performed using a standard tetrapolar technique, with participants in the supine position and electrodes placed on the hands and feet.(18) Resistance (R) and reactance (X_c) were measured in ohms at 50 kHz and 800 mA. Phase angle, reflecting the relative contributions of body fluids (resistance) and cellular membranes (reactance), was calculated using the formula: $(X_c/R) \times (180/\pi)$.(19) Fat-free mass index (FFMI, kg/m^2) was calculated as fat-free mass divided by height squared; appendicular skeletal muscle mass index (ASMI, kg/m^2) as appendicular skeletal muscle mass divided by height squared; body fat mass (BFM) as total body weight minus fat-free mass; and body fat mass index (BFMI, kg/m^2) as BFM divided by height squared.

Sarcopenia was defined according to the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) criteria, which prioritise muscle weakness over muscle mass. Sarcopenia was classified into three stages: i) Probable sarcopenia, defined by low muscle strength (dynapenia) alone

(handgrip strength <27 kg in men and <16 kg in women); ii) Confirmed sarcopenia, defined by the presence of low muscle quantity or quality in addition to low strength (ASMI < 7 kg/m² in men and < 5.5 kg/m² in women); iii) Severe sarcopenia, defined by the coexistence of the above criteria and low physical performance, assessed as gait speed <0.8 m/s.(20)

Objectives

The primary outcome was the prevalence of underweight (BMI <18.5 kg/m²).

Secondary outcomes were: i) prevalence of nutritional phenotypes (**Table 1**) (21,22); ii) risk of malnutrition and eating disorders using validated questionnaires; iii) prevalence of impaired physical performance using handgrip strength, 4-meter gait speed, and IPAQ.

Statistical analysis

Continuous variables were summarized using means and standard deviations (SD), whereas categorical variables were reported as counts and percentages. Analyses were stratified according to the radiological phenotype of NTM-PD (nodular-bronchiectatic versus cavitory form). Comparisons between the two groups were performed using the Fisher's exact test. A two-sided p-value <0.05 was considered statistically significant. Distribution of number and percent of missing values for each variable of interest are summarised in **Supplementary Table 1**. All statistical analyses were conducted using R software (version 4.5.2).

Results

Clinical Characteristics of the Study Cohort

105 consecutive patients with NTM-PD were screened and only 69 (77% women; mean age 69 years) were enrolled (**Table 2**).

The most frequently isolated NTM species were *Mycobacterium avium* complex (MAC), responsible for 52 cases (27 *M. avium*, 21 *M. intracellulare*, and 4 *M. chimaera*), followed by *M. abscessus* complex (n: 5). *M. celatum*, *M. interjectum*, *M. kansasii*, *M. malmoense*, and *M. xenopi* accounted for one case each. Diagnosis was established on sputum samples in 11 cases and on bronchoscopic specimens (bronchial aspirate or bronchoalveolar lavage) in 56 cases; 22 patients had a acid-fast smear positivity.

Forty-nine patients (71%) presented a nodular-bronchiectatic radiological pattern, whereas 20 (29%) had cavitary disease. Fifty-one (74%) patients initiated antimycobacterial therapy, whereas 18 (26%) patients were managed with watchful waiting.

The most prevalent comorbidities were arterial hypertension (n: 23), gastroesophageal reflux disease (GERD) (n: 14), osteoporosis (n: 13), chronic obstructive pulmonary disease (COPD) (n: 11), and thyroid disorders (n: 9). Twenty-nine patients (42%) had a prior smoking history, and 3 were current smokers.

Functional and Physical Performance Indices

Regarding pulmonary function tests (PFTs), 25 (36.23%) and 9 participants (13.04%) exhibited obstructive and restrictive impairment, respectively, although these were mild in most participants. Inhalation therapy and airway clearance techniques (ACT) were prescribed in 14 (20%) and 20 (29%) cases, respectively, whereas only 2 patients underwent pulmonary rehabilitation. Among inhaled therapies, inhaled corticosteroids were prescribed in only 4 cases (2 cases of patients with COPD and 1 case with asthma).

With respect to physical activity, according to the IPAQ, 15 participants (21.7%) were classified as inactive, 25 (36.2%) as moderately active, and 15 (21.7%) as having an active lifestyle, **Table 3**.

Among the 61 patients who underwent performance assessment, the mean (SD) 4-meter gait speed was 1.05 (0.61) m/s, and 25 patients (36.2%) showed impaired gait velocity (< 0.8 m/s), **Table 3**.

Regarding hand-held dynamometry, mean (SD) handgrip strength was 30.39 (10.51) kg in men and 18.82 (7.06) kg in women. Thirty-two patients (46.38%) had reduced grip strength (< 30 kg in men and < 20 kg in women). Twelve (17.39%) and 20 (28.99%) patients exhibited intermediate (27–30 kg in men and 16–20 kg in women) and weak grip strength (< 27 kg in men and < 16 kg in women), respectively.

Nutritional Assessment and Nutritional Phenotypes

Mean (SD) BMI was 20.8 (3.81) kg/m², with a predominance of normal-weight and underweight individuals (47 [68.1%] and 15 [21.7%] participants, respectively), compared with the general adult Italian population, in which the prevalence of underweight is approximately 3%. (19) Only 7 patients (10.1%) were overweight or obese (**Figure 1a**). Sixteen patients (23.2%) experienced $\geq 5\%$ body weight loss in the six months preceding the diagnosis of NTM-PD.

Regarding anthropometric measurements, 23 participants (33.3%) and 33 (48.8%) showed reduced mid-arm (≤ 23 cm) and calf circumference (< 34 cm in men and < 33 cm in women), respectively—indices of reduced energy reserves and muscle mass. Only 7 patients (10.2%) exhibited increased waist circumference (> 102 cm in men and > 88 cm in women), an indicator of android obesity, metabolic dysfunction, and increased cardiovascular risk, **Table 4**.

Nutritional risk was assessed using two screening tools: MUST and MNA. According to the MUST score, 8 participants (11.6%) were at medium (score: 1) and 24 (34.8%) at high risk of malnutrition (score ≥ 2). Based on the MNA questionnaire, 20 patients (29.0%) were at risk of malnutrition (score 17–23.5), and 5 (7.24%) were malnourished (score < 17). The EAT-26 screening tool for eating disorders was abnormal in 2 participants (2.9%), one of which with a prior history of anorexia, **Table 4**.

BIA values are summarized in **Table 4**. Low FFMI (< 17 kg/m² in men and < 15 kg/m² in women), low ASMI (< 7 kg/m² in men and < 5.5 kg/m² in women), and low BFMI (< 1.7 kg/m² in men and < 3.8 kg/m² in women) were identified in 23 (33.33%), 4 (5.8%), and 21 (30.44%) patients, respectively. A reduced phase angle ($< 4^\circ$), a marker of cell membrane integrity and muscle quality, was detected in 15 (21.7%) patients.

Regarding nutritional phenotypes, the majority of participants was normally nourished or overweight and non-sarcopenic (29; 42.0%), followed by sarcopenic (23; 33.3%), underweight/malnourished (14; 20.3%), sarcopenic obese (2; 2.9%), and obese (1; 1.5%), **Figure 1b**. Thirty-seven patients (53.6%), that represent the combined total of the sarcopenic and underweight/malnourished individuals, required nutritional recommendations, including oral nutritional supplements and individualized dietary plans, as part of routine clinical practice.

According to the EWGSOP2, sarcopenia was diagnosed in 20 patients (29.0%): predominantly probable sarcopenia (n: 15), with fewer cases of severe sarcopenia (n: 5) and no cases of confirmed sarcopenia, **Figure 1c**.

Comparison between patients with nodular-bronchiectatic and cavitary CT pattern

Patients with a cavitary pattern were more frequently underweight (7/20, 35% vs. 8/49, 16.3%; p : 0.017) and malnourished (7/20, 35% vs. 7/49, 14.3%; p : 0.06), and had also a higher risk of malnutrition according to MNA (12/20, 60% vs. 13/49, 26.5%; p : 0.001) and MUST scores (12/20, 60% vs. 12/49, 24.5%; p : 0.043). They were also more frequently affected by severe sarcopenia (4/20, 20% vs. 1/49, 2%) compared with those showing a nodular bronchiectatic pattern (**Table 5**). Conversely, the prevalence of probable and confirmed sarcopenia as well as the prevalence of altered gait speed and handgrip strength did not differ between the two groups. Patients with a cavitary form more frequently received antimicrobial therapy (19/20, 95% vs. 32/49, 65.3%) and more often required nutritional counselling (15/20, 75% vs. 22/49, 44.9%).

Discussion

This study demonstrates that patients with NTM-PD at the time of diagnosis exhibit a high prevalence of impaired nutritional status and reduced physical performance. More than 20% of patients are underweight according to BMI (compared with 3% in the Italian adult population (23)), approximately 20% present a cachectic phenotype, and about 29% have sarcopenia, despite having a mean age below 70 years, and largely lacking major comorbidities. Prior studies assessing the prevalence of sarcopenia in the Italian general population reported a prevalence of 8.6% (in adults younger than our cohort—mean age 55.6 years—and using the same EWGSOP2 definition) and 19.7% (in an elderly population with a median age of 75 years, evaluated solely through questionnaires).(24,25)

Previous studies found that NTM-PD patients have a low BMI and a history of weight loss, all of them negatively affecting their prognosis.(26,27) Low BMI was associated with clinical and radiographic progression, persistent culture positivity, and poor health-related quality of life;(28) however, most of the studies recruited Asian patients,(26-28) and only a few comprehensively evaluated their nutritional phenotype.(11) A South Korean

study reported a sarcopenia prevalence of 20% and MNA scores consistent with ours.(11)

In patients with tuberculosis, the beneficial effects of nutritional support are well documented. A randomized trial (The RATIONS trial) proved the role played by nutritional interventions in tuberculosis household contacts in India, decreasing the risk of disease (39–48%).(29) Some expert-opinion statements on the management of NTM infections are also highlighting the importance of nutritional assessment and intervention even before initiating antibiotic treatment.(30-31)

Our findings confirm that nutritional assessment is of paramount importance in patients with NTM-PD, regardless of initial disease severity, and that nutritional and physical impairments (e.g., malnutrition and sarcopenia) may be considered treatable traits of the disease. Several parameters can be readily assessed by both pulmonologists and infectious disease specialists and may raise clinical suspicion, prompting referral to a nutritionist or a specialist in rehabilitation medicine: (i) evaluation of low BMI and identification of significant weight loss (>5%), both observed in approximately 20% of our cohort; (ii) use of rapid screening tools to assess the risk of malnutrition (MNA and MUST) and physical inactivity (IPAQ); in our population, more than 35% had abnormal MUST or MNA scores, and over 20% reported a completely inactive lifestyle according to IPAQ; (iii) performance of simple physical performance tests, such as handgrip strength, which may raise suspicion of dynapenia, that was reduced in 46% of the cohort; (iv) measurement of simple anthropometric indices, such as mid-arm and calf circumference, which can provide indirect estimates of muscle mass—in our cohort, these indices were frequently abnormal, in up to 48% of cases.

Despite the high prevalence of sarcopenia and physical inactivity, only two patients underwent pulmonary rehabilitation, and 29% were taught ACT,

but >50% required nutritional intervention, further reinforcing the concept of treatable traits. Two studies, both conducted in Asian populations, reported reduced caloric intake in patients with NTM-PD compared with healthy controls.(6,32). To date, no study has established the optimal nutritional intervention for patients with NTM-PD. However, dietary counselling, supplementation support (in patients with overt or at risk of malnutrition), physical rehabilitation (in case of sarcopenia), and probiotics and/or prebiotics, in the presence of antibiotic-related adverse effects, would be advisable.

A study by Takayama et al. reported that female patients with NTM-PD often overestimated their body size, and that this distorted perception was associated with low BMI.(33) The authors suggest that this finding supports the need to address body image distortion when providing dietary advice. To explore this aspect, we included the EAT-26 questionnaire—a screening tool for eating disorders—among the administered assessments, and found abnormal results in only 2 cases, one of whom had a pre-existing diagnosis of anorexia.

Of note, although patients with cavitary disease, which is a surrogate marker of disease severity, were more frequently underweight, malnourished, and with severe sarcopenia, it is important to highlight that patients with the nodular-bronchiectatic form also showed a high prevalence of sarcopenia and malnutrition (27% and 14%, respectively), as well as a significant risk of malnutrition (26.5% and 37% for MNA and MUST, respectively). Then, assessment of nutritional and physical impairment should not be limited only to the more severe forms, but should be carried out to all patients.

Although our study is the first one to provide a prospective comprehensive nutritional assessment in a cohort of patients with NTM-PD outside Asia, several limitations must be acknowledged. First, given the relatively small

sample size, multivariable analyses including cavitary and nodular-bronchiectatic patterns could not be performed. Second, the impact of nutritional status on clinical outcomes, such as microbiological conversion or improvement on chest CT, was not evaluated because of the heterogeneity of the cohort. A substantial proportion was managed with a watchful waiting strategy, and NTM species and treatment regimens varied widely. However, the strength of this real-world study lies in the recruitment of patients with different disease severity. Third, the majority of patients had MAC-PD, limiting the interpretation for other pathogens.

Future studies should include the assessment of sarcopenia using simple and routinely available methods, such as measurement of the pectoralis muscle area on chest CT. Furthermore, a nutritionist and a rehabilitation physician, alongside a respiratory physiotherapist, should be systematically included in the multi-disciplinary team.

In conclusion, this prospective multicenter study found that impaired nutritional status and reduced physical performance are highly prevalent in patients with NTM-PD at diagnosis, even in a cohort of patients without major comorbidities. Nutritional abnormalities—including underweight, malnutrition, and sarcopenia—were frequently observed not only in more severe cavitary forms of the disease, highlighting the need for systematic and early assessment in all patients. Simple, widely available clinical, anthropometric, and functional tools can facilitate early identification of at-risk individuals and prompt referral to nutritional and rehabilitative interventions. The high proportion of patients requiring nutritional support further supports the concept of nutritional and physical impairment as treatable traits in NTM-PD. Integrating nutritional evaluation and rehabilitation into routine multidisciplinary care may represent a key strategy to optimize patient management.

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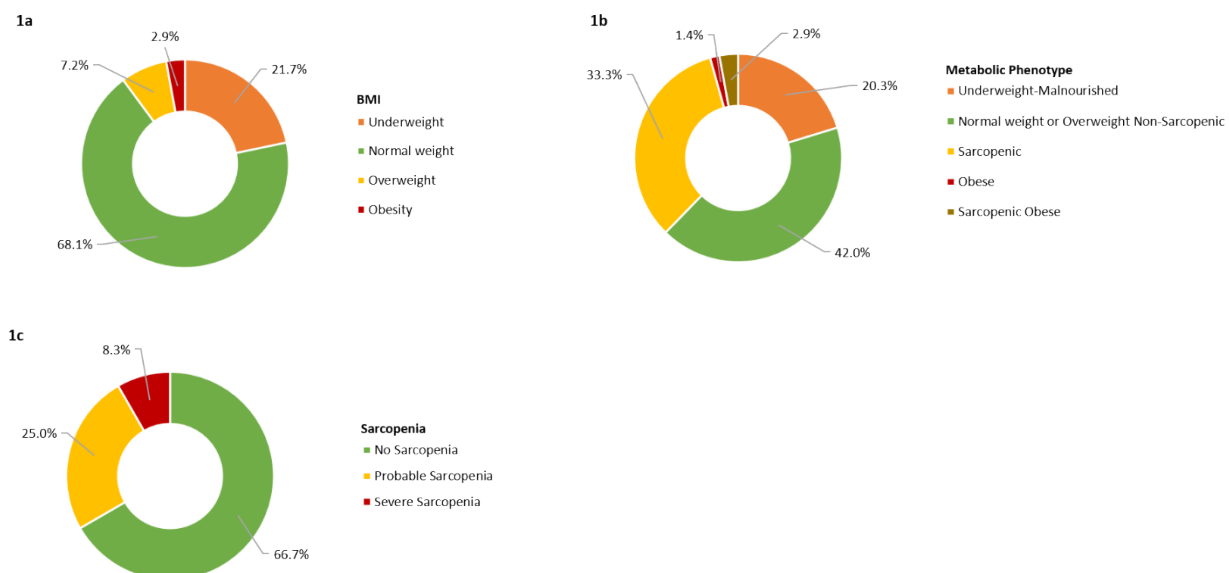
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Figures

Figure 1: Prevalence of BMI classes (1a), nutritional phenotypes (1b) and sarcopenia classes (1c) in the study cohort.



Tables

Table 1. Criteria to identify nutritional phenotypes in study population.

Metabolic phenotypes	Parameters and cut-off
UNDERWEIGHT/MALNOURISHED	- BMI < 18.5 kg/m² - Involuntary weight loss > 5% in the last 6 months - FFMI < 17 kg/m² for males or < 15 kg/m² for females - SMI < 8.87 kg/m² for males or < 6.42 kg/m² for females - BFMI < 1.7 kg/m² for males or < 3.8 Kg/m² for females
SARCOPENIA	- BMI < 30 kg/m² - FFMI < 17 kg/m² for males or < 15 kg/m² for females - SMI < 8.87 kg/m² for males or < 6.42 kg/m² for females - BFMI ≥ 1.7 kg/m² for males or ≥ 3.8 kg/m² for females - Hand Grip < 30 kg for males or < 20 kg for females - Gait Speed (4 meter) < 0.8 m/sec
NORMAL NUTRITIONAL STATUS (OR OVERWEIGHT) WITHOUT SARCOPENIA	- BMI between 18.5 and 24.9 Kg/m² (overweight if BMI ≥ 25 kg/m² and < 30 kg/m²) - FFMI ≥ 17 kg/m² for males or ≥ 15 kg/m² for females - BFMI between 1.7 kg/m² and 5.19 kg/m² for males or between 3.8 kg/m² and 8.19 Kg/m² for females - Hand Grip > 30 kg for males or > 20 kg for females - Gait Speed (4 meter) ≥ 0.8 m/sec - No involuntary weight loss > 5% in the last 3 months
OBESITY	- BMI ≥ 30 kg/m² - Abdominal circumference > 102 cm for males or > 88 cm for females

	- FFMI ≥ 17 kg/m² for males or ≥ 15 kg/m² for females - SMI ≥ 8.87 kg/m² for males or ≥ 6.42 kg/m² for females - BFMI ≥ 8.3 kg/m² for males or ≥ 11.82 kg/m² for females - Hand Grip > 30 kg for males or > 20 kg for females - Gait Speed (4 meter) ≥ 0.8 m/sec
SARCOPENIC OBESITY	- BMI ≥ 30 kg/m² - Abdominal circumference: > 102 cm for males or > 88 cm for females - FFMI < 17 kg/m² for males or < 15 kg/m² for females - SMI < 8.87 kg/m² for males or < 6.42 kg/m² for females - BFMI ≥ 8.3 kg/m² for males or ≥ 11.82 Kg/m² for females - Hand Grip < 30 kg for males or < 20 kg for females - Gait Speed (4 meter) < 0.8 m/sec

Abbreviations. BMI = body mass index; FFMI = fat free mass index; BFMI = body fat mass index; SMI = skeletal muscle mass index.

Table 2. Baseline clinical features of the study population.

Demographics and baseline	
Female gender	53 (76,80%)
Mean (std) age at enrolment	69,3 (10,7)
Smoking Status	
No	35 (50,73%)
Active	3 (4,35%)
Ex-Smoker	29 (42,03%)
Comorbidities	
Arrhythmia	5 (7,25%)
Congestive heart failure	2 (2,90%)
Myocardial infarction	3 (4,35%)
Valvular heart disease	3 (4,35%)
Coronary artery disease	2 (2,90%)
Hyperthyroidism	2 (2,90%)
Hypothyroidism	7 (10,15%)
GERD	14 (20,29%)
Osteoporosis	13 (18,85%)
COPD	11 (15,95%)
Anxiety and depression	4 (5,79%)
Diabetes	4 (5,79%)
Hypertension	23 (33,34%)
Eating disorder	1 (1,45%)
Baseline Disease Characteristics	
Positive smear microscopy	22 (31,88)
Radiographic Form	
Nodular-bronchiectatic	49 (71,01%)

Cavitary	20 (28,99%)
Source of isolated NTM specimen	
Sputum	11 (15,94%)
Bronchoscopy (BAS/BAL)	56 (81,16%)

Footnotes: GERD: gastro-esophageal reflux disease, COPD: chronic obstructive pulmonary disease; BAS: bronchial aspirate; BAL: bronchoalveolar lavage.

Table 3. Functional and Physical Performance Indices of the study cohort.

Pulmonary Function Tests	
Mean (std) FVC (L)	2,72 (0,71)
Mean (std) FVC %	90,4 (19,1)
Mean (std) FEV1 (L)	1,94 (0,59)
Mean (std) FEV1%	83,4 (23,8)
Restrictive pattern	9 (13,04%)
Obstructive pattern	25 (36,23%)
Physical activity	
Mean (std) IPAQ (METs)	2156 (2942)
IPAQ categories	
< 700 (inactive)	15 (21,74%)
700 - 2519 (moderately active)	25 (36,23%)
> 2519 (active)	15 (21,74%)
Gait speed and dynamometry	
Mean (std) gait speed (4m) (m/sec)	1,05 (0,61)
Reduced gait speed (4m) (<0.8 m/sec)	25 (36,23%)
Mean (std) handgrip strength (Kg)	21,5 (9,3)
Handgrip Strength	
Intermediate (26-30 Male, 16- 20 Female)	12 (17,39%)
Weak (<26 Male, <16 Female)	20 (28,98%)

Footnotes: FVC: forced vital capacity; FEV1: Forced expiratory volume in the 1st second; IPAQ: International Physical Activity Questionnaire; MET: Metabolic Equivalent of Task.

Table 4. Results of the Nutritional Assessment and Nutritional Phenotypes in the study population.

Anthropometric measurements

Mean (std) body weight (kg)	55,8 (11,2)
Mean (std) height (cm)	164 (8,74)
Mean (std) BMI (kg/m ²)	20,8 (3,81)
BMI category	
Underweight	15 (21,74%)
Normal weight	47 (68,12%)
Overweight	5 (7,25%)
Obesity	2 (2,89%)
Mean (std) arm circumference (cm)	25 (3,56)
Mean (std) arm circumference (cm)	25 (3,56)
Reduced arm circumference (≤ 23 cm)	23 (33,33%)
Mean (std) calf circumference (cm)	32,6 (3,40)
Reduced calf circumference (<34 cm Male, <33 cm Female)	33 (47,83%)
Mean (std) abdomen (waist) circumference (cm)	78,3 (12,9)
Increased waist circumference (>102 cm Male, >88 cm Female)	7 (10,15%)
Weight loss in 6 months $\geq 5\%$	16 (23,19%)
Nutritional Questionnaires	
MUST	
Low risk of malnutrition	32 (46,39%)
Moderate risk of malnutrition	8 (11,59%)
High risk of malnutrition	24 (34,78%)
MNA	
Malnourished	5 (7,24%)
At risk of malnutrition	20 (28,99%)
Normal nutrition	36 (52,18%)
EAT - 26	
Not at risk of eating disorder	48 (69,57%)
At risk of eating disorder	2 (2,89%)
Bioelectrical impedance analysis	
Mean (std) resistance (Ohms)	549,9 (125)
Mean (std) reactance (Ohms)	44,3 (17,3)
Mean (std) phase angle	4,46 (1,41)
Mean (std) FFMI (kg/m ²)	16,4 (2,65)
Reduced FFMI (≤ 17 Male, ≤ 15 Female)	23 (33,33%)
Mean (std) BFMI (kg/m ²)	4,5 (3,63)
Reduced BFMI ($<1,7$ Male, $<3,8$ Female)	21 (30,44%)
Mean (std) ASMI (kg/m ²)	7,9 (1,34)
Reduced ASMI (< 7 kg/m ² Male, < 5.5 kg/m ² Female)	4 (5,79%)
Nutritional assessment	
Nutritional status	
Underweight - Malnourished	14 (20,29%)
Normal or Overweight non-Sarcopenic	29 (42,03%)

Sarcopenic	23 (33,33%)
Obese	1 (1,45%)
Sarcopenic Obese	2 (2,90%)
Nutritional recommendations	37 (53,62%)

Footnotes: BMI: body mass index; MUST: Malnutrition Universal Screening Tool; MNA: Mini Nutritional Assessment; EAT-26: Eating Attitudes Test-26; FFMI: Fat-free mass index; BFMI: body fat mass index; ASMI: appendicular skeletal muscle mass index.

Table 5. Comparison between patients with nodular-bronchiectatic and cavitory CT pattern

	Radiological form		Total (N=69)	p-value
	Cavitary (N=20)	Nodular-bronchiectatic (N=49)		
BMI category				0,0175
Underweight	7 (35%)	8 (16,33%)	15 (21,74%)	
Normal weight	11 (55%)	36 (73,47%)	47 (68,11%)	
Overweight	0 (0%)	5 (10,20%)	5 (7,25%)	
Obesity	2 (10%)	0 (0%)	2 (2,90%)	0,06
Nutritional status				
Underweight - Malnourished	7 (35%)	7 (14,29%)	14 (20,29%)	
Normal or Overweight non-Sarcopenic	5 (25%)	24 (48,98%)	29 (42,03%)	
Sarcopenic	6 (30%)	17 (34,69%)	23 (33,33%)	
Obese	1 (5%)	0 (0%)	1 (1,45%)	
Sarcopenic Obese	1 (5%)	1 (2,04%)	2 (2,90%)	
Nutritional recommendations				
Prescribed	15 (75%)	22 (44,90%)	37 (53,62%)	
Handgrip Strength				
Reduced (<30 Male, <20 Female)	8 (40%)	23 (46,94%)	31 (44,93%)	
Gait Speed (4m)				
Reduced (<0,8)	11 (55%)	14 (28,58%)	25 (36,23%)	
Sarcopenia				
No Sarcopenia	10 (50%)	30 (61,23%)	40 (57,97%)	
Probable Sarcopenia	3 (15%)	12 (24,49%)	15 (21,74%)	
Confirmed Sarcopenia	0 (0%)	0 (0%)	0 (0%)	
Severe	4 (20%)	1 (2,04%)	5 (7,25%)	

Sarcopenia				
Antimycobacterial therapy				<i>0,014</i>
Prescribed	19 (95%)	32 (65,31%)	51 (73,91%)	
MNA				<i>0,0285</i>
Malnourished - At Risk of Malnutrition	12 (60%)	13 (26,53%)	25 (36,23%)	
Normal nutrition	7 (35%)	29 (59,18%)	36 (52,17%)	
MUST				<i>0,0275</i>
Low risk of malnutrition	6 (30%)	26 (53,07%)	32 (46,38%)	
High/Moderate Risk of Malnutrition	14 (70%)	18 (36,73%)	32 (46,38%)	

Footnotes: BMI: body mass index, MUST: Malnutrition Universal Screening Tool; MNA: Mini Nutritional Assessment.

Supplementary Table 1. Distribution of number and percent of missing values

Demographics and baseline	
Gender	0
Age at enrolment	0
Smoking Status	2 (2,89%)
Comorbidities	
Arrhythmia	4 (5,79%)
Congestive heart failure	4 (5,79%)
Myocardial infarction	4 (5,79%)
Valvular heart disease	4 (5,79%)
Coronary artery disease	4 (5,79%)
Dysthyroidism	6 (8,69%)
GERD	4 (5,79%)
COPD	4 (5,79%)
Anxiety and depression	4 (5,79%)
Diabetes	4 (5,79%)
Hypertension	4 (5,79%)
Eating disorder	4 (5,79%)
Osteoporosis	4 (5,79%)
Baseline Disease Characteristics	
Radiographic Form	0
Smear microscopy	2 (2,90%)
Source of isolated NTM specimen	2 (2,90%)
Pulmonary Function Tests	
FVC (absolute value)	5 (7,24%)
FVC%	4 (5,79%)
FEV1 (absolute value)	5 (7,24%)
FEV1%	4 (5,79%)

Restrictive pattern	4 (5,79%)
Os obstructive pattern	4 (5,79%)
Physical activity	
IPAQ	14 (20,29%)
Dynamometry and Gait speed	
Handgrip Strength (Kg)	9 (13,04%)
Gait Speed (4m) (m/sec)	8 (11,59%)
Anthropometric measurements	
Body weight (kg)	0
Height (cm)	0
BMI	0
Arm circumference (cm)	3 (4,35%)
Calf circumference (cm)	3 (4,35%)
Abdomen (waist) circumference (cm)	4 (5,79%)
% weight loss in 6 months	3 (4,35%)
Nutritional Questionnaires	
MUST	5 (7,24%)
MNA	8 (11,59%)
EAT-26	19 (27,54%)
Bioelectrical impedance analysis	
Resistance	8 (11,59%)
Reactance	8 (11,59%)
Phase angle	7 (10,15%)
FFM (Kg)	7 (10,15%)
BFM	7 (10,15%)
ASM/m ²	8 (11,59%)
Nutritional assessment	
Nutritional status	0
Nutritional recommendations	0
Sarcopenia	9 (13,04%)

