



Anthropometric status of individuals with COPD in the city of São Paulo, Brazil, over time - analysis of a population-based study

Josiane Marchioro^{1,a}, Mariana Rodrigues Gazzotti^{1,b}, Graciane Laender Moreira^{1,c}, Beatriz Martins Manzano^{1,d}, Ana Maria Baptista Menezes^{2,e}, Rogério Perez-Padilla^{3,f}, José Roberto Jardim^{1,g}, Oliver Augusto Nascimento^{1,4,h}; PLATINO Team

1. Disciplina de Pneumologia, Escola Paulista de Medicina, Universidade Federal de São Paulo – EPM/UNIFESP – São Paulo (SP) Brasil.
 2. Universidade Federal de Pelotas – UFPEL –, Pelotas (RS) Brasil.
 3. Instituto Nacional de Enfermedades Respiratorias, Ciudad de México, México.
 4. Faculdade de Medicina São Leopoldo Mandic, Campinas (SP) Brasil.
- a. <http://orcid.org/0000-0001-9548-7066>
b. <http://orcid.org/0000-0002-6061-785X>
c. <http://orcid.org/0000-0002-0176-5051>
d. <http://orcid.org/0000-0002-6258-799X>
e. <http://orcid.org/0000-0002-4129-0898>
f. <http://orcid.org/0000-0002-1132-5308>
g. <http://orcid.org/0000-0002-7178-8187>
h. <http://orcid.org/0000-0003-3138-2219>

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ABSTRACT

Objective: To evaluate the anthropometric data obtained for residents of the city of São Paulo, Brazil, in a study of Latin America conducted in two phases (baseline, in 2003, and follow-up, in 2012). **Methods:** This was an analysis of data obtained for São Paulo residents in a two-phase population-based study evaluating the prevalence of COPD and its relationship with certain risk factors among individuals ≥ 40 years of age. The anthropometric data included values for weight, height, body mass index (BMI), and waist circumference. In the follow-up phase of that study, the same variables were evaluated in the same population sample as that of the baseline phase. **Results:** Of the 1,000 São Paulo residents enrolled in the baseline phase of that study, 587 participated in the follow-up phase, and 80 (13.6%) of those 587 subjects had COPD. Comparing the baseline and follow-up phases, we found increases in all anthropometric measures in both groups (COPD and non-COPD), although the differences were significant only in the non-COPD group. The subjects with mild COPD showed increases in weight and BMI (Δ weight = 1.6 ± 5.7 and Δ BMI = 0.7 ± 2.2), whereas those with moderate or severe COPD showed reductions (Δ weight = -1.7 ± 8.1 and Δ BMI = -0.4 ± 3.0), as did those with severe or very severe COPD (Δ weight = -0.5 ± 5.4 and Δ BMI = -0.8 ± 3.3). **Conclusions:** Between the two phases of the study, the subjects with mild COPD showed increases in weight and BMI, whereas those with a more severe form of the disease showed reductions.

Keywords: Pulmonary disease, chronic obstructive; Body mass index; Obesity; Waist circumference.

INTRODUCTION

One of the diseases with the highest mortality rates in the world, COPD is projected to rank 3rd among the leading causes of death worldwide by 2020.⁽¹⁾ The prevalence of COPD in the city of São Paulo, Brazil, in 2003, according to the Latin American Project for the Investigation of Obstructive Lung Disease (PLATINO) study, was 15.8% of the population ≥ 40 years of age.⁽²⁾

Currently, the inflammatory component of COPD is believed not only to cause injury to the lungs but also to have a systemic effect, being associated with several morbidities, such as loss of lean body mass and muscle dysfunction.⁽³⁾ Malnutrition is one of the major systemic manifestations of COPD and is usually due to loss of mean body mass accompanied by weight loss.⁽⁴⁾ Muscle depletion is typically multifactorial, including an increased basal metabolic rate, reduced caloric intake, senile sarcopenia, inactivity,^(5,6) systemic inflammatory activity, hormonal changes, and chronic use of systemic corticosteroids.^(7,8)

It has been established that a low body mass index (BMI), as well as a low lean body mass index, is associated with a worse prognosis, a higher risk of exacerbations,

reduced exercise capacity, and reduced quality of life in individuals with COPD.⁽⁹⁻¹¹⁾

At the other end of the spectrum, the number of overweight or obese people is known to have increased in recent decades, obesity being considered a global epidemic.⁽¹²⁾ In Brazil, according to data from a telephone survey conducted by the Brazilian National Ministry of Health, the frequency of overweight was 52.5% in 2014.⁽¹³⁾ Therefore, since COPD affects the same age group in which obesity tends to increase, the association between COPD and obesity is expected to be prevalent. In addition, knowing that cardiovascular disease (a condition for which the major risk factor is being overweight) is the leading cause of death in COPD patients, the association between COPD and obesity is expected to have a great impact on patient prognosis.⁽³⁾

Analysis of the nutritional status of COPD patients over time is essential to the follow-up of such patients. Weight loss in COPD patients has been shown to be an independent risk factor for mortality.^(14,15) However, to date, we know of no studies conducted in Brazil that have evaluated weight change in COPD patients.

Correspondence to:

Oliver Augusto Nascimento. Rua Botucatu, 740, 3º Andar, Disciplina de Pneumologia, Universidade Federal de São Paulo (UNIFESP), CEP 04023-062, São Paulo, SP, Brasil.

Tel.: 55 11 5572-4301. E-mail: oliver.nascimento@unifesp.br

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The objective of the present study was to evaluate the anthropometric status of COPD patients in the greater metropolitan area of São Paulo over time by using baseline and follow-up data from the PLATINO study (a population-based study), and to compare the anthropometric status of individuals with and without COPD.

METHODS

The detailed design of the PLATINO study has been published elsewhere.⁽¹⁶⁾ In brief, in 2003, the study known as the PLATINO baseline study aimed to describe the epidemiology of COPD in five cities in Latin America: São Paulo, Santiago, Mexico City, Montevideo, and Caracas. Those cities were divided into socioeconomic level census tracts. Through systematic sampling, approximately 15 households were visited and all residents ≥ 40 years of age were invited to participate in the study. In 2012, the study known as the PLATINO follow-up study was conducted with the same subjects as before and using the same questionnaires. All interviews and tests, including pre- and post-bronchodilator spirometry, occurred in the participants' own homes. Anthropometric assessments included the measurement of height (portable stadiometer—Sanny; American Medical do Brasil Ltda., São Bernardo do Campo, Brazil); weight (electronic scale—Techline®, Taiwan); and waist circumference (WC; Fiberglass®, Brazil); as well as the calculation of BMI (kg/m^2). The WC measurement was made at the level of the umbilicus, at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest.⁽¹⁷⁾ The BMI cut-off points for nutritional status in individuals ≤ 59 years of age were those proposed by the World Health Organization⁽¹²⁾: BMI $< 18.5 \text{ kg}/\text{m}^2$ (underweight); BMI $\geq 18.5 \text{ kg}/\text{m}^2$ and $< 25.0 \text{ kg}/\text{m}^2$ (normal weight); BMI $\geq 25.0 \text{ kg}/\text{m}^2$ and $< 30.0 \text{ kg}/\text{m}^2$ (overweight); and BMI $\geq 30.0 \text{ kg}/\text{m}^2$ (obese). For individuals > 59 years of age, the BMI cut-off points were those proposed by the Pan American Health Organization⁽¹⁸⁾: BMI $\leq 23 \text{ kg}/\text{m}^2$ (underweight); BMI $> 23 \text{ kg}/\text{m}^2$ and $< 28 \text{ kg}/\text{m}^2$ (normal weight); BMI $\geq 28 \text{ kg}/\text{m}^2$ and $< 30 \text{ kg}/\text{m}^2$ (overweight); and BMI $\geq 30 \text{ kg}/\text{m}^2$ (obesity). Normal WC was defined as WC $< 80 \text{ cm}$ for women and WC $< 94 \text{ cm}$ for men.⁽¹⁷⁾ All anthropometric variables were assessed in the PLATINO baseline and follow-up studies, and were compared as absolute values and percent changes. All spirometry tests and their quality assessment were performed in accordance with the American Thoracic Society 2005 recommendations.⁽¹⁹⁾ Predicted values for the spirometric variables were calculated with an equation developed for the Latin-American population.⁽²⁰⁾

Baseline participants who were successfully contacted and declined to participate in the follow-up phase of the PLATINO study completed a shortened questionnaire with questions identical to those used in the baseline phase. Participants who developed a mental illness during the follow-up period were excluded. The exclusion

criteria for undergoing spirometry are described in detail in the PLATINO baseline study.⁽¹⁶⁾

The study project was approved by the Research Ethics Committee of the Federal University of São Paulo, and all participants gave written informed consent before any intervention, in both phases of the PLATINO study.

Statistical analysis

Numerical data are expressed as means and standard deviations. Categorical data are presented as absolute numbers and proportions. Comparison of mean numerical variables between two independent groups was performed using the Student's t-test. For comparison of means between two groups at different time points, repeated measures analysis was performed using a general linear model to compare the groups (COPD and non-COPD) and time point interaction analysis at two time points (PLATINO baseline and follow-up studies) plus the Bonferroni post hoc test. For comparison of numerical data among three or more groups, ANOVA and the Bonferroni post hoc test were used. Comparison of proportions of categorical variables between two independent groups was performed using the chi-square test. McNemar's test was used to compare categorical data for the same group at different time points (nutritional status at the time of the PLATINO baseline and follow-up studies). The level of significance was set at 5%. Statistical analyses were performed with the Statistical Package for the Social Sciences, version 10.0 (SPSS Inc., Chicago, IL, USA) and Stata, version 8.0 (StataCorp LP, College Station, TX, USA).

RESULTS

Of the 1,000 participants in the PLATINO baseline study in the city of São Paulo, Brazil, 944 were successfully contacted. Of those, 135 had died, 141 declined to participate in the follow-up, and 55 were lost to that follow-up. Therefore, interviews were performed with 613 individuals, of whom 594 underwent pre- and post-bronchodilator spirometry and 587 underwent anthropometric assessment.

Table 1 presents the demographic data for the total sample and by group (non-COPD and COPD). The mean age was higher in the COPD group than in the non-COPD group ($p < 0.001$). The two groups were similar with respect to gender and anthropometric data (weight, height, WC, and BMI). Despite being low overall, smoking history was greater in the COPD group ($p < 0.05$). As expected, FEV_1 and the FEV_1/FVC ratio were significantly lower in the COPD group.

Figure 1 (A, B, and C) presents a comparison of the results of the PLATINO baseline study and those of the PLATINO follow-up study with regard to weight, BMI, and WC in the non-COPD and COPD groups. General linear model analysis for the baseline phase revealed that there were no statistically significant differences in those variables between the COPD and non-COPD groups. Weight and BMI were found to have increased

Table 1. Demographic data on participants in the follow-up phase of the Latin American Project for the Investigation of Obstructive Lung Disease study in the city of São Paulo, Brazil.^a

Data	Groups		
	Total (N = 587)	Non-COPD (n = 507)	COPD (n = 80)
Age, years	53.3 ± 9.6	52.5 ± 9.3	58.1 ± 10.0**
Gender			
Male	262 (44.6)	223 (44.0)	39 (48.8)
Female	325 (55.4)	284 (56.0)	41 (51.2)
Height, m	1.60 ± 0.10	1.60 ± 0.94	1.58 ± 0.15
Weight, kg	72.3 ± 15.6	72.6 ± 15.0	69.7 ± 18.5
Waist circumference, cm	97.7 ± 13.3	97.6 ± 12.9	97.7 ± 15.6
BMI, kg/m ²	28.4 ± 8.1	28.3 ± 5.4	27.2 ± 6.7
Smoking history, pack-years	5.7 ± 12.0	5.2 ± 11.5	8.8 ± 14.7*
Post-BD FEV ₁ /FVC	0.79 ± 0.08	0.81 ± 0.05	0.63 ± 0.06
Post-BD FEV ₁ /FVC, % of predicted	98.95 ± 10.1	101.8 ± 6.5	81.0 ± 8.4**
Post-BD FEV ₁ , L	2.73 ± 0.75	2.81 ± 0.73	2.23 ± 0.73
Post-BD FEV ₁ , % of predicted	98.50 ± 17.0	100.8 ± 15.7	84.0 ± 18.3**
Post-BD FVC, L	3.48 ± 0.92	3.47 ± 0.89	3.51 ± 1.08
Post-BD CVF, % of predicted	99.20 ± 16.2	98.5 ± 15.2	103.3 ± 21.4 [#]

BMI: body mass index; and post-BD: post-bronchodilator. ^aValues expressed as n (%) or as mean ± SD. [#]p < 0.05. *p < 0.05. **p < 0.001.

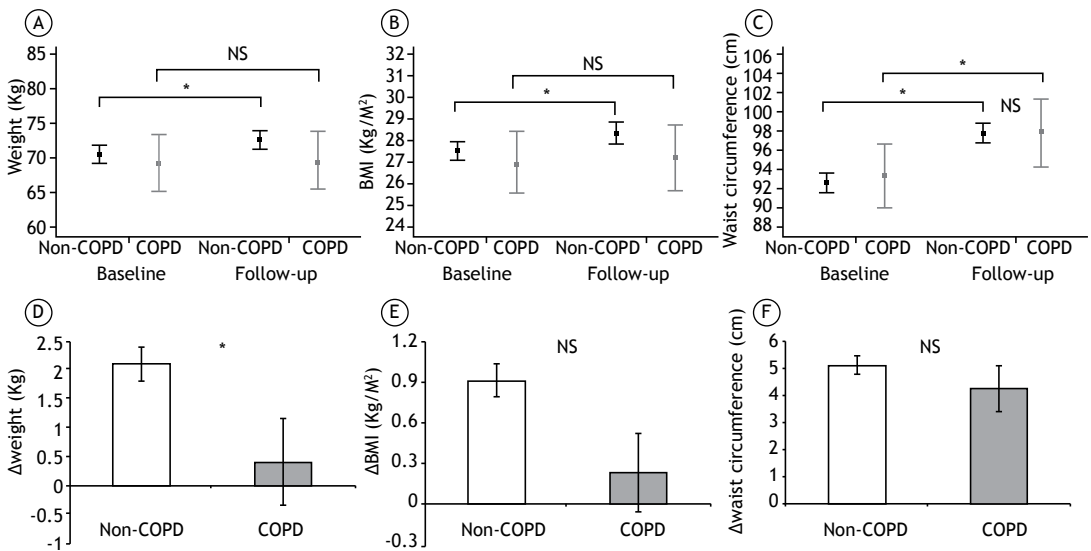


Figure 1. Comparison of mean weight, body mass index (BMI), and waist circumference - and their 95% CIs - in the baseline and follow-up phases of the Latin American Project for the Investigation of Obstructive Lung Disease study in the city of São Paulo, Brazil, between the COPD and non-COPD groups (in A, B, and C, respectively), as well as of mean changes in weight, BMI, and waist circumference between those groups (in D, E, and F, respectively). NS: not significant. *p < 0.05.

significantly only in the non-COPD group (p < 0.005). However, WC increased significantly in both groups (p < 0.005). Comparison of weight, BMI, and WC for the follow-up phase revealed no statistically significant differences between the two groups. Figures 1D, 1E, and 1F show comparisons of changes in weight, BMI, and WC, respectively, between the two groups in the follow-up phase. The non-COPD group had a weight gain of approximately 2 kg, whereas the COPD group had a weight gain of about 0.4 kg (p = 0.042). As a result of the difference in weight change, the BMI

increase was also smaller in the COPD group compared with the non-COPD group (0.23 kg/m² vs. 0.90 kg/m²), although no statistically significant difference was found (p = 0.054). There was no statistically significant difference in WC change between the COPD and non-COPD groups.

Figure 2 presents the distribution of the individuals in the non-COPD and COPD groups by nutritional status. In both groups, normal BMIs predominated in the baseline phase. In the non-COPD group, there was a reduction in the proportion of normal weight

individuals and a more significant increase in the proportion of overweight and obese individuals ($p < 0.005$). In the COPD group, however, the change in classification was not statistically significant.

Table 2 shows changes in nutritional status from the baseline to the follow-up phase of the PLATINO study in the non-COPD and COPD groups, by BMI stratification. The interesting thing about this table is that we can analyze and compare the nutritional status of the participants in the two phases. In the non-COPD group, there was always an increase in the number of individuals who had lower BMIs in the baseline phase and higher BMIs in the follow-up phase, that is, who had a greater weight gain. For example, of the individuals who had normal nutritional status in the baseline phase, 66.1% remained in the same classification, whereas 21.0% and 3.2% were reclassified as overweight and obese, respectively. Those changes also occurred in the underweight and overweight individuals and were statistically significant. In contrast, the patients in the COPD group did not experience the same changes as those seen in individuals without COPD. The vast majority of the COPD patients who were underweight in the baseline phase remained in the same classification (91.7%). A small proportion of the COPD patients who were normal weight or overweight were reclassified as

being in higher weight categories (7.0% and 16.7%, respectively). An important point is that, of the COPD patients who were overweight, 50% were reclassified as normal weight, but there was no statistically significant difference. This demonstrates that the COPD patients tended not to gain weight in the long run.

Table 3 compares changes in nutritional parameters from the baseline to the follow-up phase in the non-COPD group and in the COPD group subdivided according to disease severity (degree of obstruction) as defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria.⁽⁴⁾ The patients with moderate, severe, and very severe COPD (GOLD stage II-III-IV) showed reductions in weight and BMI, unlike the individuals in the non-COPD group and those with GOLD stage I COPD, who showed increases. Post hoc analysis revealed that weight change was statistically significantly different between the non-COPD group and the GOLD stage II COPD subgroup, either in absolute ($p = 0.03$) or relative ($p = 0.054$) values. The proportional change in BMI was also significant ($p = 0.023$), with the non-COPD group showing the greatest gain in BMI (mean = 9.6%). However, WC increased in all groups, with no statistically significant differences among the disease severity subgroups or in relation to the non-COPD group (Table 3).

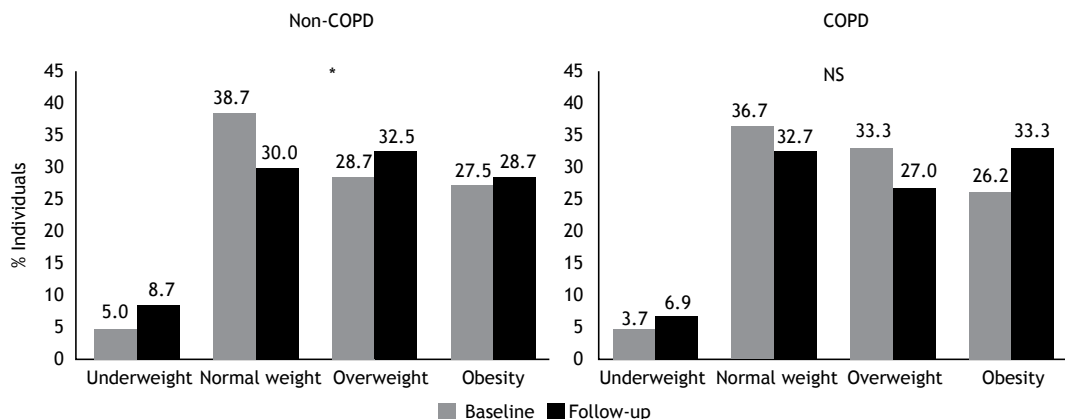


Figure 2. Nutritional status of individuals in the non-COPD and COPD groups in the baseline and follow-up phases of the Latin American Project for the Investigation of Obstructive Lung Disease study in the city of São Paulo, Brazil. NS: not significant.

Table 2. Change in nutritional status, by BMI, from the baseline to the follow-up phase of the Latin American Project for the Investigation of Obstructive Lung Disease study in the city of São Paulo, Brazil, in the COPD and non-COPD groups.

	Non-COPD				p	COPD				p
	Underweight	Normal weight	Overweight	Obesity		Underweight	Normal weight	Overweight	Obesity	
Baseline	Underweight	14 (73.7)	5 (26.3)	-	-	11 (91.7)	1 (8.3)	-	-	NS
	Normal weight	18 (9.7)	123 (66.1)	39 (21)	6 (3.2)	5 (17.9)	20 (71.4)	1 (3.6)	1 (3.4)	
	Overweight	3 (1.8)	35 (20.7)	81 (47.9)	50 (29.6)	-	9 (50)	6 (33.3)	3 (16.7)	
	Obesity	-	3 (2.3)	17 (12.8)	113 (85)	-	1 (4.5)	3 (13.6)	18 (81.8)	

NS: not significant. ^aValues expressed as n (%).

Analysis of WC over time revealed that, in the baseline phase, 67% of the individuals without COPD and 62% of the individuals with COPD already had an increased WC. It also showed that, in the follow-up phase, individuals with an increased WC continued to predominate in the non-COPD and COPD groups (81.5% vs. 72.0%; Figure 3).

DISCUSSION

Our findings showed that there were no significant changes in weight, BMI, or WC in the COPD group at 9 years from baseline. In addition, the individuals in the COPD group gained less weight than did those in the non-COPD group. There was an increase in the proportions of overweight and obese individuals, and those proportions were significantly higher in the non-COPD group than in the COPD group. Similarly, there was a greater WC gain in the non-COPD group, as well as a higher proportion of individuals with increased WC values, in the follow-up phase.

Our study showed that the prevalence rates for overweight and obesity were high in the COPD and non-COPD groups in the two phases of the PLATINO study. In the non-COPD group, the prevalence rates for excess weight (overweight and obesity) were 56.2% and 61.2% in the baseline and follow-up phases, respectively, whereas in the COPD group, they were 59.5% and 60.3%, respectively. In line with these findings, some studies have shown that the prevalence rates for excess weight in COPD patients are high, being similar to or higher than those seen in healthy individuals in the same age group.^(21,22) The prevalence of excess weight in COPD patients varies by population studied—23% in South America.⁽²³⁾ Therefore, our data underscore the idea that obesity is a global epidemic and occurs concomitantly with several morbidities. Although the objective of the present study was to evaluate anthropometric parameters over time, the results of the PLATINO baseline and follow-up studies give us an idea of the prevalence of the obesity-COPD association in Brazil, which had not been evaluated in population-based studies. Some factors can explain the possible causes of this common association. In addition to a systemic inflammatory state, common to both morbidities,⁽²⁴⁾ the risk of obesity in COPD patients

increases as a result of their sedentary lifestyle, given that they have poor physical capacity.⁽²⁵⁾

The prognostic value of nutritional status in COPD is well established. A reduced BMI is associated with an increase in all-cause mortality, regardless of the degree of obstruction.⁽²⁶⁾ Recent studies indicate that lean body mass index is an even more important prognostic determinant than BMI in patients with moderate to severe disease.^(27,28) It is of note that the relative risk of death seems to decrease with excess weight (overweight and obesity) in patients with GOLD stage III and IV COPD, whereas it increases in those with GOLD stage I and II COPD.⁽²⁶⁾ This association between obesity and paradoxical improvement in prognosis is present in several chronic diseases, such as congestive heart failure, chronic renal failure, and rheumatoid arthritis.⁽²⁹⁾ Contrary to this apparent benefit of excess weight for COPD patients, cardiovascular risk is known to be high in COPD, regardless of BMI.⁽³⁰⁾ Therefore, if we add to this the cardiovascular risks associated with obesity, there is a high risk of atherosclerotic disease in this population.⁽³¹⁾

In our sample, the patients with mild disease (GOLD stage I) gained weight and showed increases in BMI over time, whereas those with advanced stage disease (GOLD stage II-III-IV) showed reductions in weight and BMI. As in our study, Eisner et al.⁽²²⁾ reported a high

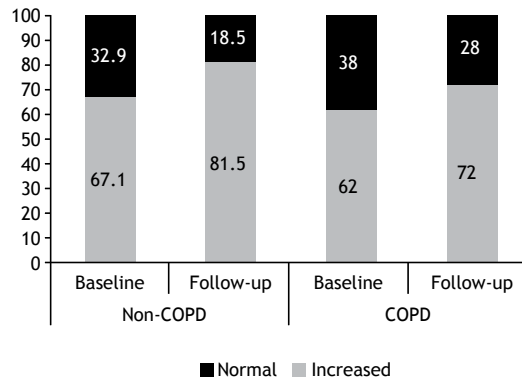


Figure 3. Waist circumference status in the non-COPD and COPD groups in the baseline and follow-up phases of the Latin American Project for the Investigation of Obstructive Lung Disease study in the city of São Paulo, Brazil.

Table 3. Change in nutritional parameters vs. COPD staging as defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD).^a

Parameter	Non-COPD		GOLD		p
	(n = 508)	I (n = 50)	II (n = 26)	III and IV (n = 4)	
Δweight, kg	2.1 ± 6.8	1.6 ± 5.7	-1.7 ± 8.1*	-0.5 ± 5.4	0.04
Δweight, %	3.3 ± 9.3	2.1 ± 8.2	-1.6 ± 10.2**	-3.0 ± 8.8	0.029
ΔBMI, kg/m ²	0.88 ± 2.8	0.65 ± 2.2	-0.41 ± 3.0	-0.79 ± 3.3	0.075
ΔBMI, %	3.62 ± 9.5	2.31 ± 8.4	-0.66 ± 9.5**	-5.95 ± 12.6	0.023
ΔWC, cm	5.1 ± 7.9	5.7 ± 6.3	1.4 ± 9.1	2.3 ± 1.3	0.101
ΔWC, %	5.8 ± 8.9	6.3 ± 6.9	2.0 ± 9.4	1.9 ± 0.7	0.142

BMI: body mass index; and WC: waist circumference. ^aValues expressed as mean ± SD. *p = 0.03 in relation to the non-COPD group. **p = 0.054 in relation to the non-COPD group.

prevalence of obesity in patients with mild obstruction, exceeding that seen in healthy individuals in the same age group. Stratified analysis of BMI by GOLD severity stage clearly shows that, because our sample consisted predominantly of individuals with GOLD stage I disease (62.5%), the overall mean BMI in the COPD group was high ($29.1 \pm 17.6 \text{ kg/m}^2$). In contrast, patients with GOLD stage II-III-IV disease experienced weight loss and a reduction in BMI over time, which is in line with the findings of a study that reported a prevalence rate of 18% for obesity in COPD, with 16% and 20% of obese individuals being classified as GOLD stage I and II, respectively, and only 6% being classified as GOLD stage IV.⁽³²⁾

Several factors can contribute to weight loss in the course of COPD. In addition to the decline in caloric intake with aging,⁽³³⁾ a worsening of dyspnea during meals,⁽³⁴⁾ and a reduction in appetite,⁽³⁵⁾ there is increased energy expenditure due to changes in lung mechanics,⁽³⁶⁾ increased muscle energy cost,⁽³⁷⁾ and increased production of inflammatory mediators.⁽³⁸⁾ These factors support our findings of lower weight gain in patients with more severe forms of COPD.

One intriguing finding in our study was the stability of WC across all COPD stages, despite the weight reduction in individuals with moderate to severe disease. Patients with GOLD stage II COPD lost weight and had a reduction in BMI, but showed a 2% increase in WC. Temporal analysis of WC status revealed that individuals in both groups had difficulty reducing their WC: only slightly more than 10% of the individuals in the non-COPD group achieved a normal WC, whereas the proportion of reduction was even lower (4.5%) in the COPD group. This difficulty in losing abdominal fat despite weight loss may be linked to the increased risk of COPD patients for developing atherosclerotic diseases.⁽³⁹⁾

We should point out some limitations of our study. Because of the population-based design of the PLATINO study, with all assessments being conducted in the participants' homes, some assessments that would be of interest could not be carried out. The diagnosis of COPD was based solely on the GOLD criteria, that is, a post-bronchodilator FEV_1/FVC ratio of < 0.70 . Despite being widely used in epidemiological studies, this criterion is criticized because the use of a fixed cut-off point for the FEV_1/FVC ratio poses a risk of COPD being underdiagnosed in younger individuals and of its prevalence being overestimated in older individuals. However, this diagnostic criterion is widely accepted and is the one most widely used in epidemiological studies, allowing comparisons of the results of the PLATINO study with those of studies conducted in other countries and regions. The determination of nutritional status was based solely on BMI stratification, a method that cannot quantify body compartments and, therefore, may fail to identify patients with reduced lean body mass but no weight reduction. However, the literature points to BMI as the most practical way to diagnose obesity, and BMI is the most widely used method in epidemiological studies. Our study was not designed to determine the causes and consequences of the nutritional changes found, which would be of interest to measuring the impact of such findings on our population.

With this study, we can conclude that, in the follow-up phase of the PLATINO study, there was an increase in weight in both groups. Among the COPD patients, those with mild disease showed increases in weight and BMI, whereas those with more advanced stage disease showed reductions. These results show the importance of knowing the nutritional profile of COPD patients and preventing both weight loss and excess weight, given that underweight and overweight/obesity have a negative effect on prognosis.

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