Body composition and health-related quality of life in patients with obstructive airways disease

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ABSTRACT: This study evaluated the effects of body weight and lean mass abnormalities on health-related quality of life (HRQL) in obstructive airways disease.

Body weight, lean mass (using dual-energy X-ray absorptiometry), and HRQL (using the St George's Respiratory Questionnaire (SGRQ)) were measured in 50 patients. Low lean mass was defined as a lean mass index (lean mass/height^2) below the fifth percentile of a control population. Dyspnoea was measured by the baseline dyspnoea index.

The mean (SD) age was 69±9 yrs; the forced expiratory volume in one second (FEV1) was 39±19% of predicted. Patients had 2.4±4.1 kg less lean mass than predicted. Increased dyspnoea was the most influential predictor of poor HRQL. Compared to normal-weight patients, those who were underweight had significantly greater impairment in activity, impact, and total SGRQ scores, while those who were overweight had greater impairment in impact and total SGRQ scores. Low lean mass was associated with greater impairment in symptoms, activity and impact subscores and the total SGRQ score. When dyspnoea was added to the model as a covariate, neither weight nor lean mass remained significantly related to HRQL.

Thus, although body weight and lean mass abnormalities influence health-related quality of life, their effects appear to be mediated through increased levels of dyspnoea.

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A significantly reduced body weight, which is common in individuals with advanced chronic obstructive pulmonary disease (COPD) [1, 2], is related to decreased exercise performance [3, 4] and increased mortality [5, 6]. In addition, analyses using bioimpedance techniques have demonstrated reductions in fat-free mass in normal-weight and underweight patients [7]. Decreased fat-free mass may be a predictor of poor exercise performance independently of body weight [3].

Although the effect of nutritional status on exercise performance is established, little attention has been given to its effect on health-related quality of life (HRQL). To evaluate this, we measured two nutritional parameters, body weight and total body lean mass determined by dual-energy X-ray absorptiometry, in 50 patients with symptomatic obstructive lung disease. These two variables were then compared with HRQL measured by the St George's Respiratory Questionnaire (SGRQ).

Methods

The study was approved by the Medical Center's Institutional Review Board and informed consent was obtained from all subjects before participation in the study. All testing was performed in the Osteoporosis Center, which is in close proximity to the University of Connecticut Health Center.

Adults with obstructive lung disease who were symptomatic with dyspnoea despite medical therapy, were recruited for the study. All had moderate-to-severe airways obstruction following bronchodilator inhalation and were clinically stable at the time of the study. Most had previously completed an out-patient pulmonary rehabilitation programme and many were in a postrehabilitation exercise maintenance programme. Patients with clinically apparent congestive heart failure, overt peripheral oedema, recurrent cancer, or recent surgery were excluded from the study.

An initial interview included determination of age, long-term oxygen use, number of nonpulmonary diagnoses and medications, cigarette smoking history, prednisone dose upon study entry, and prednisone use over the past 12 months (average dose of prednisone multiplied by the number of days on prednisone). Each patient's evaluation included: 1) Spirometry: pre-bronchodilator forced expiratory volume in one second (FEV1) was measured. This was expressed as percentage of predicted values. 2) The 6 min walking distance (6MWD): this was performed in the hallway corridor after completion of body composition measurements. Patients were instructed to walk as far as possible up and down the

corridor during a 6 min period. 3) Dyspnoea measurement: the baseline dyspnoea index (BDI) was used to measure overall dyspnoea. This score was calculated by summing its three components, magnitude of task, magnitude of effort, and functional impairment. Lower BDI scores indicate more dyspnoea. 4) The St George's Respiratory Questionnaire [8]. This 76 item, respiratory-specific measure of HRQL has a total score, plus subscores for symptoms, activity, and impact. It was filled out by the patient at home, shortly before coming in for body composition evaluation, or in the institution while awaiting testing.

Height was measured to the nearest 0.5 cm while the patient stood barefoot. Weight was measured while the patient wore light clothing but no shoes. Ideal body weight was determined from gerontology tables, which allow for matching by gender and age category [9]. Per cent of ideal body weight (PIBW) was calculated by dividing the patient's body weight by ideal body weight and multiplying by 100. Patients with PIBW <90 were considered underweight, those with PIBW of 90–110 were considered to have normal weight, and those with PIBW >110 were considered overweight.

Body composition was measured with dual-energy X-ray absorptiometry (DXA; DPX-L, Software version 1.3y, Lunar Radiation Corp., Madison, WI, USA) using fast scanning (approximately 10 min per scan) while the patient lay supine on the examination table. Total body lean mass, in kg, measured by this test, was used in subsequent analyses. The sum of total lean body mass and bone mineral content by DXA is approximately equal to fat-free mass by bioimpedance analysis. Lean mass index (LMI), analogous to body mass index, was defined as lean mass (in kg) divided by height (in m) squared. (Schols AMW and Wouters EFM, personal communication).

Since normative data on total lean body mass are not defined, a population of apparently healthy subjects previously studied for an osteoporosis prevention trial was used as a control group. Subjects recruited for this trial had never smoked and had no apparent cardiac or pulmonary disease. To match our patients' age more closely, only those subjects aged ≥50 yrs were included in the control group. The group comprised 236 males and 456 females with a mean age of 67 yrs. Total lean body mass was measured with medium-speed DXA scanning in these patients. Medium and fast-speed DXA scanning have nearly identical precision errors (1 SD) of 0.8 kg, although lean mass estimation by fast scanning is approximately 0.3 kg less than by medium scanning [10]. PIBW and LMI were also calculated for this control population.

From the control population, separate linear regression equations for males and females were developed to predict lean mass. In these equations, age (in yrs), height (in m), and weight (in kg) were related to lean mass (in kg). For males, the equation was: lean mass $=-9.27 - 0.23 \times age + 33.97 \times height + 0.26 \times weight$ ($r^2=0.66$; $p<0.0001$). For females, the equation was: lean mass $= -19.00 -0.05 \times age + 29.53 \times height + 0.19 \times weight$ ($r^2=0.62$; $p<0.0001$). These regression equations were then used to provide predicted lean mass for the 50 study patients. The patient-control difference in lean mass ($\Delta lean$), was then calculated for each patient. For this variable, negative values indicate less lean mass than predicted from the control population.

LMI in the control population was normally distributed, with a mean (SD) of 18.0 ± 1.4 kg·m^{-2} for males, and 14.4 ± 1.3 kg·m^{-2} for females. The lowest fifth percentile for LMI in the control population (16.3 kg·m^{-2} and 12.9 kg·m^{-2} for males and females, respectively) was used to define low lean mass for the patient group. Thus, male patients with LMI less than 16.3 kg·m^{-2} and female patients with LMI less than 12.9 kg·m^{-2} were considered to have low lean mass for subsequent body composition analyses.

Unless otherwise stated, data are presented as means± standard deviations. Patient characteristics were related to HRQL scores using linear regression and Spearman correlation. Separate, one-way analyses of variance were used to evaluate the relationship between nutritional variables and SGRQ, BDI dyspnoea, and FEV1. For this, body weight or lean mass category were used as independent variables, with FEV1 and dyspnoea added to the model as covariates. Least squares mean was used to compare categories if the model was significant. Statistical Analysis System software (SAS; SAS Institute Inc., Cary, NC, USA; [11]) was used for statistical analysis. A p-value of less than 0.05 was considered significant.

Results

Twenty males and 30 females were studied. Forty five were previous graduates of an out-patient pulmonary rehabilitation programme and 20 were regular participants in a postrehabilitation exercise programme. Their mean age (69 ± 9 yrs) was similar to that of the control population, (67 ± 7 yrs). Forty four had a history of cigarette smoking; the mean lifetime cigarette consumption in these subjects was 59 ± 41 pack-yrs. The mean FEV1 was 0.96 ± 0.48 L, which was $39\pm19\%$ pred. Forty six had a primary diagnosis of COPD, three had chronic asthma with severe, fixed airways obstruction, and one had cystic fibrosis and advanced pulmonary disease. Thirty two per cent were using continuous, low-flow oxygen. Nineteen patients were taking oral steroids at the time of the study, and 39 had received oral steroids during the preceding year. PIBW was $106\pm33\%$. Dyspnoea, measured by the BDI, was 5.4 ± 2.4 and the 6MWD was 296 ± 99 m. The SGRQ scores for the group were as follows: symptom 59 ± 20; activity 53 ± 21; impact 28 ± 17 and total 44 ± 16. Patient characteristics are presented in table 1.

Table 1. – Patient characteristics

Age yrs	69±9
FEV1 L	0.96±0.48
% pred	39±19
6MWD m	296±99
Baseline dyspnoea index	5.4±2.4
SGRQ total score	44±16
Percentage of ideal body weight	106±33
Lean mass index kg·m^{-2}	15.5±2.6

FEV1: forced expiratory volume in one second; % pred: percentage of predicted value; 6MWD: six minute walk distance; SGRQ: St George's Respiratory Questionnaire.

Table 2. – Patient-predicted differences in total lean body mass

	Δ_{lean} kg	p-value
Males (n=20)	-4.7±4.7	0.0002
Females (n=30)	-0.9±2.8	0.10
Total group	-2.4±4.1	0.0001

Predicted lean mass was determined by linear regression from the control population. Negative values for Δ_{lean} indicate that the patient group had reduced lean mass compared to that predicted by the control group. Δ_{lean}: mean difference± SD between patient and predicted lean mass.

Thirteen patients (26%) had IBW <90% and were categorized as underweight, 19 (38%) had IBW of 90–110% and were categorized as having normal weight, and 18 (36%) had IBW >110% and were categorized as overweight. Thirty patients (60%) had total lean mass less than the predicted values. The mean patient-predicted (Δ_{lean}) for the group was -2.4±4.1 kg (p<0.0001). This difference was much greater in males than females: -4.7±4.7 *versus* -0.9±2.8 kg, respectively (p=0.002). A comparison of total lean body mass between the patient group and predicted values determined by linear regression in the control group is given in table 2.

The mean LMI for the male patients was 16.9±2.7 kg·m^{-2}, and for females 14.6±2.0 kg·m^{-2}. Thirteen patients (26%) had LMI values below the lower fifth percentile cut-off determined from the control population, and were categorized as having low lean mass; the remainder were considered as having normal lean mass. Ten of 20 males but only three of 30 females had low lean mass (p<0.05). The relationship between body weight category and lean mass category is given in figure 1.

Age, smoking history, sex, number of nonpulmonary diagnoses, number of nonpulmonary medications, longterm oxygen therapy, (LTOT) requirement, and FEV$_1$ % pred were not significantly related to the SGRQ. Greater prednisone use over the preceding 12 months was related to poorer HRQL (r=0.40; p<0.01). The 6MWD was
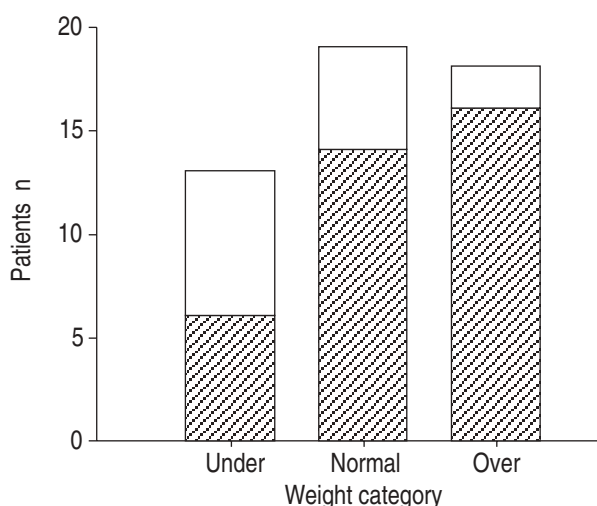

Fig. 1. – The relationship between body weight and lean mass categories. Underweight, normal-weight, and overweight categories were defined as less than 90%, 90–110%, and over 110% of ideal body weight, respectively. Low lean mass was defined as less than the fifth percentile lean mass index (LMI) of the control population. ☐: low lean mass; ▨ : normal lean mass.
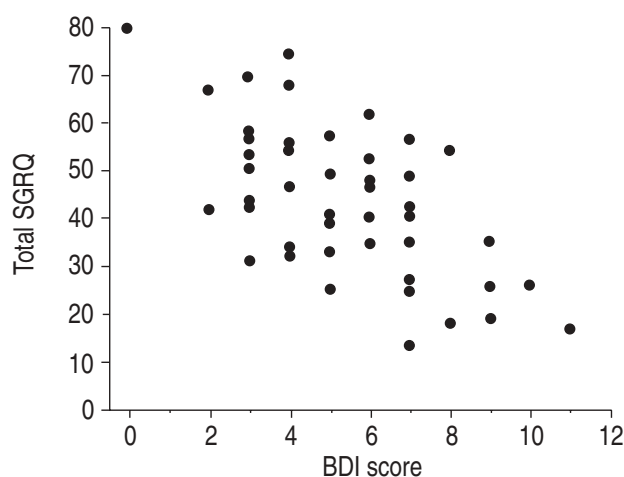

Fig. 2. – A scatterplot depicting the relationship between dyspnoea and the total St George's Respiratory Questionnaire (SGRQ) score. Dyspnoea was measured using the baseline dyspnoea index (BDI), with higher scores indicating less dyspnoea. Lower SGRQ scores indicate less impairment. Increased levels of dyspnoea were associated with greater impairment in quality of life. The correlation coefficient between the two variables was -0.58 (p<0.001).

significantly related to the SGRQ activity score (r=-0.38; p<0.01) but not to the other two components. Dyspnoea was by far the most significant variable related to total SGRQ and its dimensions; correlation coefficients for this variable and SGRQ scores were: symptom, r=-0.38 (p<0.01); activity, r=-0.66 (p<0.001); impact, r=-0.47 (p<0.001); and total SGRQ, r=-0.58 (p<0.001). A scatterplot depicting the relationship between dyspnoea and the total SGRQ score is given in figure 2.

The mean FEV$_1$ of overweight patients (48±22% pred), was significantly greater than that of underweight patients (29±12% pred, p<0.01) and tended to be greater than that of normal weight patients (38±16% pred p=0.08). Body weight category was not significantly related to age, sex, oral steroid use during the preceding 12 months, or participation in postrehabilitation exercise maintenance. Similarly, there was no significant relationship between weight category and the 6MWD: underweight patients walked a distance of 277±115 m, normal weight patients walked 305±99 m, and overweight patients walked 299±90 m. Patients with low body weight had significantly lower BDI scores (*i.e.*, greater dyspnoea) than normal body weight patients (4.1±2.2 *versus* 6.4±2.6; p<0.01).

The relationships between body weight category and the SGRQ subscores and total score are given in fig. 3. Weight category was not significantly related to the SGRQ symptom subscore. However, underweight patients had significantly higher (*i.e.*, greater impairment) activity (71±17 *versus* 55±21; p<0.05) and impact (41± 17 *versus* 19±14; p<0.001) subscores and total SGRQ score (55±13 *versus* 36±15; p<0.001) than normal weight patients. Overweight patients had more impairment in SGRQ impact subscore (p<0.01) and total score (p<0.05) than normal-weight patients. The relationship between weight category remained significant when FEV$_1$ % pred was added to the model as a covariate. However, when BDI dyspnoea was added to the model, only dyspnoea, not weight category, related significantly to HRQL.
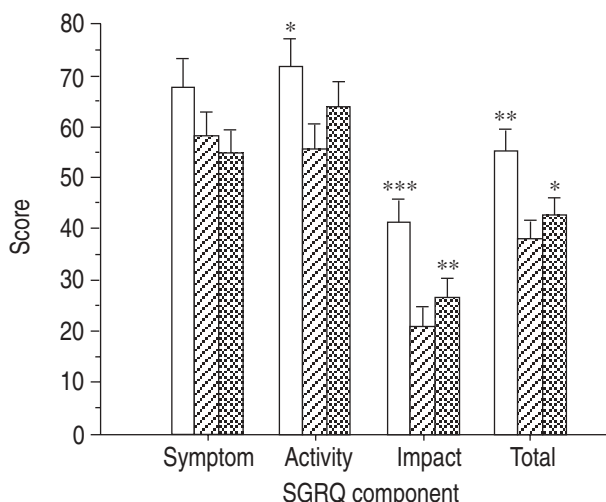
Fig. 3. – The relationship between body weight categories and St George's Respiratory Questionnaire (SGRQ) subscores and total score. Values are presented as mean±SEM. Underweight patients (☐) had significantly higher (*i.e.* greater impairment) activity, impact and total SGRQ scores than normal-weight patients (☐). Overweight patients (▨) had significantly higher impact and total scores than normal-weight patients. *: $p<0.05$; **: $p<0.01$; ***: $p<0.001$ *versus* normal-weight group.

Low and normal LMI subgroups were not significantly different with respect to age, FEV1 % pred, oral steroid use in the preceding 12 months, 6MWD, or participation in postrehabilitation exercise maintenance. Patients with low lean mass had lower BDI scores (*i.e.*, greater dyspnoea) than those with normal lean mass: 3.9±1.9 *versus* 5.9±2.2 ($p<0.01$).

The low lean mass group had significantly higher SGRQ subscores and total scores than the normal lean mass group. This included: symptom, 69±14 *versus* 56± 21; activity, 73±14 *versus* 59±21; impact, 37±19 *versus* 25±15 (all $p<0.05$); and total SGRQ, 53±13 *versus* 40± 15 ($p<0.01$). When BDI dyspnoea was added to the model, however, lean mass no longer significantly predicted HRQL. The relationships between body composition category and SGRQ are depicted in figure 4.
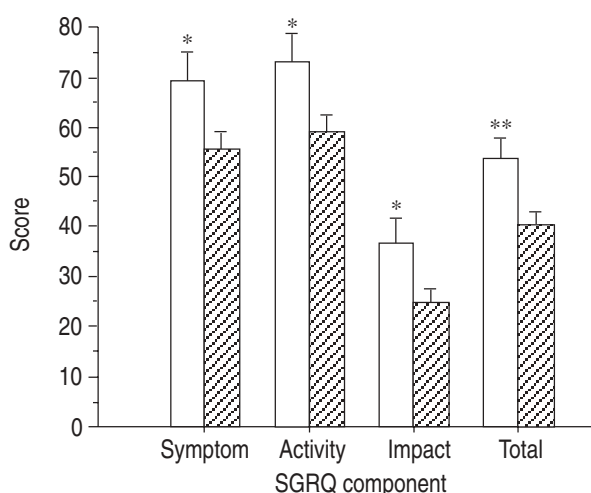

Fig. 4. – The relationship between lean mass category and St George's Respiratory Questionnaire (SGRQ) subscores and total score. Values are presented as mean±SEM. Patients with low lean mass (☐) had significantly higher symptoms, activity, impact, and total SGRQ scores than patients with normal lean mass (▨). *: $p<0.05$; **: $p<0.01$, *versus* patients with normal lean mass category.

Discussion

The purpose of this study was to evaluate the relationship between nutritional status and HRQL in 50 patients with symptomatic obstructive lung disease. Although the group was heterogeneous with respect to primary diagnosis, all had moderate-to-severe, fixed airflow obstruction and were symptomatic despite standard medical therapy. We found that either abnormally low or high body weight was associated with poorer HRQL as measured by the SGRQ. Low lean mass, which was present in each of the three weight categories, was also associated with greater impairment in HRQL scores.

The 26% prevalence of underweight patients is similar to that reported by WILSON *et al.* [12] who described prevalences of 20.6% and 34.5% in moderate and severe COPD, respectively. The mean PIBW of 106% in the present group, however, is somewhat higher than the PIBW of 91% reported by SCHOLS *et al.* [13] in 153 patients with similar morbidity. This difference probably reflects the 36% of patients who were overweight in the present study. It is worth noting that, we did not attempt to selectively recruit patients with the emphysematous form of COPD, who would be less likely to be overweight. Our aim was to study a group that typified those patients referred to out-patient pulmonary rehabilitation at our institution.

Despite the high PIBW in our patients, their mean lean body mass by DXA determination was 2.4 kg less than predicted, and 26% had a LMI below the fifth percentile of predicted values. This reduction in lean mass considerably exceeded the 0.3 kg difference in lean mass estimation described previously between fast and medium DXA scanning speeds [10]. These findings support the results of SCHOLS *et al.* [7] who showed a high frequency of abnormally low fat-free mass in normal-weight and underweight patients with chronic obstructive pulmonary disease.

By far, the most significant factor related to HRQL was dyspnoea: individuals with higher BDI scores (*i.e.*, less dyspnoea) had lower SGRQ scores (*i.e.*, better quality of life). This one variable explained 34% of the variance in total SGRQ score. This finding is in agreement with a study by MAHLER *et al.* [14] who found dyspnoea to be the single most important factor related to general health status, as measured by the Short Form-36 questionnaire.

Although body weight and lean mass categories were not as strong as dyspnoea in predicting HRQL, both underweight and overweight status were related to impairment in this variable. Underweight patients had worse activity, impact, and total SGRQ scores, while overweight patients had worse impact and total SGRQ scores. Abnormally low lean mass, which was present in each of the three weight categories, was related to greater impairment in all three subscores and the total SGRQ score. These results emphasize the importance of nutritional abnormalities on health status in moderate-to-advanced obstructive lung disease.

Since neither body weight nor lean mass category was significantly related to the 6MWD, the effect of nutritional status on HRQL was probably not mediated through an alteration in exercise ability. Our inability to find a correlation between nutritional abnormality and timed

walking distance is contrary to the findings of SCHOLS *et al*. [7] who found that underweight patients and patients with low fat-free mass had poorer exercise performance. These investigators, however, used the 12 minute walking distance, which may be more discriminative than the 6MWD used in our study.

A difference in the severity of airway obstruction between body weight groups was also probably not a major factor influencing HRQL. Underweight patients did not have significantly lower FEV1 than normal-weight patients. Additionally, overweight patients had poorer HRQL than normal-weight patients despite having a tendency (p=0.08) toward higher FEV1.

Dyspnoea, which was strongly correlated with HRQL, was increased in patients who were either underweight or had low lean mass. In all likelihood, our underweight patients had more of the emphysematous form of airway obstruction, which is associated with greater dyspnoea than the nonemphysematous form [15]. In addition, respiratory muscle weakness, which may accompany nutritional depletion [16], may aggravate dyspnoea in COPD. This symptom was probably a major intermediatary between nutritional depletion and health status impairment. Thus, when dyspnoea was added to the models as a covariate relating weight or lean mass category to HRQL, the nutritional parameters dropped out as significant factors.

In summary, dyspnoea was the strongest factor related to health-related quality of life as measured by the St George's Respiratory Questionnaire. In addition, low and high body weight and reduced lean mass were significantly related to poorer health-related quality of life. This effect was probably not mediated through differences between weight or lean mass categories in severity of airways obstruction or exercise performance. Since patients with low body weight or low lean mass had higher levels of dyspnoea, this variable was probably the important factor explaining the effect of depleted nutritional status on health-related quality of life.

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