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Neuromuscular Diseases

Research Article

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0894-9115/03/8203-0182/0
American Journal of Physical Medicine & Rehabilitation
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DOI: 10.1097/01.PHM.0000052588.28912.A4

Nutritional Assessment of Patients with Neuromuscular Diseases

ABSTRACT

Pessolano FA, Suárez AA, Monteiro SG, Mesa L, Dubrovsky A, Roncoroni AJ, De Vito EL: Nutritional assessment of patients with neuromuscular diseases. *Am J Phys Med Rehabil* 2003;82:182–185.

Objective: To study the nutritional status of patients with Duchenne muscular dystrophy and amyotrophic lateral sclerosis.

Design: A total of 34 Duchenne muscular dystrophy and seven amyotrophic lateral sclerosis patients were studied. Body mass index, patient's body weight for zero muscle mass as a percentage of the theoretical weight for zero muscle mass, and creatinine-height index were calculated.

Results: Substantial differences were found between body mass index and percentage of expected weight for zero muscle mass. No amyotrophic lateral sclerosis patients were classified as overweight by body mass index, whereas five were overweight by the percentage of expected weight for zero muscle mass method. Five Duchenne muscular dystrophy patients were classified as overweight by body mass index, and 30 were overweight by the percentage of expected weight for zero muscle mass. According to the creatinine-height index, no patient with amyotrophic lateral sclerosis or Duchenne muscular dystrophy showed normal body muscle mass. No correlation was found between creatinine-height index, percentage of expected weight for zero muscle mass, and body mass index.

Conclusions: The body mass index should be used with caution for the evaluation of the nutritional status of patients with amyotrophic lateral sclerosis and Duchenne muscular dystrophy. Indices that incorporate the assessment of the compartmental distribution of muscle and fat are more sensitive.

Key Words: Neuromuscular Diseases, Nutritional Assessment, Amyotrophic Lateral Sclerosis, Duchenne Muscular Dystrophy

The assessment of the nutritional status of patients with neuromuscular disease is important because of the impact of suboptimal nutrition on function, quality of life, and life expectancy. A 7.7-fold increased risk of death was observed in malnourished amyotrophic lateral sclerosis (ALS) patients.¹ It has been reported that at the point of requiring ventilatory support, the weight of patients with Duchenne muscular dystrophy (DMD) is down to an average of 70 lbs.² Patients with DMD have demonstrated that with weight gain they can become more independent of ventilatory assistance, manage their airway secretions better, and can sit in wheelchairs longer, with improved endurance and clinical well-being.³ It has also been suggested that for infants with spinal muscular atrophy, nutritional deprivation results in sudden weakening³ and that nutritional interventions can improve clinical status and help prolong survival.¹

Nutritional status has been most commonly assessed by the determination of body mass index (BMI), calculated by dividing the patient's weight by the patient's height squared.⁴⁻⁶ The BMI has been used in large-scale nutrition surveys and epidemiologic studies of adults because it is easy, quick, and noninvasive. It is used with the assumption that it correlates highly with obesity. Nevertheless, this index fails to distinguish between excessive weight secondary to obesity, muscularity, or edema.⁷ Because patients with neuromuscular disease can be underweight due to muscle atrophy from the primary disease processes and from decreased food intake secondary to dysphagia, changes in the compartmental distribution of muscle and fat may not be reflected in the BMI.

Griffiths and Edwards⁸ pointed out that normal growth and development charts make no allowance for

the progressive loss of muscle that occurs in DMD patients. A child with pronounced muscle wasting can look cachectic, despite having excessive soft-tissue body fat. The loss of muscle coupled with reduced activity favors accumulation of fat tissue if weight gain approximates that seen in normal growth charts.

Alternative methods have been sought to assess for excessive fat accumulation for these patients. Anthropometric and physical assessments of body composition such as triceps-skinfold thickness and midarm circumference, laboratory assessment of body composition such as bioelectrical impedance, and measure of lean body mass by the creatinine-height index (CHI%) have been proposed.^{5,9} However, these measures can be misleading for estimating obesity in dystrophic patients because they do not take into account perimuscular and intramuscular lipid infiltration, and only the CHI% takes into account muscle mass.

Weight for zero muscle mass (ZMM) was first described by Griffiths and Edwards.⁸ This method is based on creatinine excretion, body weight, and height. After a creatine-free diet for 6 days, total urinary creatinine excretion is averaged daily during the last 3 days. This provides a reliable estimation of the contribution of lean muscle to body weight according to a formula⁸ such that the patient's weight for zero muscle mass (p-ZMM) = body weight - 24-hr creatinine excretion in millimoles \times 2.2625. The theoretical body weight for zero muscle mass is t-ZMM. This is obtained by subtracting the normal theoretical muscle mass from the normal theoretical body weight. Thus, t-ZMM is obtained by the following equation: t-ZMM = theoretical body weight - (normal values of 24-hr creatinine excretion \times 2.2625).^{10,11} The p-ZMM divided by t-ZMM is the percentage of expected weight for zero muscle mass (ZMM%).^{8,12} The ZMM can, in theory,

accurately estimate the adiposity and nutritional status of patients with muscle-wasting diseases by canceling out lean muscle mass.

As far as we know, there are no studies comparing the ZMM% and BMI for the assessment of nutritional status in patients with ALS or DMD. Moreover, any comparison with our results would be difficult because the six previous studies of ZMM% have included small numbers of patients with ALS in otherwise heterogeneous study populations.⁶ We therefore studied a group of patients with either ALS or DMD without renal disease. Our main goal was to compare the adiposity and nutritional status as assessed by BMI and CHI% with that of the ZMM%.⁸

MATERIAL AND METHODS

Four men and three women with ALS, 53.2 ± 16.3 (standard deviation) years of age and 57.3 ± 9.7 kg, and 34 male patients with DMD, 15.1 ± 5.3 yr of age and 44.3 ± 16.1 kg, were studied. Normal nutrition was defined as having 90-110% ZMM%. Values >110 and <90 were considered overweight (fat mass excess) and underweight, respectively. Normal nutrition was defined by a BMI of 18.5-25 kg/m², with values >25 or <18.5 considered overweight and underweight, respectively.⁷ CHI% was determined by the 24-hr urinary creatinine divided by ideal 24-hr urinary creatinine for height and expressed as a percentage. A CHI% $>95\%$ of standard is considered normal. Values of 60-80% have been suggested to represent a moderate and $<60\%$ a severe deficit in body muscle mass.¹³

The functional class of DMD patients was evaluated from 1 (best) to 10 (worst) with the Vignos¹⁴ functional scale. Briefly described, class 1 means that the patient is able to walk and climb stairs without assistance, whereas in class 10, the patient is wheelchair or bed bound. In class 7,

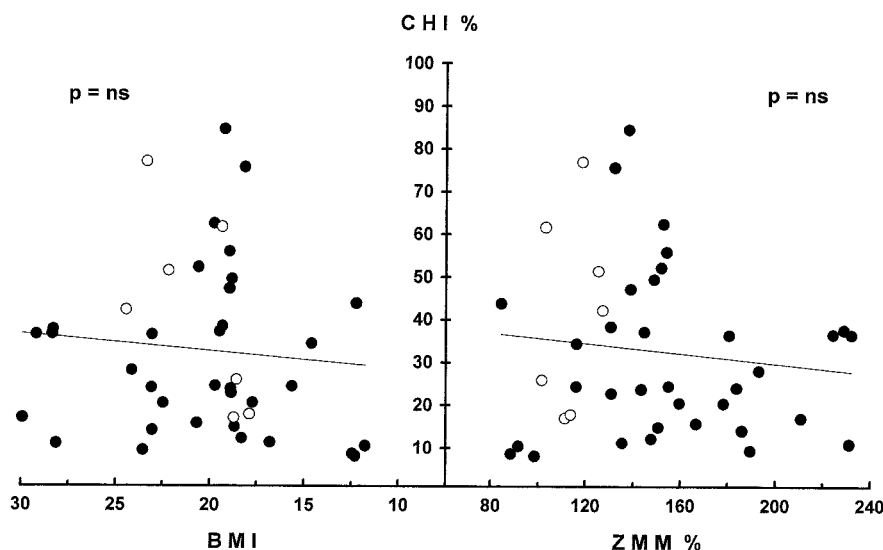


Figure 1: Muscle mass and nutritional status in two-quadrant diagram. Relationship between creatinine-height index (*CHI%*) and body mass index (*BMI*) or patient's body weight for zero muscle mass divided by the theoretical body weight for zero muscle mass (*ZMM%*). *Closed circles*, Duchenne muscular dystrophy patients; *open circles*, amyotrophic lateral sclerosis patients. No correlation was found between *CHI%* and *BMI* or *ZMM%*.

patients can only walk with assistance or long-leg bracing.

Data were analyzed by using correlation and linear regression analysis (Fig. 1). The threshold for significance was considered 0.05. Correlation between the two methods was demonstrated by a concordance diagnostic diagram (Fig. 2). The institutional review board for human studies approved this study, and informed consent was obtained.

RESULTS

Four of the seven patients with ALS were wheelchair users, two had gastrostomy tubes because of severe dysphagia, and one patient used long-term mechanical ventilation. For the DMD patients, the Vignos scale mean was 6.9 ± 3.1 . A total of 21 patients were wheelchair dependent.

The urinary creatinine excretion was 489.2 ± 348.4 and 205.4 ± 88.1 mg/day for the ALS and DMD groups, respectively. For the ALS group, the *ZMM%* was 114.3 ± 10.0 (range, 101.6–127.1), the *CHI%* was 41.9 ± 22.9 (range,

16.9–76.9), and *BMI* was 20.6 ± 2.6 (range, 18.4–24.5). For the DMD group, the *ZMM%* was 156.3 ± 40.2 (range, 84.3–232.0), the *CHI%* was 30.8 ± 19.4 (range, 8.1–84.5), and

the *BMI* was 20.0 ± 4.8 (range, 11.8–29.9). No correlation was found between *CHI%* and *ZMM%* or *BMI* (Fig. 1) (*BMI vs. CHI%*, $r^2 = 0.008$, $P = 0.571$; *ZMM% vs. CHI%*, $r^2 = 0.014$, $P = 0.464$).

According to the *BMI*, no patient with ALS was classified as overweight, whereas five patients were overweight by the *ZMM%* method (Fig. 2). Five DMD patients were classified as overweight by *BMI*, whereas 30 were overweight by *ZMM%*. Only two ALS patients were considered by both measures to have normal nutrition. According to the *CHI%*, no patient with ALS or DMD had normal body muscle mass.

DISCUSSION

The assessment of the nutritional status of patients with neuromuscular diseases is problematic. Loss of muscle mass can be due to muscle atrophy from the primary pathology, muscle replacement by fat and fibrosis, and by undernourishment. These factors can alter the

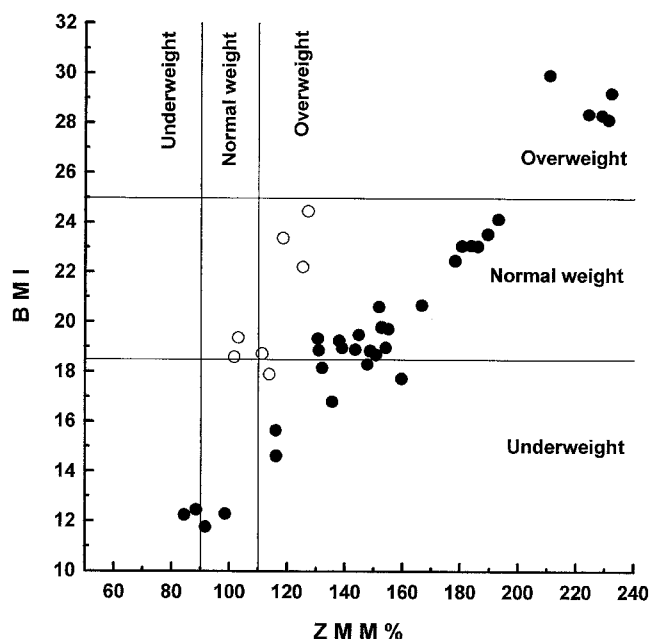


Figure 2: Nutritional status concordance diagram. Relationship between patient's body weight for zero muscle mass divided by the theoretical body weight for zero muscle mass (*ZMM%*) and body mass index (*BMI*). *Closed circles*, Duchenne muscular dystrophy patients; *open circles*, amyotrophic lateral sclerosis patients. The *lines* show the normal ranges for both methods.

compartmental distribution of muscle and fat. Because both undernutrition and overnutrition are common in people with neuromuscular disease and because both can have dire consequences,¹⁵ nutritional assessment is an essential component of patient management and rehabilitation.

Desport et al.⁶ prospectively evaluated the occurrence of malnutrition in 55 patients with ALS during a 7-mo period. They correlated malnutrition with the neuromuscular deficit and determined the impact of nutritional status on survival. Malnutrition was defined by a BMI of <18.5 kg/m². They found that a reduced vital capacity and malnutrition were associated with poor prognosis.

In DMD patients, the situation is more complex than for ALS because the muscle mass is primarily affected. For these patients, too, both undernutrition and obesity directly affect respiratory function and the ability to perform activities of daily living.¹⁵ A DMD patient with "normal" body weight and perhaps normal BMI, may seem well nourished and without need of major nutritional intervention. However, because lean muscle mass can be greatly diminished despite having normal weight by general population standards, excessive body fat can be present. In this situation, nutritional intervention to lose weight may improve clinical status.^{2,3}

Our data demonstrated that BMI underestimated excess body fat composition in both ALS and DMD patients, whereas CHI% does not estimate adiposity at all. Indeed, most of the DMD patients were found to be overnourished by the ZMM% method but not by the BMI or CHI%. The diagnostic concordance diagram (Fig. 2) shows the differences in the nutritional diagnoses using both ZMM% and BMI methods. From a total of 41 patients, only nine were in the concordance quadrants. In fact, the majority of patients had normal weight by BMI but were overweight by ZMM%. No correlation was found between CHI% and BMI or ZMM

(Fig. 1). This can be expected because CHI% evaluates only the muscle compartment and the BMI assesses global nutritional status, whereas the ZMM% evaluates nutritional status by taking into account the relationship between muscle and fat compartments.

The clinical implications of the more accurate assessment of body mass need to be further explored. For example, interventions to gain or lose weight may affect specific activities such as ambulation or physiologic variables such as vital capacity. Likewise, there may be a role for the measurement of and changes in ZMM% over time in indicating the need for gastrostomy.

Although ZMM values of >110% were considered to represent obesity and values of <90% were considered undernourishment, a 10% variation from predicted normal values, BMI levels were considered normal within a 15% range. This might lead to an increased likelihood of abnormal values using the ZMM method. However, ZMM and BMI were defined and widely used with these ranges in epidemiologic studies. Even had ranges of normal BMI been limited to 10%, only one additional DMD patient and one additional ALS patient would have been characterized as overweight.

In conclusion, although the BMI is useful for patients without neuromuscular disease,⁷ because it does not accurately reflect body composition and because it underestimates excessive body fat, it should be used with caution for the evaluation of the nutritional status of patients with these conditions. Indices like the ZMM% that incorporate the assessment of the compartmental distribution of muscle and fat are preferable.

REFERENCES

1. Harpey JP, Charpentier C, Paturneau-Jonas M, et al: Secondary metabolic defects in spinal muscular atrophy type II. *Lancet* 1990;336:629–30
2. Bach JR, Tippett DC, McCrary MM:

Bulbar dysfunction and associated cardiopulmonary considerations in polio and neuromuscular disease. *J Neuro Rehabil* 1992;6:121–8

3. Bach JR, Kazanjian M, Guylas A, et al: Swallowing and gastrointestinal concerns, in *Management of Neuromuscular Disease*. Philadelphia, Hanley and Belfus, 1999

4. Mazzini L, Correa T, Zacala M, et al: Percutaneous endoscopic gastrostomy and enteral nutrition in amyotrophic lateral sclerosis. *J Neurol* 1995;242:695–8

5. Kasarskis E, Berryman S, Vanderleest J, et al: Nutritional status in patients with amyotrophic lateral sclerosis: Relation to the proximity of death. *Am J Clin Nutr* 1996;63:130–7

6. Desport JC, Preux PM, Truong TC, et al: Nutritional status is a prognostic factor for survival in ALS patients. *Neurology* 1999;53:1059–63

7. Gibson RS: Anthropometric assessment of growth, in *Principles of Nutritional Assessment*, chapter 10. New York, Oxford University Press, 1990, pp 163–85

8. Griffiths RD, Edwards RHT: A new chart for weight control in Duchenne muscular dystrophy. *Arch Dis Child* 1988; 63:1256–8

9. Slowie LA, Paige MS, Antel JP: Nutritional considerations in the management of patients with amyotrophic lateral sclerosis (ALS). *J Am Diet Assoc* 1983;83:44–7

10. Graystone JE: Creatinine excretion during growth, in Cheek DB (ed): *Human Growth*, chapter 12. Philadelphia, Lea and Febiger, 1968, pp 182–97

11. Gibson RS: Anthropometric and other reference data, in *Principles of Nutritional Assessment*. New York, Oxford University Press, 1990, pp 601–71

12. Heymsfield SB, Arteaga C, Mc Manus C, et al: Measurement of muscle mass in humans: Validity of the 24-hour urinary creatinine method. *Am J Clin Nutr* 1983; 37:478–94

13. Gibson RS: Assessment of protein status, in *Principles of Nutritional Assessment*, chapter 16. New York, Oxford University Press, 1990, pp 307–48

14. Vignos PJ, Spencer GE, Archivald KC: Management of progressive muscular dystrophy of childhood. *JAMA* 1963;184: 89–110

15. Bach JR: General diagnostic and management considerations, in Bach JR (ed): *Guide to the Evaluation and Management of Neuromuscular Diseases*. Philadelphia, Hanley and Belfus, 1999, pp 23–34