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Utility of skinfold thickness measurement in non-ambulatory patients with Duchenne muscular dystrophy

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Abstract

Nutritional disorders in Duchenne muscular dystrophy (DMD) worsen the medical condition. In particular, obesity is a serious problem that increases the risk of cardiomyopathy and affects nursing care. However, it is often difficult to evaluate body fatness in the advanced stages of DMD. Skinfold thickness measurement is a classical method to evaluate body fatness and is easily performed, even for bed-bound patients at home. We aimed to investigate the utility of skinfold thickness measurement in non-ambulatory DMD patients. Twenty-two patients with non-ambulatory, steroid-naive DMD ranging in age of 12–47 years were evaluated by body mass index (BMI), blood tests, measurement of triceps skinfold thickness (TSF), and abdominal computed tomography (CT) measurement of the areas of both subcutaneous and visceral fat. TSF showed good correlation with BMI ($r = 0.80$; $p < 0.001$), serum triglycerides ($r = 0.67$; $p < 0.01$), area of subcutaneous fat ($r = 0.85$; $p < 0.0001$), and area of visceral fat ($r = 0.76$; $p < 0.0001$). These results indicate the skinfold thickness measurement may be applicable as a screening tool in clinical practice where CT and magnetic resonance imaging assessment is often difficult in patients with advanced DMD.

Keywords: Duchenne muscular dystrophy; Abdominal fat; Nutritional assessment; Obesity; Skinfold thickness measurement

1. Introduction

Duchenne muscular dystrophy (DMD) is a progressive muscle-wasting disorder that is eventually fatal. It is caused by a mutation in the dystrophin gene (Xp21.2). Patients become confined to a wheelchair in their early teens, and life expectancy is typically limited to the second or third decade secondary to respiratory or cardiac dysfunction [1]. However, recent medical progress, including respiratory care, nutritional support, and cardioprotective drugs, has extended the life expectancy of DMD patients into their 40s [2].

Skeletal muscle is thought to be the important source of heat or metabolic activity and the metabolism is a major determinant of resting energy expenditure [3]. Therefore, in their early teens, DMD patients often become obese due to decreased resting energy expenditure resulting from severe muscle loss [4,5] and decreased physical activity associated with loss of ambulation [6]. Obesity aggravates skeletal deformity, complicates orthopedic surgery [7], and also increases the risk of heart failure [8]. In addition, parents or caregivers are often burdened by obesity because of difficulties in moving the patient and in nursing care.

Body composition in DMD patients is variable because of the dramatic volume loss of muscle, and body mass index (BMI) is not a very accurate screening test for obesity in these patients [9]. Therefore, accurate methods to assess body composition are needed for nutritional evaluation of patients with DMD. Recently, bioelectrical impedance analysis (BIA) [10], dual-energy X-ray absorptiometry (DEXA) [11], and magnetic resonance imaging (MRI) [12] have been shown to be accurate and appropriate for assessing the body composition of patients with DMD. However, these instruments are not available in all medical institutions. Moreover, these examinations cannot be easily performed on patients with advanced DMD because of spinal deformity, articular contracture, ambulation difficulties, and artificial ventilation. In contrast, the classical method of skinfold thickness

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measurement to evaluate body composition has the advantages of ease, noninvasiveness, portability, and decreased expense [13], and it can be performed at the bedside, even for patients with advanced DMD. Alternatively, scanning intra-abdominal fat volume by abdominal computed tomography (CT) is often used to assess the degree of visceral fat in Japan. One diagnostic criterion for obesity is a BMI ≥ 25 and an area of more than 100 cm^2 of visceral fat using abdominal CT examination [14]. To our knowledge, there is no clinical study in which skinfold thickness measurement and area of abdominal fat by CT examination have been compared for patients with DMD. The aim of this study is to investigate whether skinfold thickness measurement can be clinically useful for the nutritional assessment of non-ambulatory DMD patients.

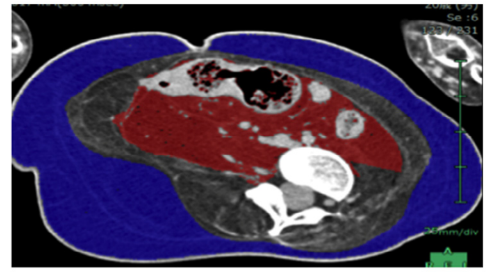

Fig. 1. Measurements of subcutaneous fat (blue square) and visceral fat (brown square) volume at the umbilical level by computed tomography.

2. Patients and methods

2.1. Patients

Twenty-two patients (18 inpatients and 4 outpatients) with DMD receiving medical care at National Hospital Organization, Kumamoto Saishunsou Hospital (Kumamoto, Japan) were included in this study. All patients underwent anthropometric measurements, blood tests, and abdominal CT examination. No patients were treated with steroids either during or prior to the study. Informed consent for this study was given by all patients or their parents. The study was approved by the Ethics Committee of Kumamoto Saishunsou Hospital.

2.2. Anthropometric measurements

Body mass was measured by a digital weight scale. Using a measuring tape, height was measured from head to feet along with the body line in the supine position [15]. BMI was calculated as weight/height^2 (kg/m^2). Skinfold thickness measurements were performed separately by two experienced examiners (a medical doctor and a nutritionist), at the triceps (back of the upper arm), using an adipometer (Abbott, Japan Co., Ltd., Tokyo) [13].

2.3. Abdominal CT examination

Patients were examined in the supine position using an abdominal CT scanner (Siemens Healthcare GmbH, Forchheim, Germany). The quantitative analyses of the areas of subcutaneous and visceral fat were calculated at the umbilical level using Synapse Vincent image analysis (FUJIFILM Medical Co., Ltd., Tokyo) (Fig. 1).

2.4. Blood tests

Serum triglycerides, albumin, and cholesterol were measured in our DMD patients after fasting.

2.5. Statistical analysis

Statistical analysis was conducted using JMP®, version 9.0. (SAS Institute, Inc., Cary, NC). Statistical comparisons were performed using two-factor analysis of variance followed by Wilcoxon analysis with Pearson's product–moment correlations. Significance was established at $p < 0.05$.

3. Results

Table 1 summarizes the clinical and nutritional data of DMD patients. Mean age was 24.4 years (range 12–47). Of 22 patients, eight patients (36.3%) did not need respiratory assistance (ventilator-free group). Five patients (22.6%) used non-invasive positive-pressure ventilation (NPPV) and nine patients (40.9%) used tracheostomy positive-pressure ventilation (TPPV). Eighteen patients (81.8%) were able to take oral nutrition and four patients (18.2%) were fed enterally. All patients were unable to walk and were either wheelchair-bound (40.9%) or bed-bound (59.1%). Average BMI was 17.0 ± 5.9 kg/m^2 (range 9.3–26.9). Average TSF was 20.2 ± 10.8 mm (range 6–40; average TSF of healthy Japanese adults is 13.7 ± 6.79 mm [16]). Hypoalbuminemia was present in 9% and elevated levels of triglycerides in 11%. Hypercholesterolemia was not detected. We measured the areas of visceral and subcutaneous fat separately by abdominal CT examination. The average area of visceral fat was 52.2 ± 28.7 cm^2 (range 22.7–140.9), and that of subcutaneous fat was 117.3 ± 88.0 cm^2 (range 18.6–254.0).

We next assessed whether BMI, TSF, or abdominal CT area of subcutaneous or visceral fat were different among the three groups, depending on ventilator use: ventilator-free group (n = 8), NPPV group (n = 5), and TPPV group (n = 9) (Table 1). No relationships were found between BMI and age or TSF and age. Average BMI in the ventilator-free group (22.9 ± 4.1 kg/m^2) was significantly higher than that in the NPPV group (11.4 ± 1.4 kg/m^2, $p < 0.0001$) and the TPPV group (14.9 ± 4.1 kg/m^2, $p < 0.001$), respectively. Three patients in their early teens (mean age 14.7 years) in the ventilator-free group had a BMI ≥ 25, demonstrating obesity. Average TSF in the ventilator-free group (28.9 ± 8.6 mm) was significantly higher than that in the NPPV group (13.8 ± 9.0 mm, $p < 0.05$) and in the TPPV group (16.0 ± 8.9 mm, $p < 0.05$). Average area of subcutaneous fat in the ventilator-free group (206.5 ± 67.2 cm^2) was significantly higher than that in the NPPV group (45.6 ± 30.1 cm^2, $p < 0.0001$) and in the TPPV group (77.8 ± 54.8 cm^2, $p < 0.001$). Average area of visceral fat