Nutrition 120 (2024) 112348

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Role of irisin and myostatin on sarcopenia in malnourished patients diagnosed with GLIM criteria

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ARTICLE INFO

Article History:
Received 1 October 2023
Received in revised form 26 December 2023
Accepted 28 December 2023

Keywords:
Irisin
Malnourished patients
Myostatin
Sarcopenia

ABSTRACT

Objectives: Sarcopenia is characterized by the loss of muscle mass. Skeletal muscle can produce and secrete different molecules called myokines. Irisin and myostatin are antagonistic myokines, and to our knowledge, no studies of both myokines have been conducted in patients with disease-related malnutrition (DRM). **This study aimed** to investigate the role of circulating irisin and myostatin in sarcopenia in patients with DRM.

Methods: The study included 108 outpatients with DRM according to the Global Leadership Initiative on Malnutrition criteria. Participants had a mean age of 67.4 ± 3.4 y. Anthropometric data, muscle mass by ultrasound at the rectus femoris quadriceps (RFQ) level, impedancemetry (skeletal muscle mass [SMM], appendicular SMM [aSMM], and aSMM index [aSMMI]), dynamometry, biochemical parameters, dietary intake, circulating irisin and myostatin levels were determined in all patients. Confirmed sarcopenia was diagnosed as criteria of probable sarcopenia (low muscle strength) plus abnormal aSMMI.

Results: Of the 108 patients, 44 presented sarcopenia (41%); 64 did not present with the disorder (59%). The following parameters were worse in patients with sarcopenia:•Body weight (−6.8 ±2.3 kg; P = 0.01),•Calf circumference (−2 ±0.3 cm; P = 0.02),•Phase angle (−0.6 ±0.1°; P = 0.01),•Reactance (−40.8 ±12.3Ω; P = 0.03),•SMM (−2.4 ±0.3 kg; P = 0.04),•aSMM (−2.2 ±0.2 kg; P = 0.03),•aSMMI (−0.9 ±0.2 kg; P = 0.02),•Dominant muscle area RFQ (−0.9 ±0.2 cm^2; P = 0.04),•Dominant Y-axis RFQ (−0.3 ±0.1 cm; P = 0.03),•Dominant X/Y-axis RFQ (0.8 ±0.3 cm; P = 0.04),•Albumin (−0.8 ±0.1 g/dL; P = 0.04), and•Prealbumin (−3.6 ±0.7 mg/dL; P = 0.02).

Patients without sarcopenia were stronger than those with the disorder (7.9 ±1.3 kg; P = 0.01). Circulating irisin levels were higher in patients without sarcopenia than those with sarcopenia (651.3 ± 221.3 pg/mL; P =0.01). Myostatin levels were similar in both groups. Finally, logistic regression analysis reported a low risk for sarcopenia (odds ratio, 0.39; 95% confidence interval, 0.19−0.92; P = 0.03) in high irisin median levels as a dichotomic parameter after adjusting for body mass index, sex, energy intake, and age.

Conclusion: The present study reported that low levels of serum irisin were closely associated with sarcopenia in patients with DRM.

Introduction

Disease-related malnutrition (DRM) is an important health problem in hospitalized and community patients. Some investigations have reported that the prevalence of DRM in hospitalized patients was 24% [1] and 33% [2]. Despite the efforts to prevent this entity, a high prevalence has been maintained. In this way, the Spanish Study malnutriton related with diseases (SeDREno) study conducted in 2021 reported that 30% of patients had malnutrition according to the Global Leadership Initiative on Malnutrition (GLIM) criteria [3]. DRM is related to the patient's inflammatory status, the alterations associated with underlying disease, low dietary intake, and decreases in body weight and muscle mass. In this context, sarcopenia is a condition characterized by low muscle mass, muscle weakness, and poor functional capacity [4]. These features give way to important health risks, including risk for fractures and falls [5] and comorbidities [6].

Considering the previously mentioned situation, muscle is the most important protein reserve in the human body and its mass is

DAdL reports were provided by the University of Valladolid and is a member of its board. The authors have no conflicts of interest to declare.

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https://doi.org/10.1016/j.nut.2023.112348
0899-9007/

one of the parameters used to evaluate DRM. On the other hand, skeletal muscle can produce and secrete different molecules to communicate with other tissues in an endocrine, either paracrine or autocrine way, named myokines [7]. Irisin and myostatin are two of the most studied myokines in the literature [8]. Irisin is associated with strength and muscle mass [9]. This myokine may activate A-protein-kinase (AkT) and extracellular-signal-regulated kinase (ERK) to upregulate signaling through the insulin-like growth factor (IGF)-1/Akt/mammalian target of rapamycin (mTOR) pathway [10]. Moreover, to our knowledge, there is very little data to confirm these pathways in humans. For example, Park et al. [11] showed that postmenopausal women with sarcopenia had lower circulating irisin concentrations than women without sarcopenia. In this study, nutritional status was not evaluated. In this investigation, irisin concentration was also positively associated with quadriceps muscle cross-sectional area. In contrast to irisin, myostatin downregulates skeletal muscle protein synthesis via activation of mothers against decapentaplegic homolog protein (Smad) 2 and Smad 3, which inhibit the IGF-1/Akt/mTOR pathway [12]. With increasing age, myostatin levels may be upregulated [13], which may explain muscle atrophy and decreased strength, with an increased risk for sarcopenia [14]. Individuals with increased myostatin levels were more likely to have low handgrip strength [14]. Moreover, these findings are not consisted in the literature, and some investigations did not demonstrate a relationship between circulating myostatin and sarcopenia [15,16].

Given that irisin and myostatin are antagonistic myokines, and no studies of either myokine are realized in patients with DRM, perhaps an imbalance in the levels of these two myokines could play a relevant role in the presence of sarcopenia in patients with DRM. As such, we investigated the role of circulating irisin and myostatin on sarcopenia in patients with DRM and a high rate of sarcopenia.

Material and methods

Study population

This was an open-label, real-world study with outpatients with DRM. These outpatients were sent from primary care to the Nutrition Unit for evaluation of their nutritional situation due to suspicion of a nutritional risk. The nutritional status of all patients was evaluated with anthropometric and biochemical parameters and serum myokine levels. All patients signed an informed consent for inclusion before participating in the study. The protocol was approved by the Bioethical Committee of the Health Area of HCUVa and the study was conducted in accordance with the Declaration of Helsinki.

The study was conducted with patients with DRM referred to the Clinical Nutrition consultation of Valladolid Area. Patient recruitment was carried out between January 2021 and December 2022. The patient inclusion criteria were patients with DRM diagnosed by GLIM criteria [17] and >60 y of age. The exclusion criteria were alcohol habit, active oncology process, decompensated liver disease, diabetes mellitus, patients with decompensated cardiopulmonary disease and fluid overload, chronic kidney disease stage IV or higher, inability to walk, and failure to sign the informed consent. The Eastern Cooperative Oncology Group scale (ECOG) determined the stability of oncology patients. Only patients with a score of 0 or 1 were included.

Procedures

Anthropometric composition analysis was performed, and the blood samples were collected at the same clinical visit. During this visit, the next anthropometric data were collected (weight, height, body mass index [BMI], waist circumference [WC]), parameters bioelectrical impedance analysis (BIA), muscle mass by ultrasound at the level of the rectus femoris quadriceps (RFQ), and blood sample. To measure the biochemical parameters, 15 mL of venous blood were aliquoted into tubes coated with ethylenediaminetetraacetic acid (EDTA) after a 10-h overnight fast. The following parameters were determined: albumin (g/dL); C-reactive protein (CRP; mg/dL), prealbumin (mg/dL); and irisin and myostatin.

Anthropometric parameters, muscle ultrasound, and impedancemetry

Height (cm) and WC (cm) were measured with a non-elastic tape measure (Omrom, LA, CA, USA). Body weight was determined with the participants without clothes, using a digital scale (Omrom). Using these parameters, BMI (body weight (kg) divided by the square of height (m^2) was calculated. Calf circumference was measured in the zone of maximum diameter of the gastrocnemius femoris muscle with a tape measure. The impedancemetry measured the two components of impedance (Z): resistance (R) and the capacitance component (X). The phase angle (PhA) was derived for following equation:

$$\text{PhA} = (\text{X}/\text{R}) \text{ x } (180^\circ/\pi).$$

The BIA provided data regarding fat mass (FM), skeletal muscle mass (SMM), appendicular muscle mass (aSMM), and appendicular muscle mass index (aSMMI) as aSMM divided by squared height [18] (EFG BIA 101 Anniversary, Akern, Italy).

All participants underwent muscle ultrasound of the RFQ of the dominant lower extremities with a 10- to 12-MHz probe and a multifrequency linear array (Mindray Z60, Madrid, Spain). The probe was aligned perpendicular to the longitudinal and transverse axis of the RFQ. The evaluation was performed without compression at the lower third level from the superior pole of the patella and the anterosuperior iliac spine. The measurements made using this technique were rectus femoris area (cm^2), the RFQ circumference (cm), the X axis of RFQ (cm), the Y axis of RFQ (cm), and the X/Y-index RFQ [19].

Dominant hand dynamometry was performed with the patient seated and the arm at a right angle to the forearm handgrip strength (JAMAR dynamometer, Sammons Preston, Bolingbrook, IL, USA). Three measurements were made and the average of the three measurements was calculated. The diagnostic criteria of low muscle strength proposed by the European Working Group on sarcopenia in older people (EWGSOP2) 12 were used (<27 kg in men and <16 kg in women) [20]. Confirmed sarcopenia was diagnosed as criteria of probable sarcopenia (low muscle strength) plus abnormal aSMMI on BIA (<7 kg/m^2 for men and <5.5 kg/m^2 for women) [20].

Dietary intake and physical exercise

All enrolled patients were instructed to save their daily dietary intake for 3 d non-consecutively (2 d during the week and 1 d on the weekend). Dietary records were determined using specific software (Dietsource, Geneve, Switzerland), including national composition food tables as reference [21]. Patients recorded the minutes of physical activity performed daily in a diary.

Biochemical parameters

Nutritional parameters were measured with a Cobas c-711 autoanalyzer (Roche Diagnostics, Geneve, Switzerland): albumin (g/dL); CRP (mg/dL), and prealbumin (mg/dL). For myokines (irisin and myostatin), we used a commercial kit (MILLIPLEX Human Myokine Magnetic Bead Panel, EMD Millipore Corporation, Burlington, MA, USA), for which we followed the manufacturer's instructions. The interassay coefficients of variation (CV) of irisin and myostatin were 2.5% and 3.4%, respectively. Finally, the intra-assay CV of irisin and myostatin were 3.5% and 3%, respectively.

Statistical analysis

Statistical analysis was performed using SPSS version 23 (SPSS Inc. Chicago, IL, USA). The sample size was determined to detect differences of 100 pg/mL of circulating myokine levels between both groups of patients with DRM (no sarcopenia versus sarcopenia). The Kolmogorov test evaluated the normality of the variables. Descriptive statistics for all variable values are presented as mean and SD for continuous variables and percentages for categorical variables. The variables were analyzed with the Student's t test (for the variable with normal distribution). The Bonferroni test was applied for multiple tests to reduce the type I error in the association analysis. The χ^2 test was used to assess the qualitative variables. Multiple logistic regression models were used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) to examine the relationship between myokine levels and the presence of sarcopenia (median value of irisin 336.97 pg/mL). $P < 0.05$ was considered statistically significant.

Results

The present study included 108 patients with DRM according to GLIM criteria. The participants had a mean age of 67.4 y (±3.4 y). Of the participants, 64 were women (59%), and 44 were men (41%). The causes of DRM were as follows:

- Stable oncology pathology: 33 patients (31%);

- Cardiopulmonary pathology: 21 patients (19%);
- Chronic neurologic pathology: 18 patients (17%);
- Digestive pathology: 17 patients (16%); and
- Miscellaneous: 18 patients (17%).

These patients are representative of the patients we see with DRM in our Clinical Unit.

Table 1 shows the studied sample's anthropometric, ultrasound, impedancemetry, and biochemical characteristics, showing a BMI within normal limits.

Fourty-four patients (41%) presented sarcopenia according to the criteria of EWGSOP2 [20], and 64 patients did not present sarcopenia (59; Table 2). The distribution by sex was similar in both groups. There were 24 women (56%) and 20 men (44%) in the sarcopenia group and 40 women (63%) and 24 men (37%) in the group without sarcopenia. Table 2 reports the statistical differences in anthropometric parameters, such as body weight (−6.8 ±2.3 kg; $P = 0.01$) and calf circumference (−2 ±0.3 cm; $P = 0.02$). Impedancemetry parameters were also worse in patients with sarcopenia: phase angle (−0.6 ±0.1°; $P = 0.01$), reactance (−4.8 ±2.3 Ω; $P = 0.03$), SMM (−2.4 ±0.3 kg; $P = 0.04$), aSMM (−2.2 ±0.2 kg; $P = 0.03$), and aSMMI (−0.9 ±0.2 kg; $P = 0.02$). Moreover, ultrasound parameters of RFQ were worse in patients with sarcopenia dominant muscle area (−0.9 ±0.2 cm^2; $P = 0.04$), dominant Y axis (−0.3 ±0.1 cm; $P = 0.03$) and dominant X/Y axis (0.8 ±0.3 cm; $P = 0.04$). Finally, patients without sarcopenia had greater strength than those with (7.9 ±1.3 kg; $P = 0.01$).

Table 2 shows biochemical parameters. Patients with sarcopenia had worse serum protein levels: albumin (−0.8±0.1 g/dL; $P = 0.04$) and prealbumin (−3.6 ±0.7 mg/dL; $P = 0.02$). Circulating irisin levels were higher in those patients without sarcopenia (651.3 ±221.3 pg/mL; $P = 0.01$). Myostatin levels were similar between both groups without statistical differences. In patients with dynapenia (low force according to the EWGSOP2; <27 kg in men and <16 kg in women) [20], those with low strength had lower levels of irisin (1626.3 ±121.3 versus 556 ±122 pg/mL; $P = 0.01$) than patients with normal strength (>27 kg in men and >16 kg in women). Moreover, myostatin values were similar in both muscle strength groups (461.3 ±64.3 versus 496 ±62 pg/mL; $P = 0.41$).

Table 3 reports dietary intake and physical exercise. Minutes per day of activity were similar between both groups. Moreover, energy intake and carbohydrates, fat, and protein intake were worse in patients with sarcopenia.

Correlation analysis showed a positive and significant correlation of irisin levels with parameters of RFQ ultrasound: dominant muscle area, dominant circumference, dominant Y axis, SMM, aSMM, aSMMi, and impedancemetry (PhA and reactance; Table 4). Myostatin did not show statistical correlations with these parameters.

Considering the previous data, the patients were divided into two groups according to the median value of irisin (336.97 pg/mL), and the OR was calculated for the risk for developing sarcopenia. Patients with an irisin value above the median cut-off point had less risk for sarcopenia than those under the cutoff points (OR, 0.28; 95% CI, 0.12−0.63; $P = 0.02$). Finally, logistic regression analysis reported a low risk for sarcopenia (OR, 0.39; 95% CI, 0.11−0.92; $P = 0.03$) in high irisin median levels as a dichotomic parameter after adjusting for BMI, sex, energy intake, and age.

Table 1
Epidemiologic, anthropometric, and biochemical parameters of study patients (mean ± SD).

Parameters	All patients (N = 108)
Age (y)	67.4 ± 3.4
BMI (kg/m^2)	22.4 ± 5.6
Weight (kg)	56.3 ± 7.1
Fat mass (kg)	18.4 ± 4.1
SMM (kg)	20.1 ± 1.9
aSMM (kg)	16.3 ± 2.4
aSMMI (kg)	7.8 ± 0.8
CC (cm)	31.3 ± 1.1
Phase angle (°)	4.9 ± 0.3
Reactance (Ω)	51.1 ± 8.1
Resistance (Ω)	592.7 ± 74.1
Dominant muscle area RFQ (cm^2)	3.2 ± 1.1
Dominant circumference area RFQ (cm)	8.4 ± 1.4
Dominant X-axis RFQ (cm)	3.3 ± 0.7
Dominant Y-axis RFQ (cm)	1.1 ± 0.3
Dominant X/Y-axis RFQ (cm)	3.3 ± 0.2
Dominant ecointensity (points)	91.2 ± 25.1
Strength (kg)	20.6 ± 3.8
CRP (mg/dL)	7.1 ± 2.1
Albumin (g/dL)	4.5 ± 3.1
Prealbumin (mg/mL)	21.6 ± 3.8
Irisin (pg/mL)	1076.3 ± 331.3
Myostatin (pg/dL)	476.3 ± 87.3
Myostatin-to-irisin ratio (pg/dL)	2.3 ± 1.3

aSMM, appendicular muscle mass; aSMMI, appendicular muscle mass index; BMI, body mass index; CC; calf circumference; CRP, C-reactive protein; RFQ, rectus femoris quadriceps; SMM, skeletal muscle mass.

Table 2
Differences in epidemiologic, anthropometric, and biochemical parameters between patients with and without sarcopenia (mean ± SD).

Parameters	Patients without sarcopenia (n = 64)	Patients with sarcopenia (n = 44)	*P*-value
Age (y)	67.3 ± 3.1	67.9 ± 2.4	0.18
BMI (kg/m^2)	22.8 ± 2.6	21.7 ± 2.1	0.13
Weight (kg)	59.1 ± 4.1	52.3 ± 3.1	0.01
Fat mass (kg)	21.1 ± 3.1	13.5 ± 2.1	0.03
Skeletal muscle mass (kg)	21 ± 1.4	18.8 ± 1	0.04
Appendicular muscle mass	17.3 ± 1.4	15.1 ± 1.1	0.03
Appendicular muscle mass index	8 ± 0.3	7.1 ± 0.4	0.02
CC (cm)	32.2 ± 1.1	30.3 ± 1.1	0.02
Phase angle (°)	5.2 ± 0.2	4.6 ± 0.4	0.01
Reactance (Ω)	52.9 ± 2.1	48.1 ± 4	0.03
Resistance (Ω)	582.7 ± 72.1	603.7 ± 54.2	0.06
Dominant muscle area RFQ (cm^2)	3.5 ± 0.5	2.6 ± 0.3	0.04
Dominant circumference RFQ (cm)	8.6 ± 1.1	8. ± 1	0.10
Dominant X-axis RFQ (cm)	3.4 ± 0.4	3.2 ± 0.3	0.19
Dominant Y-axis RFQ (cm)	1.2 ± 0.1	0.9 ± 0.2	0.03
Dominant X/Y-axis RFQ (cm)	3.1 ± 0.2	3.9 ± 0.3	0.04
Dominant ecointensity (points)	90.6 ± 24.1	92.9 ± 15.1	0.21
Strength (kg)	24 ± 3.1	15.9±3.0	0.01
CRP (mg/dL)	6.9 ± 2.2	7.3 ± 2.4	0.31
Albumin (g/dL)	4.9 ± 0.4	4.1 ± 0.6	0.04
Prealbumin (mg/mL)	22.7 ± 3.1	19.1 ± 2.8	0.02
Irisin (pg/mL)	1387.2 ± 134.3	628.3 ± 101.3	0.01
Myostatin (pg/dL)	464.3 ± 217.3	500.9 ± 187.3	0.33
Myostatin-to-irisin ratio (pg/dL)	2.4 ± 1.1	2.3 ± 1.2	0.29

BMI, body mass index; CC, calf circumference; RFQ, rectus femoris quadriceps

Discussion

The present study reported that circulating irisin was inversely associated with sarcopenia in patients with DRM. In patients with sarcopenia, irisin levels were significantly low. The relationship between circulating irisin and the risk for sarcopenia remained significant after adjusting for potential confounding factors in the logistic regression model.

Irisin was identified as the cleavage product of the transmembrane protein fibronectin type II domain containing 5 (FNDC5); this myokine is released after proteolytic cleavage and glycosylation [8−10]. In humans, FNDC5 expression is detected in skeletal

Table 3
Differences between patients with and without sarcopenia: basal, average daily intakes, and physical activity (mean ± SD).

Parameters	All patients (N = 108)	Patients without sarcopenia (n = 64)	Patients with sarcopenia (n = 44)	*P*-value
Calorie intake (kcal/d)	1561.1 ± 347.2	1648.1 ± 248.1	1422.1 ± 219.2	0.01
Carbohydrate intake (g/d) (PTC%)	163.8 ± 58.1 (40.3%)	171.5 ± 60.1 (43.2%)	148.4 ± 49.1 (44.0%)	0.02
Fat intake (g/d) (PTC%)	68.3 ± 12.1 (41.1%)	74.3 ± 13.2 (40.0%)	59.6 ± 10.9 (39.6%)	*P* = 0.03
Protein intake (g/d) (PTC%)	68.7 ± 10.1 (18.7%)	70.3 ± 9 (17.8%)	66.3 ± 5 (19.4%)	0.02
Fiber intake (g/d)	13.6 ± 6	13.3 ± 5.1	13.9 ± 4.9	0.39
Physical activity (min/d)	58.3 ± 8.2	55.3 ± 9.8	49.5 ± 8.1	0.46

PTC, percentage of total calorie

muscles and muscular organs such as the tongue and heart and in adipose tissue [11]. The expression of FNDC5 is 200 times higher in muscle tissue than in adipose tissue [11]. The definition of sarcopenia includes muscle mass as well as muscle strength [20]. Notably, in the present study, irisin was associated with strength and muscle mass parameters of ultrasound of RFQ and parameters of impedancemetry. Moreover, only the relationship between muscle mass with different parameters and irisin levels remained statistically significant in the correlation analysis, and the association with strength disappeared, implying that serum irisin levels may be determined by quantitative parameters rather than by functional parameters of the muscle. However, contradictory dates were reported in the literature. For example, Park et al. [11] showed a positive correlation between quadriceps cross-sectional area by tomography corrected by body weight with circulating irisin in well-nourished postmenopausal women. Moreover, Choi et al. [22] did not find any association between irisin levels and muscle mass parameters. Homa-Miak [23] reported patients with head and neck cancer and malnutrition had higher irisin values than well-nourished patients. In this work, the presence of sarcopenia was not evaluated; therefore, we do not know the percentage of patients with cancer who presented this problem, and it may be that the type of tumor and the secondary inflammation are related to the elevation of irisin, more than the patient's nutritional [24–26]. Contradictory results have been reported in the literature in patients with cancer: higher levels of irisin in patients with benign and malignant breast tumors compared with controls [24], higher levels in patients with gastric cancer than the control group [25], and lower levels of irisin in patients with cancer compared with the control group [26]. Considering everything previously mentioned, the greatest strength of the present study was that, for the first time in the literature, the circulating levels of irisin and myostatin in patients with DRM and their relationship with the presence of sarcopenia were evaluated.

Perhaps differences in the literature may be explained by the different baseline characteristics of the study samples, ratio of men to women, average age, basal body weight, nutritional status, and comorbidities. Other studies in different populations have reported interesting data; for example, Maimoun et al. [27] reported a specific myokine profile in patients with anorexia nervosa and DRM characterized by lower myostatin and normal irisin levels. In this study, irisin levels were correlated with body cell mass by impedancemetry. In other studies, a non-significant reduction in irisin levels has been reported in malnourished patients with anorexia nervosa [28]. Lee et al. [29] showed that no modification in irisin levels was detected despite a substantial decrease in muscle mass induced by starvation. He et al. [30] reported that hemodialysis patients with protein-energy wasting had lower irisin levels, fat mass, and muscle mass than patients not on hemodialysis. Additionally, Huerta et al. [31] reported that in obese individuals treated with a 30% energy-restricted diet, irisin levels decreased significantly. In our study, the patients with sarcopenia presented a decreased intake, which could be related to low irisin levels. However, in the regression analysis, the intake was adjusted, and the relationship between low irisin levels and the presence of irisin was maintained in sarcopenia. However, no association between dietary intake and irisin levels was reported in healthy young individuals [32]. Lastly, our work has not demonstrated any association of myostatin levels with muscle mass parameters. Thus, our results agree with previous studies [15,16].

The present study had some limitations. First, the sample size was relatively small. Second, this was a cross-sectional study; therefore, causality could not be assessed. Third, our design only included patients with DRM; generalization to all populations was not possible. The study had strengths, such as the use of different techniques to measure muscle mass, impedancemetry, and RFQ ultrasound, both of which are bloodless techniques, without ionizing radiation and fast. Second, the spectrum of patients with DRM is wide, being habitual in real clinical practice. Perhaps this fact can be considered as a limitation. However, the presence of various pathologies that cause DRM in our sample makes our results more generalizable to patients usually treated in nutrition units. Finally, we measured dietary intake and physical exercise in these patients, excluding an action of different amounts of exercise in our results.

Table 4
Correlation analysis between irisin and other parameters*

Parameters	Irisin
Dominant muscle area RFQ (cm^2)	*r* = 0.21, *P* = 0.02
Dominant circumference RFQ (cm)	*r* = 0.25, *P* = 0.01
Dominant Y-axis RFQ (cm)	*r* = 0.21, *P* = 0.02
SMM (kg)	*r* = 0.18, *P* = 0.03
aSMMI (kg/m^2)	*r* = 0.17, *P* = 0.04
aSMMI (kg/m^2)	*r* = 0.17, *P* = 0.03
Phase angle (UI/L)	*r* = 0.15, *P* = 0.03
Reactance (Ω)	*r* = 0.14, *P* = 0.03

aSMM, appendicular muscle mass; aSMMI. appendicular muscle mass index; RFQ, rectus femoris quadriceps; SMM, skeletal muscle mass
*Myostatin did not show significant correlations.

Conclusion

The present study reported that low levels of serum irisin were closely associated with sarcopenia in patients with DRM. Our data suggest that it is a potentially useful marker for diagnosis or potential novel treatments of sarcopenia in patients with DRM. Future lines of research should be considered, evaluating other populations and potential interventions to assess the role of irisin in malnourished patients with sarcopenia. It is necessary to investigate dietary or pharmacologic actions that increase irisin levels to improve muscle mass in patients with sarcopenia.

Declaration of competing interest

None.

CRediT authorship contribution statement

Daniel de Luis: Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **David Primo:** Resources, Project administration, Investigation, Data curation. **Olatz Izaola:** Resources, Project administration, Investigation, Formal analysis, Data curation. **Juan José López Gómez:** Visualization, Validation, Data curation, Conceptualization.

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