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ORIGINAL ARTICLE

Study of muscle strength using hand-held dynamometry in pediatric patients with obesity

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KEYWORDS
Pediatric obesity;
Manual dynamometry;
Muscle strength;
Electrical impedance;
Body composition

Abstract
Objective: To evaluate muscle strength based on grip strength in children and adolescents with obesity and comparing it with reference values. To analyse the association with body composition findings obtained by bioelectrical impedance analysis as well as clinical and biochemical variables.
Material and methods: Retrospective observational cohort study in pediatric patients with obesity (6–16 years) followed up in an outpatient clinic in a tertiary care hospital. We collected data on physical activity and anthropometric, biochemical, sonographic, bioimpedance and dynamometry parameters.
Results: The sample included 125 patients (mean age, 12.06 years; 50.4% female; body mass index [BMI] Z-score, 3.87 [SD, 1.46]). Male participants were less severely obese and had a healthier body composition. Prepubertal patients were less physically active and had a higher fat mass (FM) percentage. The prevalence of metabolic comorbidities, such as hyperuricemia and insulin resistance, increased with the degree of obesity. Children with obesity had a mean muscle strength Z-score of +0.71 in the dominant hand, with differences based on sex and stage of pubertal development. We found dynapenia in 4.8%, with a greater prevalence in prepubertal children. Muscle strength was positively correlated to physical activity, fat-free mass and phase angle and negatively correlated to FM percentage. Fat-free mass was the strongest predictor of muscle strength.

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Conclusions: In this sample of children with obesity, muscle strength was not decreased compared to the healthy reference population. Fat-free mass is the strongest predictor of muscle strength. The findings highlight the positive influence of physical activity and the amount of lean mass on strength in children and adolescents with obesity.

PALABRAS CLAVE
Obesidad infantil;
Dinamometría manual;
Fuerza muscular;
Impedancia eléctrica;
Composición corporal

Estudio de la fuerza muscular mediante dinamometría de prensión manual en pacientes pediátricos con obesidad

Resumen
Objetivo: Evaluar la fuerza muscular a través de la fuerza prensil manual en niños y adolescentes con obesidad y comparar los resultados con valores de referencia. Analizar su relación con el estudio de composición corporal mediante bioimpedanciometría y su asociación con variables clínicas y bioquímicas.
Material y métodos: Estudio observacional retrospectivo tipo cohorte de pacientes pediátricos con obesidad. Se recopilaron parámetros de actividad física, antropométricos, bioquímicos, ecográficos, bioimpedanciometría y dinamometría.
Resultados: Se incluyeron 125 pacientes (media 12,06 años, 50,4% mujeres, Z-score índice de masa corporal [IMC]: 3,87 ± 1,46 desviación estándar [DE]). Los varones presentaban una obesidad menos grave y una mejor composición corporal. Los prepúberes realizaban menos actividad física y tenían más porcentaje de masa grasa. La presencia de comorbilidades metabólicas, como hiperuricemia e insulinorresistencia, aumentó con el grado de obesidad. Los niños con obesidad presentaron un Z-score medio de fuerza muscular de +0,71 en la mano dominante. Un 4,8% presentaba dinamopenia, más frecuente en prepúberes. La fuerza muscular se correlacionó positivamente con actividad física, masa libre de grasa y ángulo de fase (PA) y negativamente con porcentaje de masa grasa, siendo la masa libre de grasa el predictor más fuerte.
Conclusiones: La fuerza muscular en nuestra muestra de niños con obesidad no se encuentra disminuida respecto a la población de referencia. La masa libre de grasa es el factor predictor más fuerte de la fuerza muscular. Se destaca la influencia positiva de la actividad física y la masa magra en la fuerza de los niños y adolescentes con obesidad.

Introduction

The World Health Organization (WHO) defines obesity as abnormal or excessive fat accumulation that presents a risk to health, a form of malnutrition resulting from overnutrition, and considers it a global public health problem, as it is the most prevalent noncommunicable disease in children and adolescents, to the point that it has been labeled a 21st century pandemic.[1] In 2022, 43% of the global adult population was overweight, compared to 25% in 1990.[2] According to the ALADINO 2023 study, more than one third of children aged 6–9 years in Spain have excess weight, although there had been an overall decrease in the prevalence of excess weight of 4.5% in the last 4 years.[3,4]

Childhood obesity is a risk factor for a variety of physical and psychosocial complications and carries a risk of progression and chronification in adolescence and adulthood.[1,5] Anthropometry has traditionally been the most widely used method for classifying and diagnosing obesity through the use of measures such as the body mass index (BMI), the triponderal mass index (TMI), the waist circumference, the waist-to-height ratio, and skinfold thicknesses.[5,6]

Other techniques for assessment of body composition that are more accurate have become increasingly important. Electrical bioimpedance analysis (BIA) is the most widely used among them, as it is a simple, inexpensive, noninvasive, portable technique that can be used to estimate body composition and, therefore, assess the nutritional and hydration status of an individual quickly and easily. Serial BIA assessments allow monitoring of nutritional progress in greater detail.[7] This technique also contributes useful information through the phase angle (PA), a reliable indicator of the integrity and vitality of cell membranes and has been found to be useful as a prognostic indicator for several diseases and a predictor of morbidity and mortality in the pediatric population.[8]

A combination of diagnostic techniques, which may be quantitative or qualitative, is required to assess skeletal muscle mass and function by measuring muscle quantity and muscle strength.[9] One of the most widely used quantitative techniques is hand-held dynamometry, a quick, simple, and non-invasive test that measures maximum static grip strength. In Spain, reference values for age and sex are available for this test.[10] On the other hand, several studies suggest the need to adjust hand grip strength measurements to body weight.[11] In this regard, the relative handgrip strength (grip strength divided by the body mass index [BMI]) could serve as an additional measure to assess body fat mass, as a greater fat mass is associated with a lower relative handgrip strength,[12] and therefore could be useful for the screening and assessment of sarcopenic obesity in children.[13]

Sarcopenia is a condition defined as low skeletal muscle mass and function.[14] Its etiology is complex and multifactorial, and it is associated with age, lifestyle, diet, inflammation, insulin resistance, and oxidative stress. Sarcopenia can be primary (related to old age) or secondary (related to chronic diseases).[9] On the other hand, dynapenia refers to low muscle strength as evinced by low grip strength measured by dynamometry (more than 2 SDs below the mean for age and sex in the reference population)[10] and can be related to low muscle mass.

Obesity and sarcopenia can overlap in what is known as sarcopenic obesity, originally described in the elderly population.[15] Their interaction is bidirectional and synergistic, and their combination increases the risk of metabolic disease and functional impairment more than either obesity or sarcopenia alone.[16]

There are few studies on sarcopenia as a comorbidity in young people, although it is known that the prevalence of low muscle mass is higher in children with chronic diseases compared to the healthy population.[17] Sarcopenic obesity in childhood is associated with an increased risk of metabolic diseases and disability in adulthood.[18] However, since this aspect had yet to be investigated in depth, we designed a study with the aim of assessing muscle strength using handheld dynamometry in a cohort of pediatric patients with obesity.

Material and methods

Study design

We conducted a retrospective and descriptive cohort study in patients aged 6–16 years referred to the pediatric nutrition clinic with a diagnosis of obesity (BMI *z* score $\geq$ 2[19]) who underwent the initial assessment at the clinic between August 1, 2023 and December 31, 2024. We recorded data on epidemiological variables (age, biological sex, engagement in extracurricular physical activity and its intensity [type of activity and number of hours a week, obtained in the history-taking], with subsequent calculation of the metabolic equivalents of task (METs/week), anthropometric variables (weight, height, BMI and BMI *z* score,[19] TMI and TMI *z* score,[19] waist circumference and waist circumference *z* score[20] and waist-to-height ratio), biochemical variables, sonographic variables (presence or absence of hepatic steatosis), BIA parameters (assessments made with an Akern 101 system), and grip strength measured with an analog handheld dynamometer (Takei TKK 5001 Grip-A). To perform the BIA, the patient was placed in a supine position, allowing at least 2 min of rest before starting the test, with arms and legs abducted forming an angle of 30° to 45° in relation to the trunk. Four electrodes were placed on the right side of the body on the dorsal surfaces of the wrist and ankle, 4–5 cm apart. The measurements were taken in the outpatient clinic without taking into account fasting, hydration, or previous exercise. For the grip strength test, the patient was directed to stand with the arm extended and parallel to the trunk, holding the dynamometer, and to exert the maximum possible force with both hands.

Ethical aspects

The study was conducted in adherence to the ethical principles and the laws and regulations currently in force in Europe and Spain. It was evaluated and approved by the Human Research Ethics Committee of the Complejo Hospitalario Universitario de Canarias. The Committee granted a waiver of informed consent in view of the nature of the study.

Statistical analysis

In the bivariate analysis, we compared independent groups using the Student *t* test in the case of continuous variables and the χ^2 test or Fisher exact test, as applicable, for categorical variables. The Pearson correlation coefficient was used to assess the association between two continuous variables.

Multiple regression models were fitted through block analysis to evaluate the association between handgrip strength in the dominant hand (dependent variable) and demographic, anthropometric, and bioimpedance variables. We also assessed for multicollinearity. For each model, we calculated and recorded the beta coefficient, 95% confidence interval, standard error (SE), *t*-statistic, as well as the *P* value to assess the statistical significance of each predictor. Finally, we selected the models with the highest coefficient of determination (R^2).

The statistical analysis was performed with SPSS version 21, and we considered *P* values of less than 0.05 statistically significant.

Results

The sample included a total of 125 participants aged 6.01–16.43 years (mean [SD], 12.06 [2.64]). Fifty-four percent were female patients, who, overall, had higher values for the TMI z score (mean [SD], 6.21 [2.45] vs 5.07 [1.7] in males; $P = .002$) and waist circumference z scores (mean [SD], 3.27 [0.59] vs 2.66 [0.79]; $P < .001$).

In addition, 41 patients were in the prepubertal stage (prepubertal group: mean age [SD], 9.16 [1.97] years) while 84 were in the pubertal stage (pubertal group: mean age [SD], 13.48 [1.53] years). The TMI z score was lower in the prepubertal group (mean [SD], 5.06 [1.69] kg/m[3] vs 5.93 [2.34] kg/m[3]; $P = .037$), without significant differences in waist circumference or BMI *z* scores.

Table 1 presents the anthropometric data for the sample.

Of the total sample, 67.2% engaged in extracurricular physical activity (mean [SD], 27.64 [13.47] METs/week),

Table 1 Anthropometric characteristics of the sample.

Anthropometric values	Total (n = 125) Mean (SD)	Male (n = 62) Mean (SD)	Female (n = 63) Mean (SD)	*P*
Body mass index (kg/m^2)	32.64 (5.69)	31.66 (4.92)	33.59 (6.26)	.058
Body mass index z score	3.87 (1.46)	3.68 (1.29)	4.07 (1.60)	.137
Triponderal mass index (kg/m^3)	20.93 (3.06)	20.09 (2.59)	21.78 (3.27)	.002
Triponderal mass index z score	5.64 (2.18)	5.07 (1.71)	6.21 (2.45)	.003
Waist circumference (cm)	100.25 (14.72)	101.64 (14.53)	98.76 (14.94)	.349
Waist circumference z score	2.96 (0.76)	2.66 (0.79)	3.27 (0.59)	< .001
Waist-to-height ratio	0.64 (0.07)	0.64 (0.06)	0.64 (0.07)	.956

Table 2 Characteristics of the bioelectrical impedance analysis test.

BIA parameter	Total (n = 125) Mean (SD)	Male (n = 62) Mean (SD)	Female (n = 63 Mean (SD)	*P*
FFM (kg)	53.49 (16.16)	55.68 (17.95)	51.3 (13.96)	.132
TBW (L)	39.94 (10.82)	41.6 (12.07)	38.28 (9.21)	.088
BCM (kg)	30.11 (9.98)	31.89 (11.27)	28.34 (8.21)	.047
FM (kg)	28.17 (10.47)	26.25 (9.98)	30.09 (10.68)	.041
PA (°)	6.48 (0.7)	6.66 (0.75)	6.29 (0.60)	.004
FMpct (%)	34.51 (6.88)	32.31 (6.95)	36.7 (6.11)	< .001
FFMpct (%)	65.49 (6.88)	67.69 (6.95)	63.3 (6.11)	< .001
TBWpct (%)	49.37 (5.14)	51.07 (4.84)	47.68 (4.90)	< .001
ICWpct (%)	57.76 (2.89)	57.46 (3.03)	58.07 (2.74)	.243
FMI (kg/m^2)	11.69 (5.42)	10.32 (3.03)	13.06 (6.80)	.005
FFMI (kg/m^2)	21.17 (3.61)	21.44 (3.48)	20.9 (3.75)	.411

Abbreviations: BCM, body cell mass; FFM, fat-free mass; FFMI, fat-free mass index; FFMpct, fat-free mass percentage; FM, fat mass; FMI, fat mass index; FMpct, fat mass percentage; ICWpct, intracellular water percentage; PA, phase angle; TBW, total body water; TBWpct, total body water percentage.

with significant differences between the sexes: the mean (SD) for males was 31.56 (14.44) METs/week compared to 23.23 (10.85) METs/week in female patients ($P = .003$). There were also differences based on pubertal development (prepubertal: 24.19 [9.92] METs/week; pubertal: 29.72 [14.92] METs/week; $P = .044$).

The most frequent biochemical abnormalities were insulin resistance (in 60.76%) and HbA1c elevation (in 17.07%), followed by vitamin D deficiency (in 15.38%), hyperuricemia (in 11.32%), euthyroid hyperthyroxinemia (in 11.11%), and dyslipidemia (in 10.43%).

Patients with hyperuricemia had more severe obesity, with higher BMI *z* scores (mean [SD], 5.55 [2.2] vs 3.69 [1.17]; $P = .014$), and waist circumference *z* scores (3.55 [0.87] vs 2.88 [0.75]; $P = .017$), and a higher fat mass percentage (39.15 [9.41] vs 33.77 [6.18]; $P = .009$). Patients with insulin resistance also had a higher *z* scores for the TMI (6.59 [2.23] vs 5.05 [1.7]; $P = .002$), BMI (4.47 [1.58] vs 3.4 [1.04]; $P = .001$), waist circumference (3.2 [0.59] vs 2.69 [0.58]); $P = .003$) and waist-to-height ratio (0.67 [0.07] vs 0.62 [0.05]; $P = .009$), as well as a higher total fat mass (32.58 [9.45] vs 25.21 [8.2] kg; $P < .001$).

The findings were suggestive of hepatic steatosis in 57.47% of patients. Overall, 82.8% of patients had associated metabolic abnormalities (biochemical or sonographic). The percentage was 69% in the prepubertal group compared to 88.6% in the pubertal group ($P = .034$).

Table 2 shows the results of BIA for the entire sample, as well as the differences between male and female patients. There were differences in fat mass in relation to the level of physical activity: mean (SD) of 31.42 (13.15) kg in those who exercised compared to 26.62 (8.59) kg in those who did not ($P = .040$).

On the other hand, the fat mass percentage was significantly lower ($P = .024$) and the fat-free mass index was significantly higher ($P < .001$) in the pubertal group.

Table 3 presents the results of the grip strength test for the total sample and by sex. The mean (SD) grip strength value for the dominant hand (the right hand in 91.07% of patients) was 23.64 (9.51) kg with a *z* score of 0.71 (1.36). Only six patients exhibited dynapenia (4.8%), four of whom were male.

There were no significant differences in the dominant hand grip strength *z* score based on the stage of pubertal development. The grip strength/BMI ratio was significantly lower in prepubertal patients (mean [SD], 0.46 [0.16] vs 0.78 [0.23]; $P < .001$). It should be noted that five of the six patients with dynapenia were in the prepubertal stage ($P = .014$).

There were no statistically significant differences in grip strength values based on whether or not the patient engaged in physical activity. However, we did find that the frequency and intensity of the activity (METs) was positively correlated to the grip strength/BMI ratio, with a Pearson linear correla-

Table 3 Results of grip strength test.

	Total (n = 125) Mean (SD)	Male (n = 62) Mean (SD)	Female (n = 63) Mean (SD)	*P*
Dominant hand grip strength (kg)	23.64 (9.51)	25.05 (11.02)	22.26 (7.57)	.102
Dominant hand grip strength *z* score	0.71 (1.36)	0.43 (1.14)	0.99 (1.50)	.021
Nondominant hand grip strength (kg)	22.01 (8.8)	23.25 (10.22)	20.81 (7.03)	.125
Nondominant hand grip strength *z* score	0.50 (1.34)	0.21 (1.25)	0.78 (1.37)	.017
Hand grip strength/BMI ratio	0.68 (0.26)	0.74 (0.30)	0.62 (0.18)	.014

Abbreviation: BMI, body mass index.

tion coefficient (*r*) of 0.241 ($P = .027$) and to the grip strength of the dominant hand ($r = 0.217$; $P = .046$).

The muscle strength study showed no differences based on the presence of biochemical comorbidities. All children with dynapenia (n = 6) had sonographic findings suggestive of hepatic steatosis.

Table 4 shows the correlations between the dynamometry, anthropometry, and metabolic measurements in the total sample.

In the analysis of the association between muscle strength in the dominant hand (Table 5) in model 1, we observed that sex and pubertal stage combined explained more than half of the model's variance ($R^2 = 53.2\%$). When the BMI was included in model 2, we observed a marginal increase in the explained variance ($R^2 = 54.5\%$; $\Delta R^2 = 1.3\%$), although the coefficient for the BMI was not statistically significant ($P = .072$). Fat-free mass was the variable most strongly associated with muscle strength (model 3), with these variables exhibiting a bivariate correlation of 0.80 ($P < .001$), and the inclusion of the fat-free mass in the model substantially increased the R^2 ($R^2 = 69.6\%$) and modified the direction of the effect of the BMI, with its coefficient becoming negative as well as significant ($\beta = -0.33$; $P = .007$). This finding suggests that, once lean mass is controlled for, BMI predominantly reflects the effect of the fat mass, which has a negative impact on muscle strength. Finally, model 4 assessed the contribution of the phase angle instead of the FFM. The association between the phase angle and muscle strength was positive and significant; however, this model explained a smaller proportion of the variance ($R^2 = 57.2\%$).

It should be noted that the fat mass was not included directly in the models along with the BMI due to multicollinearity. However, bivariate correlation analyses (Table 4) revealed that fat mass and waist circumference were negatively correlated with muscle strength.

Discussion

Obesity can be associated with various diseases or comorbidities, including sarcopenia. Previous studies have shown that muscle strength offers a high discriminatory ability to detect cardiometabolic risk/metabolic syndrome, sarcopenic obesity risk, and bone health in children and adolescents aged 5–17 years.[21]

Most of our patients were severely obese, and up to 82% of them already presented with some metabolic comorbidity. However, overall, our sample had standardized muscle strength values above the reference population mean,[10] and only 4.8% had dynapenia. The prevalence of dynapenia was slightly lower compared to other studies of muscle strength in the context of childhood obesity.[22,23]

With regard to differences between male and female patients, in our sample, boys exercised more, which was consistent with previous data published at the national level,[3] and had less severe obesity, in addition to a healthier body composition based on the BIA findings. However, in the analysis of the dynamometry test results, the grip strength *z* score was paradoxically lower in male patients, although this apparent difference was nullified when obesity was taken into account, as male patients had a higher grip strength-to-BMI ratio. Several studies have established different cut-off points for this ratio to identify children of any sex at risk of sarcopenic obesity.[13,23,24] Nevertheless, the current evidence suggests that boys tend to have a higher ratio than girls.[25] Furthermore, previous studies on the role of biological sex in the development of sarcopenic obesity in children have yielded contradictory findings.[24,26,27]

With regard to pubertal development, we found several differences between the prepubertal and pubertal groups, both in terms of physical activity (lower level of physical activity in prepubertal children) and body composition (higher TMI *z* score and a lower fat mass percentage in the pubertal group). When it came to muscle strength, we found no differences in its z scores between the two groups, but the grip strength-to-BMI ratio was lower in prepubertal children, in whom the prevalence of dynapenia was also higher, a finding that may be related to the results described above. However, it must be taken into account that dynapenia may have been overestimated in younger children, as they may not have cooperated fully in the grip strength test.

In the sample under study, most children (67%) did not engage in any form of extracurricular physical activity, in contrast to the far more encouraging data collected in the 2023 Aladino study (12% sedentary). It should be noted that the sample in our study had a broader age range and consisted solely of children with obesity, which could be both a cause and a consequence of sedentary behavior. The direct association of physical activity with both dominant hand strength and the grip strength-to-BMI ratio observed in our study confirms the important relationship between sedentary lifestyles, which lead to lower muscle mass and strength, and their deleterious effect in the onset and maintenance of obesity.[22,24,28]

With regard to metabolic comorbidities, the salient findings in our study were the greater degree of obesity and greater fat mass found in patients with hyperuricemia or insulin resistance. Previous studies have shown that eleva-

Table 4 Correlation between dynamometry, anthropometric, and metabolic measurements.

	Grip strength/BMI	Dominant hand grip strength (kg)	Dominant hand grip strength *z*	Nondominant hand grip strength (kg)	Nondominant hand grip strength *z*
METs/week	$r = 0.24$ ($P = .027$)	$r = 0.22$ ($P = .046$)	$r = 0.06$ ($P = .558$)	$r = 0.1$ ($P = .088$)	$r = 0.04$ ($P = .755$)
BMI *z*	$r = -0.31$ ($P \leq .001$)	$r = 0.02$ ($P = .817$)	$r = 0.15$ ($P = .104$)	$r = 0.04$ ($P = .674$)	$r = 0.19$ ($P = .038$)
TMI *z*	$r = -0.27$ ($P = .002$)	$r = 0.07$ ($P = .412$)	$r = 0.05$ ($P = .572$)	$r = 0.09$ ($P = .341$)	$r = 0.10$ ($P = .297$)
Waist circumference *z*	$r = -0.40$ ($P \leq .001$)	$r = -0.20$ ($P = .056$)	$r = 0.02$ ($P = .831$)	$r = -0.19$ ($P = .069$)	$r = 0.05$ ($P = .622$)
Basal insulin	$r = -0.17$ ($P = .137$)	$r = -0.01$ ($P = .007$)	$r = 0.08$ ($P = .480$)	$r = -0.02$ ($P = .875$)	$r = 0.10$ ($P = .398$)
HOMA–IR	$r = -0.16$ ($P = .164$)	$r = 0.80$ ($P \leq .001$)	$r = 0.05$ ($P = .657$)	$r = -0.01$ ($P = .961$)	$r = 0.08$ ($P = .481$)
FFM	$r = 0.62$ ($P \leq .001$)	$r = 0.81$ ($P \leq .001$)	$r = 0.16$ ($P = .079$)	$r = 0.81$ ($P \leq .001$)	$r = 0.16$ ($P = .080$)
BCM	$r = 0.64$ ($P \leq .001$)	$r = 0.44$ ($P \leq .001$)	$r = 0.17$ ($P = .059$)	$r = 0.83$ ($P \leq .001$)	$r = 0.18$ ($P = .051$)
PA	$r = 0.43$ ($P \leq .001$)	$r = -0.37$ ($P = .164$)	$r = 0.14$ ($P = .113$)	$r = 0.48$ ($P \leq .001$)	$r = 0.17$ ($P = .065$)
FMpct	$r = -0.55$ ($P \leq .001$)	$r = -0.374$ ($p < 0.001$)	$r = 0.04$ ($P = .668$)	$r = -0.37$ ($P = .164$)	$r = 0.05$ ($P = .566$)

Abbreviations: BCM, body cell mass; BMI, body mass index; FFM, fat-free mass; FMpct, fat mass percentage; HOMA, homeostasis model assessment; MET, metabolic equivalent of task; PA, phase angle; TMI, triponderal mass index; *z*, *z* score.

Table 5 Multivariate regression models for the study of muscle strength. Dependent variable: dynamometry of the dominant hand (in kg).

	Model 1 ($R^2 = 53.2\%$)				Model 2 ($R^2 = 54.5\%$)			
	Beta (95% CI)	SE	*t*	*P*	Beta (95% CI)	SE	*t*	*P*
Constant	−7.5 (−9.74 to −5.25)		−6.61	< .001	−6.47 (−8.96 to −3.98)		−5.14	< .001
Sex	−4.5 (−6.84 to −2.16)	−0.47	−3.80	< .001	−4.76 (−7.1 to −2.43)	−0.50	−4.04	< .001
Pubertal	14.53 (12.04–17.02)	1.53	11.54	< .001	13.2 (10.34–16.06)	1.39	9.13	< .001
BMI	—	—	—	—	0.22 (−0.02 to 0.46)	0.13	1.82	.072
	Model 3 ($R^2 = 69.6\%$)				Model 4 ($R^2 = 57.2\%$)			
	Beta (95% CI)	SE	*t*	*P*	Beta (95% CI)	SE	*t*	*P*
Constant	−3.03 (−5.28 to −0.78)		−2.67	.009	−6.3 (−8.74 to −3.86)		−5.12	< .001
Sex	−0.76 (−2.94 to 1.42)	−0.08	−0.689	.492	−3.6 (−6.01 to −1.19)	−0.37	−2.96	.004
Pubertal	5.14 (1.97–8.31)	0.54	3.212	.002	12.15 (9.23–15.06)	1.27	8.25	< .001
BMI	−0.33 (−0.58 to −0.09)	−0.20	−2.721	.007	0.19 (−0.04 to 0.43)	0.11	1.64	.104
FFM	0.44 (0.33 to 0.55)	0.74	7.64	< .001	—	—	—	—
PA	—	—	—	—	2.49 (0.71–4.26)	0.18	2.77	.006

Abbreviations: BMI, body mass index; FFM, fat-free mass; PA, phase angle; *t*, Student *t*.

tion of uric acid could serve as a cardiometabolic marker associated with decreased handgrip strength.[29] On the other hand, there is evidence that insulin plays an important role in the risk of developing type 2 diabetes,[30] cardiovascular disease[9] and metabolic syndrome, as well as sarcopenic obesity in adulthood.[29,31] However, our study did not find an association between grip strength and the presence of these disorders.

Despite the low total number of children with dynapenia, all of them had sonographic features of hepatic steatosis. These results are consistent with previous findings in adults, which show that low muscle strength is associated with a higher hepatic fat content and an increased risk of hepatic steatosis.[32]

We were able to demonstrate a positive correlation between muscle strength and physical activity, as well as lean mass, cell mass, and PA. Furthermore, we have objectively shown that, although sex and the stage of pubertal development are important factors in explaining muscle strength, the most decisive predictor is fat-free mass, while fat mass had a negative impact.

In summary, in our pediatric sample, with a high prevalence of severe obesity and sedentary lifestyles, the study of body composition combined with the assessment of muscle strength yielded relevant data that highlights the importance of incorporating new diagnostic tools to enable a more comprehensive evaluation, in order to predict metabolic complications and guide individualized therapeutic strategies.

The main limitations or areas for improvement in our work, given that it was a retrospective study, chiefly concern standardization, in terms of performing additional tests or patient assessments.

Future studies could include additional diagnostic methods, such as musculoskeletal ultrasound or dynamic muscle strength measures, to help assess muscle function, and advance toward establishing a consensus on the definition of pediatric sarcopenic obesity, establishing standardized assessment methods and cut-off points for age and sex.

Conclusions

Children with obesity in our study sample did not exhibit lower muscle strength compared to the reference population, and the observed percentage of dynapenia was low. Male patients reported higher levels of physical activity and were in better physical condition based on the anthropometric and body composition values, and prepubertal patients exercised less, had a higher percentage of fat mass, and a higher prevalence of dynapenia compared to the pubertal group. Muscle strength correlated to the level of physical activity, fat-free mass, cell mass, and PA, and the fat-free mass was the strongest predictor of muscle strength, while the fat mass correlated negatively to muscle strength.

Declaration of competing interest

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