

Handgrip Strength in Individuals with Major Depressive Disorder: Associations with Psychosocial and Physical Factors

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Abstract

Objective: Major depressive disorder (MDD) is a heterogeneous clinical condition associated with impairments not only in mood and cognition but also in physical functioning. This study aimed to examine the associations of handgrip strength with depression severity, self-esteem, and orthorexic tendencies in individuals with MDD. **Materials and Methods:** This cross-sectional study included 63 patients with MDD and 50 healthy controls. Depression severity was assessed using the Hamilton Depression Rating Scale (HAM-D), self-esteem using the Rosenberg Self-Esteem Scale (RSES), and orthorexic tendencies using the Orthorexia Nervosa Inventory (ONI). Handgrip strength was measured in kilograms using a digital hand dynamometer according to standard procedures. Because of the strong physiological dependence of handgrip strength on sex, sex-stratified and sensitivity analyses were performed. **Results:** Compared with controls, patients with MDD had significantly higher HAM-D scores and significantly lower RSES scores and handgrip strength. ONI scores did not differ significantly between groups. Within the MDD group, handgrip strength was negatively correlated with depression severity and positively correlated with self-esteem. In sex-stratified analyses, handgrip strength was numerically lower in patients with MDD among both women and men, although the difference reached statistical significance only among men. Sex-standardized handgrip strength was also lower in the MDD group. In the multivariable sensitivity model accounting for sex and body mass index, depression severity remained independently associated with handgrip strength, whereas the association with self-esteem was attenuated. **Conclusion:** Individuals with MDD showed lower handgrip strength than healthy controls. These findings suggest that handgrip strength may provide complementary information on physical functioning in MDD. However, clinical interpretations should remain cautious because of the cross-sectional design, modest sample size, and possible residual confounding.

Keywords: major depressive disorder; self-esteem; handgrip strength; orthorexia nervosa; physical functioning

1. Introduction

Major depressive disorder (MDD) is a heterogeneous psychiatric disorder associated not only with disturbances in mood and cognition but also with impairments in somatic

and physical functioning. Depressive symptoms are frequently accompanied by reduced energy, psychomotor slowing, decreased daily activity, sleep and appetite changes, and alterations in inflammatory and metabolic processes¹⁻⁴. Therefore, the evaluation of MDD may require attention not only to symptom severity but also to physical functioning and related psychosocial factors.

Handgrip strength (HGS) is a simple, non-invasive measure of general muscle strength and functional capacity. Previous population-based and clinical studies have reported associations between lower HGS and depressive symptoms, suggesting that reduced muscle strength and depression-related functional impairment may be interrelated³⁻⁵. However, HGS is also strongly influenced by biological and physical determinants such as sex, age, body size, body composition, and physical activity level⁵⁻⁷. For this reason, studies examining HGS in psychiatric populations should consider these factors when interpreting group differences and clinical associations.

Self-esteem is closely related to MDD and reflects an individual's global evaluation of self-worth. Previous studies and meta-analytic evidence have shown that lower self-esteem is associated with greater depressive symptom severity and may contribute to vulnerability to depression over time^{8,21,22}. Cognitive models of depression also emphasize the role of negative self-schemas, negative self-evaluation, and reduced perceived competence in the maintenance of depressive symptoms^{23,24}. In addition, self-esteem has been linked to physical activity and perceived physical fitness, suggesting that self-evaluation and physical functioning may be related through both psychological and behavioral pathways²⁸. Based on this literature, examining self-esteem together with HGS may help clarify whether lower physical performance in MDD is associated only with depressive symptom severity or also with broader self-evaluative processes.

Orthorexic tendencies represent another cognitive-behavioral domain that may be relevant in individuals with MDD. Orthorexia nervosa is characterized by excessive preoccupation with healthy eating and dietary purity, although it is not currently included as a formal diagnosis in major diagnostic systems^{10,11}. Previous studies have suggested that orthorexic tendencies may be associated with anxiety, perfectionism, eating-related rigidity, eating disorder symptoms, and self-esteem⁹⁻¹². In clinical samples, orthorexia-related features may overlap with broader psychopathological dimensions rather than representing a construct specific to eating behavior alone^{10,11}. Therefore, examining orthorexic tendencies alongside depression severity and self-esteem may help determine whether eating-related cognitive rigidity is associated with physical functioning or whether it represents a separate accompanying feature in patients with MDD.

Although HGS, self-esteem, and orthorexic tendencies have each been examined in relation to depression or related psychopathological constructs, relatively limited evidence has evaluated these variables together in clinically assessed individuals with MDD. This combined approach may be useful because MDD involves overlapping physical, cognitive, motivational, and behavioral dimensions^{1-4,21-24}. Evaluating HGS together with depression severity, self-esteem, and orthorexic tendencies may therefore provide a more integrated view of physical and psychosocial functioning in MDD. At the same time, because HGS is physiologically sex-dependent and influenced by body composition, analyses should account for these factors to avoid overinterpreting crude group differences²⁹.

The present study aimed to examine handgrip strength in individuals with MDD and healthy controls and to evaluate its associations with depression severity, self-esteem, and orthorexic tendencies among patients with MDD. We hypothesized that patients with MDD would show lower HGS than healthy controls. We also hypothesized that, within the MDD group, greater depressive symptom severity and lower self-esteem would be associated with lower HGS. The association between orthorexic tendencies and HGS was examined as an exploratory objective, given the limited and mixed evidence regarding

orthorexia-related features in MDD. In addition, because HGS is strongly influenced by sex and body composition, sex-stratified and sensitivity analyses were planned to support a more cautious interpretation of the findings.

2. Material and Method

2.1. Procedure

The study included patients aged 18–65 years who applied to the Psychiatry Outpatient Clinic of Çukurova University Faculty of Medicine Balcalı Hospital and were diagnosed with MDD according to DSM-5 criteria, and healthy volunteers with similar socio-demographic characteristics. All patients with MDD were receiving selective serotonin reuptake inhibitor (SSRI) treatment at the time of assessment. Individuals with additional psychiatric diagnoses, neurological disorders, musculoskeletal disorders, endocrine diseases, severe chronic physical illnesses, hand injury, dominant-hand limitation, or any upper-extremity condition that could affect handgrip strength were excluded. The control group was evaluated through clinical interview, and individuals with any current psychiatric diagnosis or history of psychotropic medication use were excluded.

In order for the self-report scales to be administered and the clinical interviews to be conducted properly, being at least literate was determined as a basic inclusion criterion. The research process was carried out through face-to-face clinical interviews conducted by the first author and lasting approximately 30–40 minutes. Within the scope of these interviews, the sociodemographic data form, Rosenberg Self-Esteem Scale (RSES), Hamilton Depression Rating Scale (HAM-D), and Orthorexia Nervosa Inventory (ONI) were administered. During the completion of the forms, expressions that participants had difficulty understanding were explained by the interviewer. Within the scope of physical performance assessment, handgrip strength was measured using a digital hand dynamometer according to standard protocols.

As a result of the evaluation, participants in the patient group who were found to have additional psychiatric diagnoses, including obsessive-compulsive disorder ($n=2$) and anxiety disorder ($n=10$), were excluded from the analysis. In the control group, individuals diagnosed during the clinical interview with MDD ($n=4$) or generalized anxiety disorder ($n=5$), and those who completed the scales incompletely ($n=16$), were excluded. The final sample consisted of 113 participants, including 63 patients with MDD and 50 healthy controls. The study protocol was approved by the Non-Interventional Clinical Research Ethics Committee of Çukurova University Faculty of Medicine. Written informed consent was obtained from all participants, and the study was conducted in accordance with the Declaration of Helsinki.

2.2. Scales

2.2.1. Rosenberg Self-Esteem Scale (RSES)

The Rosenberg Self-Esteem Scale (RSES) is a 10-item self-report measure developed by Rosenberg (1965) to assess global self-esteem¹³. Each item is rated on a 4-point scale ranging from 'very untrue' to 'very true.' Positively worded items (items 1, 2, 4, 6, and 7) were scored from 1 to 4, whereas negatively worded items (items 3, 5, 8, 9, and 10) were reverse-scored. Item scores were summed to obtain a total score ranging from 10 to 40, with higher scores indicating higher self-esteem. The Turkish adaptation of the scale was conducted by Çuhadaroglu (1986)¹⁴.

2.2.2. Hamilton Depression Rating Scale (HAM-D)

It is a 17-item clinician-rated scale developed by Hamilton (1960) to assess the severity of depressive symptoms¹⁵. Each item is scored between 0–2 or 0–4, and the total score

ranges from 0 to 52. As the score increases, the severity of depression increases. The Turkish validity and reliability study of the scale was conducted by Akdemir et al. (2001), and the internal consistency coefficient was found to be between 0.87 and 0.98¹⁶.

2.2.3. Orthorexia Nervosa Inventory (ONI)

It is a self-report scale developed to assess eating attitudes related to orthorexia nervosa. Participants responded to each item in a 4-point Likert-type format (1 = “not at all true” – 4 = “very true”). A high score obtained from the scale indicates pathologically obsessive attitudes related to healthy eating. The Turkish validity and reliability study was conducted by Kaya et al. (2022), and the Cronbach's alpha coefficient was reported as 0.91¹⁷.

2.2.4. Physical Strength Measurement (Handgrip Strength)

As an indirect indicator of physical functioning and general muscle strength, handgrip strength was measured with a calibrated digital hand dynamometer. The measurement protocol was carried out in accordance with the standards recommended by the American Society of Hand Therapists. During the measurements, participants were positioned in a seated posture with the shoulders in adduction, elbows at 90° flexion, forearms in a neutral position, and wrists at 0–30° extension and 0–15° ulnar deviation. Handgrip strength was measured in the dominant hand. Three consecutive measurements were obtained with rest periods of at least 60 seconds between trials, and the highest of the three measurements was used in the analyses. In order to maintain procedural standardization, all measurements were performed by the same researcher in a quiet environment free from external stimuli. Before each trial, device calibration and participant posture were checked, and measurement errors were minimized.

2.3. Statistical Analysis

Data were analyzed in two groups: patients diagnosed with MDD and healthy controls. Descriptive statistics were presented as mean $\pm$ standard deviation for continuous variables and as frequency and percentage for categorical variables. Distributional characteristics of continuous variables were examined using skewness and kurtosis values. Welch's independent-samples t-test was used for between-group comparisons of continuous variables. Categorical variables were compared using Fisher's exact test or its extension for larger contingency tables, as appropriate. For subgroup comparisons according to suicide attempt history, Mann–Whitney U tests were used because of the small subgroup size. Correlations among clinical scale scores and handgrip strength within the MDD group were examined using Spearman correlation coefficients.

Multiple linear regression analyses were performed to examine variables associated with handgrip strength among patients with MDD. In the primary clinical model, handgrip strength was defined as the dependent variable, while HAM-D, RSES, ONI, age, and illness duration were included as independent variables. Because handgrip strength is physiologically sex-dependent, sex-stratified descriptive analyses were also performed. In addition, sensitivity analyses were conducted using sex-standardized handgrip strength z-scores and a second regression model including sex and body mass index (BMI) to evaluate whether the observed associations were robust to major biological determinants of handgrip strength. Standardized beta coefficients, 95% confidence intervals, and multicollinearity diagnostics were reported for regression models. Variance inflation factor values below 5 were considered acceptable. Given the exploratory nature of the study and the number of statistical comparisons, borderline findings were interpreted cautiously. All analyses were performed using IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA). The statistical significance level was set at $p < 0.05$.

3. Results

Detailed comparisons of sociodemographic and habit-related variables are presented in Table 1. The final sample consisted of 113 participants, including 63 patients with MDD and 50 healthy controls. No statistically significant difference was found between the groups in terms of sex distribution, mean age, education level, place of residence, smoking, alcohol use, substance use, or BMI categories ($p>0.05$ for all comparisons). Although the proportion of women was higher in the MDD group than in the control group, this difference did not reach statistical significance. A history of suicide attempt was present in 15 patients with MDD and in none of the controls ($p<0.001$).

Table 1. Comparison of sociodemographic and habit-related variables between the depression and control groups

Variable	Category	Control (n=50)	Depression (n=63)	p
Sex	Female	25	39	0.253
	Male	25	24	
Age	Mean $\pm$ standard deviation	35.92 $\pm$ 12.17	40.46 $\pm$ 13.29	0.061
Education	Below primary school	0	1	1.000
	Primary school and above	50	62	
Place of residence	District/Village	2	10	0.063
	City center	48	53	
Smoking	No	33	39	0.697
	Yes	17	24	
Alcohol use	No	36	55	0.056
	Yes	14	8	
Substance use	No	50	63	–
	Yes	0	0	
Body mass index	Underweight (<18.5 kg/m ²)	0	1	0.947
	Normal (18.5–24.9 kg/m ²)	30	40	
	Overweight (25.0–29.9 kg/m ²)	16	17	
	Obese ($\geq$ 30 kg/m ²)	4	5	
History of suicide attempt	No	50	48	<0.001
	Yes	0	15	

Fisher's exact test (or its extension for larger contingency tables) was used for categorical comparisons; Welch's independent-samples t-test was used for age. Blank cells indicate a category row belonging to the variable above.

When clinical scale scores and physical performance measurements were compared, patients with MDD had significantly higher HAM-D scores than controls (13.63 $\pm$ 4.41 vs. 2.56 $\pm$ 0.50; $p<0.001$). RSES scores were significantly lower in the MDD group than in the control group, indicating lower self-esteem among patients with MDD (18.03 $\pm$ 4.86 vs. 22.90 $\pm$ 6.15; $p<0.001$). Handgrip strength was also significantly lower in the MDD group compared with controls (29.03 $\pm$ 8.61 kg vs. 33.86 $\pm$ 9.78 kg; $p=0.007$). ONI scores did not differ significantly between groups (36.24 $\pm$ 11.21 vs. 33.56 $\pm$ 9.42; $p=0.170$). Detailed statistics are presented in Table 2.

Table 2. Comparison of scale scores between the depression and control groups

Variable	Control n=50 Mean $\pm$ SD	MDD n=63 Mean $\pm$ SD	t	p	Cohen's d	95% CI
Handgrip strength, kg	33.86 $\pm$ 9.78	29.03 $\pm$ 8.61	2.75	0.007	0.53	1.34 to 8.32
HAM-D	2.56 $\pm$ 0.50	13.63 $\pm$ 4.41	-19.78	<0.001	-3.34	-12.19 to -9.96
RSES	22.90 $\pm$ 6.15	18.03 $\pm$ 4.86	4.58	<0.001	0.89	2.76 to 6.98
ONI	33.56 $\pm$ 9.42	36.24 $\pm$ 11.21	-1.38	0.170	-0.26	-6.52 to 1.17

HAM-D: Hamilton Depression Rating Scale; RSES: Rosenberg Self-Esteem Scale; ONI: Orthorexia Nervosa Inventory; SD: standard deviation; CI: confidence interval. Higher HAM-D scores indicate greater depression severity, higher RSES scores indicate higher self-esteem, and higher ONI scores indicate greater orthorexic tendencies. Handgrip strength was recorded in kilograms.

Because handgrip strength is physiologically sex-dependent, sex-stratified comparisons were also performed. Handgrip strength was numerically lower in patients with MDD in both women and men. The difference reached statistical significance among men, whereas the difference among women showed the same direction but did not reach statistical significance. These subgroup findings should be interpreted cautiously because of the limited sample size.

As an additional sensitivity analysis, handgrip strength values were standardized within sex groups and converted into sex-specific z-scores. Patients with MDD had significantly lower sex-standardized handgrip strength scores than controls (-0.25 ± 1.05 vs. 0.31 ± 0.83 ; $p=0.002$), suggesting that the lower handgrip strength observed in the MDD group was not explained solely by the unequal sex distribution.

Table 3. Sex-stratified comparison of handgrip strength between the MDD and control groups

Sex	Control Mean $\pm$ SD	MDD Mean $\pm$ SD	t	p
Female	25.04 $\pm$ 3.19	23.59 $\pm$ 3.63	1.68	0.099
Male	42.68 $\pm$ 4.78	37.88 $\pm$ 6.81	2.85	0.007

In the correlation analyses performed within the MDD group, handgrip strength was negatively correlated with HAM-D scores ($r=-0.37$; $p<0.01$) and positively correlated with RSES scores ($r=0.40$; $p<0.01$). Thus, greater depression severity and lower self-esteem were associated with lower handgrip strength. ONI scores were not significantly correlated with handgrip strength ($r=0.13$; $p>0.05$). HAM-D scores were negatively correlated with both RSES and ONI scores. Age was not significantly correlated with handgrip strength. The correlation coefficients are presented in Table 4. In the full sample, an additional linear regression model adjusted for sex, age, and BMI showed that MDD status remained associated with lower handgrip strength ($B=-2.29$ kg, 95% CI: -3.99 to -0.59; $p=0.009$).

Table 4. Correlations among clinical variables and handgrip strength in patients with MDD

Variable	Handgrip strength	HAM-D	RSES	ONI
HAM-D	-0.37**	—	—	—
RSES	0.40**	-0.32*	—	—
ONI	0.13	-0.40**	0.21	—
Age	-0.02	0.25*	-0.11	-0.23

HAM-D: Hamilton Depression Rating Scale; RSES: Rosenberg Self-Esteem Scale; ONI: Orthorexia Nervosa Inventory. Spearman correlation coefficients are presented. * $p<0.05$, ** $p<0.01$.

Multiple linear regression analyses were performed to examine variables associated with handgrip strength among patients with MDD. In the primary clinical model, HAM-D, RSES, ONI, age, and illness duration were entered as independent variables. In this model, RSES showed a borderline independent association with handgrip strength, whereas HAM-D, ONI, age, and illness duration were not independently associated with handgrip strength. The overall model was statistically significant but explained a modest proportion of variance.

Because handgrip strength is strongly influenced by sex and body composition, a second sensitivity model additionally including sex and BMI was performed. In this adjusted model, HAM-D score remained independently and negatively associated with handgrip strength, whereas the association between RSES and handgrip strength was attenuated and no longer statistically significant. Male sex showed the strongest association

with handgrip strength, as expected for a physical strength measure. No evidence of problematic multicollinearity was observed, with all VIF values below 5. Regression coefficients are presented in Table 5.

Table 5. Linear regression models examining variables associated with handgrip strength among patients with MDD

Variable	B	SE	β	95% CI	t	p	VIF
Model 1: Primary clinical model							
Intercept	29.529	9.073	—	11.361 to 47.698	3.255	0.002	—
HAM-D	-0.498	0.273	-0.255	-1.044 to 0.048	-1.828	0.073	1.34
RSES	0.451	0.222	0.254	0.006 to 0.895	2.030	0.047	1.08
ONI	-0.097	0.105	-0.126	-0.308 to 0.114	-0.922	0.360	1.29
Age	0.073	0.110	0.113	-0.147 to 0.293	0.665	0.509	1.99
Disorder duration	-0.146	0.186	-0.136	-0.518 to 0.226	-0.787	0.435	2.06
Model 2: Sensitivity model adjusted for sex and BMI							
Intercept	24.896	6.885	—	11.098 to 38.694	3.616	0.001	—
HAM-D	-0.464	0.149	-0.237	-0.763 to -0.166	-3.115	0.003	1.39
RSES	0.194	0.124	0.109	-0.054 to 0.442	1.567	0.123	1.16
ONI	-0.007	0.058	-0.009	-0.123 to 0.109	-0.120	0.905	1.35
Age	-0.106	0.063	-0.163	-0.233 to 0.021	-1.669	0.101	2.29
Disorder duration	0.041	0.101	0.038	-0.162 to 0.244	0.408	0.685	2.12
Male sex	14.323	1.206	0.814	11.906 to 16.740	11.877	<0.001	1.12
BMI	0.235	0.183	0.093	-0.131 to 0.602	1.287	0.203	1.25

B: unstandardized regression coefficient; SE: standard error; β : standardized beta coefficient; CI: confidence interval; VIF: variance inflation factor; HAM-D: Hamilton Depression Rating Scale; RSES: Rosenberg Self-Esteem Scale; ONI: Orthorexia Nervosa Inventory; BMI: body mass index. Model 1: $R^2=0.174$, adjusted $R^2=0.101$, $p=0.048$. Model 2: $R^2=0.769$, adjusted $R^2=0.740$, $p<0.001$.

Patients with MDD were divided into two groups according to the presence or absence of a history of suicide attempt. Patients with a history of suicide attempt had lower RSES scores than those without a suicide attempt history, indicating lower self-esteem ($p=0.046$). HAM-D, ONI, and handgrip strength values did not differ significantly between the two groups. Given the small subgroup size and exploratory nature of these comparisons, the RSES finding should be interpreted cautiously. The subgroup comparisons are presented in Table 6.

Table 6. Clinical and physical parameters according to suicide attempt history among patients with MDD

Variable	No suicide attempt n=48 Median (IQR)	Suicide attempt n=15 Median (IQR)	p
HAM-D	13.0 (10.0–15.0)	14.0 (13.5–18.0)	0.088
RSES	19.0 (15.75–23.0)	16.0 (11.0–18.5)	0.046
ONI	34.0 (29.0–39.25)	33.0 (30.0–38.5)	1.000
Handgrip strength, kg	28.0 (23.0–35.25)	24.0 (21.0–29.0)	0.119

HAM-D: Hamilton Depression Rating Scale; RSES: Rosenberg Self-Esteem Scale; ONI: Orthorexia Nervosa Inventory; IQR: interquartile range. Comparisons were performed using Mann–Whitney U tests. Higher RSES scores indicate higher self-esteem.

4. Discussion

The present study examined handgrip strength in individuals with MDD and evaluated its associations with depression severity, self-esteem, and orthorexic tendencies. The principal findings were as follows: patients with MDD had lower handgrip strength than healthy controls; this difference remained observable in sex-stratified and sex-standardized analyses; within the MDD group, lower handgrip strength was associated with greater depression severity and lower self-esteem in correlation analyses; however, after accounting for sex and BMI, depression severity remained independently associated with

handgrip strength, whereas the association with self-esteem was attenuated. Orthorexic tendencies were not directly associated with handgrip strength.

The lower handgrip strength observed in the MDD group is consistent with evidence suggesting that depressive symptoms are associated with reduced physical performance, lower activity levels, psychomotor slowing, and sedentary behavior. Previous studies have reported associations between reduced grip strength and depressive symptoms across different populations, supporting the view that muscle strength and mental health are interrelated domains^{3,5,18–20}. In the present study, the MDD group showed lower handgrip strength than controls even after sex-standardization, and MDD status remained associated with lower handgrip strength after adjustment for sex, age, and BMI in the full sample. These findings suggest that the lower handgrip strength in the MDD group was not explained solely by the unequal sex distribution between groups.

Handgrip strength is widely used as a feasible measure of general muscle strength and functional capacity; however, its interpretation requires caution because absolute values vary substantially according to sex and age, and may also be influenced by body size, body composition, and physical activity level. Large normative studies have shown that men have higher handgrip strength than women from adolescence onward and that grip strength follows a life-course pattern, increasing to early-adult peak values and declining from midlife onward²⁹. In addition, recent international reference data emphasize the importance of interpreting handgrip strength using sex-, age-, and body-size-specific norms³⁰. Therefore, although handgrip strength is clinically feasible, raw values should not be interpreted without considering major biological and functional determinants.

The sex-stratified analyses provided additional context for interpreting the group difference in handgrip strength. Previous literature suggests that the relationship between grip strength and depressive symptoms may vary by sex and age group^{5–7}. In the present study, handgrip strength was numerically lower among patients with MDD in both women and men, although the difference reached statistical significance only among men. This pattern should not be interpreted as evidence that the association between MDD and handgrip strength is specific to men, because the subgroup analyses were based on relatively small numbers and may have been underpowered, particularly among women. Rather, these findings indicate that sex-related differences in muscle strength should be explicitly considered when evaluating handgrip strength in psychiatric samples.

Self-esteem was significantly lower in the MDD group than in controls and was correlated with handgrip strength within the MDD group. This finding is compatible with the cognitive model of depression, in which negative self-evaluation, feelings of inadequacy, and reduced perceived competence represent important psychological dimensions of the disorder^{21–24}. From this perspective, lower self-esteem may accompany reduced motivation, lower perceived competence, and more negative evaluations of one's own physical and functional capacity. This interpretation is consistent with cognitive models of depression, in which negative self-schemas and reduced self-efficacy contribute to symptom persistence and functional impairment^{23,24}. It is also supported by literature showing that physical activity is directly and indirectly associated with self-esteem through perceived physical fitness and body-related self-evaluation²⁸. Therefore, the correlation between lower self-esteem and lower handgrip strength in the present sample may reflect an overlap between depressive cognition, perceived physical capacity, and actual physical performance.

However, the cross-sectional design does not allow the direction of the association between self-esteem and handgrip strength to be determined. Lower self-esteem may be associated with reduced motivation, lower activity engagement, and poorer perceived physical capacity, but the reverse direction is also plausible. Reduced physical capacity, fatigue, or perceived bodily weakness may contribute to demoralization and lower self-

esteem. Therefore, the relationship between self-esteem and handgrip strength should be interpreted as an association rather than as evidence of a directional pathway.

The multivariable findings further support a cautious interpretation. In the primary clinical model, RSES showed a borderline independent association with handgrip strength. However, when sex and BMI were included in the sensitivity model, this association was attenuated and no longer statistically significant, whereas depression severity remained independently associated with handgrip strength. This suggests that the bivariate relationship between self-esteem and handgrip strength may partly reflect shared variance with depression severity and biological determinants of muscle strength. Accordingly, self-esteem should not be presented as the main independent determinant of handgrip strength in this sample. Instead, the findings indicate that self-esteem is clinically relevant in MDD and is associated with physical performance at the correlational level, but its independent contribution requires confirmation in larger and better-controlled samples.

The finding that depression severity remained associated with handgrip strength after adjustment for sex and BMI is clinically relevant. Depressive symptom severity may be linked to lower handgrip strength through several non-mutually exclusive mechanisms, including psychomotor slowing, reduced energy, diminished physical activity, sleep disturbance, appetite changes, inflammatory processes, and treatment-related factors^{3,18–20}. Although the present study cannot test these mechanisms directly, the results support the view that physical functioning should be considered when evaluating patients with MDD. Handgrip strength may provide a brief and feasible physical performance measure, but it should be interpreted as complementary information rather than as a stand-alone clinical indicator of psychological functioning.

The findings regarding orthorexic tendencies require careful interpretation. ONI scores did not differ significantly between patients with MDD and controls, and ONI was not significantly associated with handgrip strength. Orthorexia nervosa is characterized by excessive preoccupation with healthy eating and dietary purity, but its diagnostic boundaries and relationship with other psychopathological constructs remain debated^{10,11}. Previous studies have suggested that orthorexic tendencies may be associated with anxiety, low self-esteem, perfectionism, and eating disorder symptoms^{9–12}. In the present study, depression severity showed an inverse correlation with ONI within the MDD group, which is not the expected direction based on the assumption that depressive symptoms may accompany greater cognitive rigidity, perfectionistic concerns, or eating-related preoccupation. Several explanations may be considered. More severe depressive states may include appetite loss, anhedonia, and psychomotor retardation³¹; these features could plausibly reduce engagement with food-related rules or dietary control. Alternatively, the inverse association may reflect sample-specific characteristics or restricted variability in ONI scores. More broadly, the marked clinical heterogeneity of MDD and the methodological variability across orthorexia studies and assessment instruments may contribute to context-dependent associations^{32,33}. Therefore, this finding should be regarded as exploratory and hypothesis-generating rather than as evidence of a stable inverse relationship between depression severity and orthorexic tendencies.

In the subgroup analysis according to suicide attempt history, patients with a history of suicide attempt had lower self-esteem than those without such a history, whereas depression severity, orthorexic tendencies, and handgrip strength did not differ significantly between the groups. This finding is consistent with literature suggesting that negative self-evaluation and reduced self-worth are relevant to suicidal vulnerability^{25–27}. However, the subgroup size was small, and the *p* value was borderline. Therefore, this result should be interpreted cautiously and should not be overextended beyond the present sample. The absence of significant differences in handgrip strength according to suicide attempt

history also suggests that handgrip strength should not be considered a marker of suicidal behavior based on these data.

Overall, the present findings suggest that physical and psychological functioning may be interrelated in MDD. Lower handgrip strength in patients with MDD may reflect a broader pattern of reduced physical functioning associated with depressive symptom burden. At the same time, the attenuation of the self-esteem association after adjustment for sex and BMI indicates that psychological interpretations of handgrip strength should remain cautious. Clinical assessment of MDD may benefit from considering physical functioning alongside symptom severity and self-perception, but the present findings do not establish handgrip strength as a diagnostic, prognostic, or causal marker.

This study has several limitations. First, the cross-sectional design prevents any inference regarding directionality or causality. Lower handgrip strength may be associated with greater depressive symptom severity, but the reverse direction is also possible; reduced physical capacity, fatigue, or perceived bodily weakness may contribute to demoralization, lower self-esteem, and greater depressive symptoms. Second, the study was conducted in a single center with a modest sample size. This may limit generalizability and may increase the instability of borderline findings, particularly in subgroup analyses. Third, although sex-stratified and sensitivity analyses were performed, handgrip strength is strongly sex-dependent, and residual confounding related to sex-related biological differences cannot be fully excluded. Fourth, BMI was considered, but more detailed body composition measures, muscle mass, nutritional status, and physical activity level were not assessed. The lack of these measures may have led to residual confounding and may have resulted in either overestimation or underestimation of the associations between psychological variables and handgrip strength. Fifth, all patients with MDD were receiving SSRI treatment, but treatment duration, dose, adherence, and specific medication-related effects were not analyzed. Therefore, possible treatment-related influences on depressive symptoms, appetite, activity level, and physical performance could not be fully evaluated. Sixth, although individuals with neurological, musculoskeletal, endocrine, severe chronic physical illnesses, hand injury, dominant-hand limitation, or upper-extremity conditions were excluded, subclinical physical factors affecting handgrip strength may still have been present. Seventh, physical functioning was assessed only through handgrip strength; other components such as gait speed, muscle mass, endurance, and broader functional capacity were not evaluated. Finally, the number of statistical comparisons was relatively high, and some findings were borderline. Therefore, the results should be considered exploratory and hypothesis-generating.

5. Conclusion

In conclusion, individuals with MDD showed lower handgrip strength than healthy controls, and this difference remained observable in sex-stratified and sex-standardized analyses. Within the MDD group, lower handgrip strength was associated with greater depression severity and lower self-esteem in correlation analyses. However, after accounting for sex and BMI, depression severity remained the more robust psychological correlate of handgrip strength, whereas the association with self-esteem was attenuated. These findings suggest that handgrip strength may provide complementary information on physical functioning in MDD, but its clinical utility should be interpreted cautiously in light of the cross-sectional design, modest sample size, and residual confounding.

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Informed Consent Statement: All participants were informed in detail about the study procedures and provided written informed consent prior to participation.

Data Availability Statement: The datasets generated and analyzed in the present study are not publicly available due to the inclusion of sensitive clinical and personal information; however, they may be obtained from the corresponding author upon reasonable request, subject to approval by the local ethics committee.

Conflict of Interest: There is no conflict of interest among the authors.

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