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ORIGINAL CONTRIBUTION

Clinical and biological correlates of adolescent anorexia nervosa with impaired cognitive profile

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Abstract Some neuropsychological studies of anorexia nervosa (AN) have yielded conflicting results, and it has been established that not all adult patients with AN are cognitively impaired. The objective of this study is to determine the percentage of adolescents with AN who present worse cognitive functioning according to neuropsychological criteria of cognitive impairment, and to study their clinical characteristics. Thirty-seven adolescents (11–18 years) with a diagnosis of AN in an acute state of the illness and with low body mass index (BMI) were compared with 41 healthy subjects of the same sex and similar age and intelligence using a comprehensive neuropsychological battery. Overall, AN patients took longer to copy Rey's Figure than the control group ($p = 0.001$). Thirty per cent of patients showed impaired neuropsychological functioning (defined as scoring two standard deviations lower than the average or lower than their intelligence level in two tasks) with worse performance on visuo-spatial tasks. This subgroup of patients presented lower BMI ($p = 0.023$) and higher trait anxiety ($p = 0.028$). The performance of adolescents in an acute state of AN was similar to that of the healthy control group, with the exception of lower time to completion in copying a complex figure. However, cognitive performance varied in these patients, being clearly impaired in one-third of the sample. The cognitive impairment subgroup showed lower BMI and higher anxiety. Longitudinal follow-up studies are necessary to assess the stability of this profile after longer treatment periods

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Introduction

Many studies have investigated cognitive performance in anorexia nervosa (AN), but their results are conflicting. The majority have shown abnormalities in cognitive domains such as attention, memory, visuospatial abilities and executive functions [1–7], but a few studies have found no abnormalities in patients when compared with healthy controls [1, 2]. These incongruities may be due to the fact that not all adult patients with AN show alterations in cognitive performance and that only a subgroup of these patients show an impaired cognitive profile prior to treatment [3–5]. These studies have used population-based criteria to define "Impaired cognitive performance" as a score at least two standard deviations below the control group mean. Overall, in these studies of adults in a starved state, around 65% of patients with AN had well-preserved cognitive skills, while about 35% presented impaired cognitive functioning. To our knowledge, all previous studies have been carried out with adult samples; to date, no adolescent samples with AN and a relatively short duration of the illness have been analysed.

So it appears that cognitive performance is sensitive to clinical stage. In terms of biological status, it seems that starvation has a large impact on neuropsychological function, but the relationship between body mass index (BMI) and neuropsychological performance is confusing. Some authors have found worse neuropsychological performance in underweight AN patients (BMI < 17.5) than in weight-recovered AN patients (BMI > 18.5) [6] or improved

cognitive profile in AN patients after treatment and weight increase [4, 7, 8], but other studies have found neither better cognitive performance following nutritional restoration [3, 9] nor any correlation with low BMI [8, 10]. Moreover, other biological variables such as hormonal levels may be related to cognitive impairment in underweight AN patients. Triiodothyronine (T3) has been shown to be highly sensitive to malnutrition in adolescents [11]. This hormone is essential for normal behavioural, intellectual and neurological development; it has a broad spectrum of effects on the developing brain and has been shown to influence cognitive processes in adults and children [12, 13]. Cortisol is another hormone that has demonstrated an association with brain alterations in adolescents with AN [14, 15] and poor cognitive performance [16].

The absence of definite conclusions concerning neuropsychological impairment and its relationship with clinical variables in AN may reflect the fact that fewer studies of cognitive performance have been carried out in this disorder than in other major psychiatric disorders like schizophrenia or obsessive–compulsive disorder [17–19]; alternatively, there may have been methodological differences in the selection of samples or neuropsychological tests. The importance of recruiting well-defined and homogeneous samples of patients in terms of age, diagnoses, clinical status, time of evolution and comorbidity in the study of AN neuropsychology has been stressed [20].

The first aim of this study was to describe the neuropsychological profile of a homogeneous sample of AN adolescents with a short duration of the disorder, acute stage of the illness, BMI lower than 17.5 kg/m^2 and without comorbidity in comparison to a healthy control group. The second and main aim was to determine the percentage of AN adolescents with an impaired cognitive profile and to analyse the clinical and biological characteristics associated with them. We hypothesised that, overall, adolescent AN patients would present worse cognitive performance in some functions than the healthy controls, but the sample of patients with clearly impaired cognitive functioning would present worse clinical and biological parameters than patients with no clear cognitive alterations.

Method

Subjects

Patients who met the DSM-IV-TR diagnostic criteria for AN were consecutively recruited from the Department of Child and Adolescent Psychiatry and Psychology at the Hospital Clinic in Barcelona between February 2004 and February 2006. In this period, 43 adolescents between 11 and 18 years of age were assessed and diagnosed of AN in our service. The majority of them were outpatients (four inpatients), but all were at the acute stage of the disorder and had BMI below 17.5 kg/m^2. Patients and their parents were administered a semi-structured interview used in our department for clinical practice to assess current psychopathology and developmental history. Exclusion criteria were comorbidity with any other psychiatric disorder, mental retardation or history of neurological illness. Six (14%) patients were excluded because they presented comorbidity with obsessive–compulsive disorder (2 patients), affective disorder (1), anxiety disorders (1), and low intellectual quotient (IQ) (2). Patients included in the sample did not present any comorbid diagnoses, but the presence of obsessive, anxious or depressive symptomatology was not an exclusion criterion. The final sample with AN at an acute stage of illness and without comorbidity comprised 37 subjects.

The control group comprised volunteers of the same set and similar age and school grade recruited from schools in the same geographical area. Subjects and parents of control group volunteers were administered the Kiddie-Schedule for Affective Disorders and Schizophrenia interview (K-SADS-PL, [21] to exclude subjects with any current or past psychiatric disorder. Exclusion criteria in this group were mental retardation or history of neurological illness. Six (13%) volunteers were excluded and referred to their mental health centre; one presented an attention deficit hyperactivity disorder, one an affective disorder, two eating disorders and two had low IQ. The 41 subjects included in the control group did not have any psychiatric history and none presented psychiatric disorders at the time of assessment.

All patients, controls and parents gave written informed consent to participate in the study. The procedures were approved by the Ethical Committee of the hospital.

Clinical and biological assessment

The severity of depressive, anxious, obsessive and eating symptomatology was quantified by self-reported questionnaires in all subjects (patients and controls). Depressive symptomatology was assessed by the Children's Depression Inventory (CDI) [22]. Obsessive symptoms were measured with the Leyton Obsessional Inventory-Children Version (LOI-CV) [23], which assessed the severity and interference of symptoms. The severity of eating symptoms was quantified by the Eating Attitudes Test (EAT-40) [24]. Anxious symptoms were assessed by the State-Trait Inventory for Children (STAIC) [25]. Age of onset, months of amenorrhea and illness duration were registered for all patients.

Biological status in AN patients was assessed on the basis of the BMI and hormonal determinations. Using BMI tables of Spanish children and adolescents [26], the percentage of difference between actual BMI and the expected BMI for the age and sex of the subject was calculated [%BMI = (expected BMI−presented BMI/expected BMI) × 100]. Regarding hormonal variables, T3 and cortisol were assessed because both have been associated with cognition. Both hormonal parameters were measured by a competitive quimioluminiscent method (ADVIA Centaur, Siemens, USA), in samples obtained before 9a.m. in fasting conditions. T3 sensitivity was 0.1 ng/ml and the coefficient of variation was 6.8%. Cortisol sensitivity was 0.2 μg/dl and the coefficient of variation was 5%.

Neuropsychological tests

Neuropsychological assessment in children and adolescents is difficult, because these patients present different developmental levels. A comprehensive battery with internationally validated tests for assessing different cognitive areas has been designed [27–30], but some of the tests used are not appropriate at particular ages. To minimise this bias, we worked with raw scores in the data analyses and selected an age-matched control group.

Wechsler Intelligence Scale for Children-Revised (WISC-R) [31] the vocabulary subtest was used to estimate the level of intelligence, as proposed by Lezak [28]. Block design was used as a visual organisation measure and digit span and coding as measures of operations of attention, visuo-motor speed and working memory. WISC-R was used because the Wechsler Intelligence Scale for Children-IV (WISC-IV) had not yet been validated in our country when the battery was designed.

Wechsler Memory Scale III (WMS-III) [32] the Logical Memory (LM) test assesses the number of details from two stories told by a psychologist that patients remember immediately (immediate recall, LM1) and one hour later (delayed recall, LM2). The Visual Reproduction (VR) test measures the number of details from five geometric figures that patients remember in immediate (VR1) and delayed (VR2) recall.

Rey Complex Figure Test (RCFT) [33] evaluates perceptual organisation and visual memory. We assessed the organisational strategy used to copy the RCFT [34]. Subjects can obtain 6 points for different structural elements (central square, vertical and horizontal lines, central cross and final angle) drawn during the copying task (RCFT Org). Accuracy of the copy (RCFT Copy) and immediate recall (RCFT Recall) of the figure were measured. Time taken to copy RCFT was recorded (RCFT Time).

Rey Auditory Verbal Learning Test (RAVLT) [33] measures immediate memory span, providing a learning curve of 15 words. The immediate recall score is obtained by adding all words correctly recalled in the five trials (Sum AVL). The percentage of words recalled after one hour in comparison to the last trial is taken as the measure of delayed recall (% AVL).

Trail Making Tests A and B (TMT) [35] assess speed in processing information, attention and cognitive flexibility. A score of working memory was obtained on the basis of the differences between TMT A and B times, so as to exclude the speed of processing of the capacity for flexibility.

Wisconsin Card Sorting Test (WCST) [36] measures sorting and set shifting ability. It assesses the categories achieved (number of correct runs of ten sorts) (WCST-cat), number of sorting errors (WCST-err) and perseverations in a response (WCST-per).

Controlled Oral Word Association Test (COWAT) [28] assesses the oral production of spoken words beginning with a designated letter in 90s. The letters used were F, A and S. The score is the sum of three trials.

Stroop Test (Stroop) [37] consists in naming the colour of the ink in which the word is printed while ignoring the actual written name of the colour. The interference score is calculated for each subject.

Impaired cognitive functioning

According to the means and standard deviations (SD) provided for the respective tests, the T Score (mean 50; SD 10) was calculated for every test and the cognitive profiles were made. Because some of the tests were not normalised for all ages (WISC-R for older than 17 and WMS-III for younger than 15), the mean and deviation nearest to the chronological age were chosen for subjects (patients and controls) with extreme ages. A visual analysis of all profiles was made to classify the patients into two groups: an impaired cognitive performance group and a normal cognitive performance group. Impaired performance on a task can be defined following normative criteria (derived from an appropriate population) or individual criteria (derived from the characteristics of the patient) [28]. Both criteria were applied in the present study. The impaired cognitive profiles presented values 2 SD lower than the normative mean in 2 tasks (population-based criteria) or 2 SD lower than the estimated intelligence level in 2 tasks (individual criteria). With these criteria, patients were divided into "impaired cognitive performers" and "normal cognitive performers". Impaired cognitive performers included patients who showed a profile with two or more impaired tasks in relation to normative data or their own intelligence level. Normal cognitive performers showed impaired performance in only one or in none of the tasks. This is a strict criterion, but it was chosen to identify the most

neuropsychologically impaired patients because we hypothesised that the subgroup of patients with a worse cognitive profile would be the one with more severe clinical characteristics.

Statistical analysis

Normality of the distributions of different variables in the two samples was not confirmed by the means of Kolmogorov–Smirnov tests, and therefore non-parametric tests were used to compare the groups. The differences between AN and control groups were compared using the Mann–Whitney *U* test in the case of quantitative variables (neuropsychological and some clinical variables) and the Chi-square test in the case of dichotomous variables (sex and percentage of Impaired cognitive performers). Correlations were analysed using Spearman's rho. To study the differences in cognitive variables between impaired cognitive performers, normal cognitive performers and the control group a Kruskal–Wallis analysis was performed, and two by two comparisons of these groups were performed with Mann–Whitney *U* tests. A p value of 0.05 or less was used in all the analyses.

Results

Demographic, clinical and biological characteristics

The AN group comprised 35 (94.6%) girls and two (5.4%) boys, and the control group 37 (90.2%) girls and four (9.8%) boys ($\chi^2 = 0.518$, $p = 0.678$). As shown in Table 1, there were no significant differences between AN and control groups in terms of age or estimated intelligence, and all psychopathological questionnaires showed significantly higher scores in the AN group than the control group.

AN patients were recruited at an acute stage of the disorder, with a BMI ranging between 11 and 17.4 kg/m2 (mean = 15.3, SD = 1.4). Deviation from normal BMI (%BMI) showed a minimum of 15 and a maximum of 39.5% (mean = 25.17, SD = 6.3). T3 levels lower than the normal range were found in 89% of the patients (mean = 0.76, SD = 0.2; normal range = 0.97–2.06 ng/mL). Mean levels of cortisol in the patients were within the normal range (17.77 ηg/dL, SD = 3.93; normal range = 10–25 ηg/dL). Patients in this study showed a relatively short duration of illness, between 3 and 54 months (mean = 13.2, SD = 10.7), with a beginning of the disorder between 9 and 17 years of age (mean = 13.9, SD = 1.7). Thirty-two (86.4%) presented restrictive AN and only five (13.6%) purging type. Eight patients (21.6%) were taking an SSRI (fluoxetine between 20 and 60 mg/day or sertraline 100 mg/day) at the time of assessment. The rest of the patients (78.4%) were not receiving any medication.

Neuropsychological differences between AN and control groups

Only the time to copy RCFT presented statistical differences between AN and control groups (Table 2). This test measures the time in seconds that the subjects take to copy the figure. The results showed that AN patients were slower than controls, using a mean of 60s more to complete the task. No other neuropsychological variable showed statistically significant differences between the two groups. Nevertheless, there were some slight but potentially significant trends in three tests related to visual abilities: organisation and recall of Rey's Figure, and block design.

Correlations between clinical and neuropsychological variables

To avoid multiple correlations, this analysis was performed between all clinical variables and neuropsychological tests that showed significant (or a trend towards significant) differences between patients and controls. Then, correlations were calculated between questionnaires' scores (CDI, LOI-CV, EAT-40 and STAIC) and biological variables

Table 1 Comparison of age, questionnaires and estimated intelligence between Anorexia nervosa and control groups

	Anorexia Nervosa ($n = 37$) mean (SD)	Control ($n = 41$) Mean (SD)	*U*	*p*
Vocabulary	10.46 (2.96)	11.02 (2.12)	693	0.508
Age (years)	15.4 (1.5)	15.4 (1.5)	724	0.724
EAT-40	46.53 (27.3)	8.76 (6.7)	82.5	<0.001
STAIC state	79.36 (25.66)	51.1 (29.67)	281	<0.001
STAIC trait	59.39 (32.41)	36.09 (24.95)	392.5	0.010
CDI	16.30 (9.14)	8.51 (3.69)	347	<0.001
LOI-severity	9.56 (3.44)	7.74 (2.55)	429.5	0.020
LOI-interference	9.31 (8.5)	5.40 (4.3)	469.5	0.064

EAT-40 Eating Attitudes Test, *STAIC* State-Trait Inventory for Children, *CDI* Children's Depression Inventory, *LOI* Leyton Obsessional Inventory-Children Version

Table 2 Differences in neuropsychological tests between Anorexia group and Control Group

	Anorexia nervosa $n = 37$ Mean (SD)	Control $n = 41$ Mean (SD)	U	p
LM1	40 (9.7)	39.6 (9.5)	738.5	0.841
LM2	26.1 (7.1)	26.7 (6.7)	742	0.869
Sum AVL	57.7 (7.1)	55.4 (7.1)	593	0.097
% AVL	91.2 (9.6)	90 (14.1)	754	0.963
VR1	93.7 (10.2)	97.1 (5.8)	645	0.255
VR2	74.3 (15.1)	71.1 (19.9)	653	0.291
Rey recall	21.2 (6.8)	24.1 (5.7)	569	0.058
Digit Span	12.9 (3.5)	14.9 (9.5)	679	0.424
Coding	72.1 (13.2)	73.6 (17.6)	649	0.273
RCFT time	190.6 (90.7)	130.6 (42.6)	414	0.001
Block design	47.4 (9.8)	51.66 (8.5)	565.5	0.053
Org. RCFT	3.7 (1.8)	4.4 (1.8)	575.5	0.059
Copy RCFT	34.8 (1.6)	34.9 (1.9)	674	0.358
TMT	35.2 (21)	31 (19.6)	660	0.324
Stroop	52.2 (10.3)	53.7 (10.9)	629.5	0.196
FAS	44.4 (12.1)	43.6 (14.3)	706.5	0.603
WCST-cat	5.7 (0.8)	5.7 (0.9)	749	0.857
WCST-errors	20.4 (15.7)	15.7 (9.9)	624.5	0.179
WCST-perserv	7.6 (11.5)	5.1 (6.5)	705.5	0.591

LM1 Logical Memory, immediate recall (WMS-III); *LM2* Logical Memory, delayed recall; *Sum AVL* Sum of 5 trials of Rey Auditory Verbal Learning test; *% AVL* Percentage of recalled words in delayed recall; *VR* Visual reproduction; *VR1* Visual reproduction, immediate recall (WMS-III); *VR2* Visual reproduction, delayed recall, *Rey recall* Rey Complex Figure test (RCFT), immediate recall, *RCFT time* seconds for copy of RCFT; *Org RCFT* Organisation of copy of RCFT; *TMT* Trail Making Test-B rest A; WCST; *Cat* Categories, *persev* perseverative responses

(BMI, T3 and cortisol) on one hand, and some variables of Rey's Figure (time of copy, recall and organisation) and block design on the other. The results showed significant correlations between time to copy Rey's Figure and scores on the Leyton Obsessive Inventory (LOI-CV) ($r = 0.463$, $p = 0.004$) and state anxiety on the STAIC ($r = 0.345$, $p = 0.042$). No other significant correlations were found.

Impaired and normal cognitive performers

An individual analysis of each cognitive profile revealed that more patients showed an impaired cognitive profile than control subjects. Following the criteria established in the methods section, 11 (30%) of the AN patients exhibited impaired cognitive performance, compared with only three (7%) control subjects ($\chi^2 = 6.634$, $p = 0.010$). Cognitive performance was normal in the rest of the patients ($n = 26$; 70%) and controls ($n = 39$; 93%).

To study the characteristics of patients with impaired performance, comparisons between the two groups of patients were made in all clinical variables (Table 3). The impaired cognitive performance group showed a greater percentage of difference with respect to normal BMI (%BMI) and a higher trait anxiety score. In the analysis of clinical variables, illness duration was slightly longer in the impaired cognitive performers, but the differences between the groups were not statistically significant. The groups were comparable in duration of illness, current age and age of onset. In the hormonal variables, the results were very similar and the differences were not statistically significant. In clinical questionnaire scores for depression, anxiety, obsessiveness and eating symptoms were slightly higher in the impaired group, but the differences were not significant.

Comparison between normal, impaired cognitive performers and control group

Neuropsychological performance was compared in these three groups (Table 4). The Kruskal–Wallis analysis showed that impaired cognitive performers did worse on visual memory tests (immediate recall of Visual Reproduction and RCFT), took more time to copy RCFT, and learned fewer words in the curve memory of Rey than the control and normal cognitive performer groups. Organisation of Rey's figure during copying also showed a clear

Table 3 Demographic and clinical differences between 2 groups of patients with Anorexia: impaired cognitive performers (2 or more tasks 2 SD lower than the average or lower than the intelligence level of the subject) and normal cognitive performers (1 or less)

	Impaired cognitive performers ($n = 11$) Mean (SD)	Normal cognitive performers ($n = 26$) Mean (SD)	*U*	*p*
Age (years)	15.7 (1.2)	15.3 (1.6)	130.5	0.682
Duration of AN (months)	15.8 (10.8)	12.1 (10.7)	109.5	0.270
Age of onset	14.0 (1.5)	13.9 (1.8)	141.5	0.961
%BMI	28.7 (6.1)	23.7 (5.9)	75	0.023
Cortisol (ηg/dL)	17.6 (1.9)	17.8 (4.6)	75	0.501
T3 (ng/mL)	0.69 (0.12)	0.79 (0.2)	64	0.438
CDI	17.4 (6.2)	15.9 (10.2)	115.5	0.366
STAIC-S	85.2 (10.2)	76.2 (28.7)	117.5	0.788
STAIC-T	76.1 (22.5)	48.4 (34.8)	65.6	0.028
LOI-severity	10.4 (3.5)	9.2 (3.4)	114.5	0.435
LOI-interference	10.6 (8.5)	8.7 (8.6)	110.5	0.359
EAT-40	51 (31.9)	42.7 (26.0)	113.5	0.517
Amenorrhea (months)	6.1 (4.2)	6.7 (6.5)	77.5	0.860

%BMI percentage of difference between presented BMI and the expected BMI for the age and sex of the subject; *T3* triiodothyronine; *CDI* Children Depression Scale; *STAIC* State-Trait Inventory for Children *CDI* Children's Depression Inventory; *LOI* Leyton Obsessional Inventory-Children Version; *EAT-40* Eating Attitudes Test

trend towards significance. Controls and normal performers presented similar results on all tests, with the exception of time in completion of copying the RCFT where all patients were slower than controls, and the Rey Auditory Verbal Learning Test where AN without impairment learned more words than controls and the impaired AN group.

Effects of pharmacological treatment and sex in cognitive performance

One of the inclusion criteria for the study was being in the acute stage of the illness. Eight (21.6%) patients who were taking medication were included because they fulfilled all diagnostic criteria for AN at the moment of assessment. Clinical variables were compared with the Mann–Whitney *U* test and, as expected, the subgroup with medication showed higher scores on depression (CDI Mann–Whitney $U = 35.0$; $p = 0.002$) and state anxiety (STAI-S: Mann–Whitney $U = 39.0$; $p = 0.013$). When comparing neuropsychological tests, none of the tasks reached statistical significance. When these comparisons were made between girls and boys with AN, no clinical, biological or neuropsychological variables presented statistical differences.

Table 4 Cognitive performance in both groups of anorexia patients (Impaired and Normal cognitive performers) vs Control group

	Impaired cognitive performers ($n = 11$)	Normal cognitive performers ($n = 26$)	Control Group ($n = 41$)	χ^2	*p*
VR1	87.6 (13.5)	96.3 (7.4)	97.1 (5.8)	6.211	0.045[a,c]
RCFT Recall	16.2 (7.2)	23.3 (5.5)	24.1 (5.7)	9.967	0.007[a,c]
RCFT time	184.9 (82.1)	193.0 (95.6)	130.6 (42.6)	11.991	0.002[b,c]
Org. RCFT	2.9 (2)	4 (1.6)	4.4 (1.8)	5.793	0.05[c]
Sum AVL	53.5 (6.5)	59.4 (6.8)	55.4 (7)	9.626	0.008[a,b]

VR1 Visual reproduction, immediate recall (WMS-III), *Rey recall* Rey Complex Figure test (RCFT), immediate recall, *RCFT time* seconds for copy of RCFT; *Org RCFT* Organisation of copy of RCFT; *Sum AVL* Sum of 5 trials of Rey Auditory Verbal Learning test

[a] Significance between Normal and Impaired cognitive performers ($p < 0.05$)

[b] Significance between Normal cognitive performers and Control group ($p < 0.05$)

[c] Significance between Impaired cognitive performers and Control group ($p < 0.05$)

Discussion

The first finding of this study is that underweight adolescents with AN differed from a healthy control group only on a speed processing task, possibly due to a higher level of obsessiveness and anxiety in execution. The main finding was that not all patients show the same cognitive profile. Thirty per cent showed cognitive impairment, with significant differences in visuo-spatial tasks such as visual memory. To our knowledge, this is the first study to analyse the cognitive performance of a highly homogeneous sample of adolescents with AN and the relationships between cognitive, clinical and biological variables.

Because sample heterogeneity is a possible cause of the conflicting results in the neuropsychology of AN, this study included only adolescents while underweight and without comorbidity in an acute stage of the illness. As a whole, the AN group showed worse performance than controls in time to copying a complex visuo-spatial test (Rey Figure). Other studies of AN adults have also reported alterations in speed processing when patients are underweight [6, 8]. This cognitive characteristic has been related with higher obsessiveness and anxiety scores, so it may be that AN patients are slower because they are more anxious and obsessive regarding details of the task.

As for the second aim of the study, the results corroborated our hypothesis that cognitive performance was not equal in all patients. Some studies with adults suggest that not all patients show the same cognitive profile [3–5, 8]. It may be that these patients show a continuum of deficits and that only some of them present a worse cognitive profile. To study a possible subgroup of patients with a worse cognitive performance, our sample was divided into two groups according to individual neuropsychological profiles. A third of our sample (30%) showed impaired cognitive performance following strict criteria for deficit (defined as scoring two standard deviations lower than the average or lower than their intelligence level on two tasks). Studies of patients with eating disorders have found similar percentages of affected patients following similar criteria (26% in [3]; 33% in [5]; 42% in [4]), but in those studies different eating disorder diagnoses were considered together and, moreover, patients were adults with a longer time of evolution. Our results show that adolescents present a similar proportion of impaired cognitive performers as adults. These 30% of patients performed worse in visuospatial tasks than the remaining patients and controls, and they showed higher trait anxiety and lower BMI, two clinical variables which have been related with poor neuropsychological performance [38] and worse clinical course in studies with adults. Follow-up studies in adolescents with AN have shown BMI at the start of treatment to be predictive of a poor short-term outcome [39] and after 6–11 years [40]. Neuropsychological performance may play a mediating role between BMI, anxiety and prognosis, but longitudinal studies are necessary to confirm this hypothesis. As in other studies [4], no significant statistical differences were found between the groups in terms of duration of illness, age of onset, hormonal parameters or other psychopathologic symptomatology. Nevertheless, qualitative analysis of the results showed that the impaired cognitive performance group scored slightly worse on clinical and biological measures, as indicated by questionnaires for depression, anxiety, eating, obsessiveness, duration of disorder, or T3. It is possible that the size of our sample is too small to detect slight differences between subgroups of patients in psychopathological or hormonal variables.

In relation to the other subgroup of patients (the 70% with a normal cognitive profile), their cognitive performance was worse than the control group only on time to copy RCFT. Moreover, this subgroup showed a better performance than the control group and impaired AN group in the curve of memory of RAVLT. This task consists in learning a series of 15 words and requires a considerable conscious effort. This finding is congruent with other studies [41] that have attributed the better performance and higher cerebral activation of AN patients in some cognitive tasks to an effortful and supervisory cognitive control during the performance.

The most important limitation of this study is the sample size, which complicates the study of subgroups. Some of the clinical and neuropsychological parameters that show only a trend towards differences between the groups may show statistically significant differences with bigger samples. Moreover, a longitudinal study of these patients is needed to examine the evolution of illness and the association between cognitive performance and the course of illness in adolescents with AN in parameters such as BMI or anxiety. Another limitation of this study is the selection of the tests, because not all of them are normalised for the ages of our participants. To minimise this error we worked with raw scores in the data analyses and selected an age-matched control group, but this is an aspect that must be improved on in future studies.

In summary, certain cognitive impairments such as slow processing speed are common to the majority of patients with AN. They may be due to the physiological effects of the low weight and the perfectionism and obsessiveness of these patients. Other impairments, such as visual memory deficits, were only present in a third of patients and were related with low BMI and higher trait anxiety. Longitudinal follow-up studies should assess whether this visual deficit may represent a more stable trait or whether it improves with longer time of treatment and total recovery of weight and clinical state.

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Conflict of interest None

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