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Article

Cognitive Failures in Women with Anorexia Nervosa Compared to the General Female Population

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Abstract

We focused on a comparison of cognitive failures in nine women with anorexia nervosa and nine women of the regular population. **Background/Objectives:** It primarily focuses on memory, attention, psychomotor tempo, and executive function in a group of women with a diagnosis of anorexia nervosa and a group of women in the general population without a diagnosis of anorexia nervosa or other psychiatric diagnosis. The following **methods** were used for research purposes: the Cognitive Failure Questionnaire (CFQ), the Trail Making Test (TMT), and a semi-structured interview subsequently processed into a case study. We observed a significantly negative impact of anorexia nervosa on the cognition of respondents. **Results:** Through the above objective methods, it detects the significantly negative impact of mental anorexia on the cognition of female respondents. The findings from the quantitative methods are verified through the qualitative part in the form of an interview, which is also consistent with previous findings. **Conclusions:** We also consider it important to carry out longitudinal studies that would allow us to monitor how cognitive functions change during treatment and recovery from anorexia nervosa.

Keywords: anorexia nervosa; cognitive failures; attention; general population

1. Introduction

There is no epidemiological study of the prevalence of ED in Slovakia yet. The most frequently diagnosed disorders of the aforementioned spectrum include anorexia nervosa, a serious psychiatric illness characterized by extreme food restriction, pathological fear of weight gain, and a distorted perception of one's own body [1]. AN is primarily studied in our country from the point of view of somatic consequences. Taking into account the fact that women with AN outnumber men with AN 10 to 1 [2], we decided to select exclusively female sex. Women diagnosed with AN show reduced cognitive flexibility, problems with selective attention, impaired ability to process information, and impaired memory [3]. In decades, the prevalence of ED in the global population has significantly increased [4]. ED affect more than 70 million people worldwide, with the global prevalence of ED increasing from 3.5% to 7.8% between 2000 and 2018 [5]. The reported cognitive impairments can significantly affect their daily functioning, including decision-making, education, and interpersonal relationships [6]. ED, or abnormal eating behavior and beliefs about food and body shape, are classified as a psychiatric or mental disorders [7]. It is a multifactorial disease that, in order to be successful, must be treated in a broader bio-psycho-social context [1]. Food has a various psychological and social meanings in people's lives [8]. The main aspects include low self-esteem, social or somatic problems, depending mainly on the way of controlling body weight [8]. Starvation triggers neurobiological changes, the temporary consequence of which is fatigue, but in the long term it causes a worsening of the symptoms of PPP [10,11]. Food intake is radically limited in patients, it can be accompanied by many rules [12]. The criteria for the specific psychopathology of ED include a disturbance in attitudes related to the body weight and shape, which are a source and an indicator of self-worth and mood for patients. Other criteria include amenorrhea, or the absence of at least three consecutive menstrual cycles [12,13]. Malnutrition also has a profound impact on psychological

health and cognitive functions [14–17]. Cognitive failures are minor errors in thinking that can occasionally occur in any individual during everyday life [18]. In recent years, more and more research has been devoted to possible cognitive deficits typical for AN [19]. (Attention is a fundamental cognitive function that allows individuals to focus on relevant stimuli and ignore distracting factors [20]. Patients with AN often exhibit a reduced ability to sustain attention, which is a consequence of physiological changes caused by malnutrition. These changes in the brain can impair the ability to concentrate, leading to more frequent task interruptions and reduced productivity [21]. Selective attention allows us to efficiently process information and perform everyday tasks [22–24]. Executive functions include higher cognitive processes such as planning, decision-making, inhibition of inappropriate responses, and flexibility of thought. In a general population, executive functions are crucial for effective learning, work, and daily functioning. Their development and strengthening contribute to better behavioral control, planning, and achieving personal and professional goals. Patients with AN often exhibit reduced cognitive flexibility, manifested by rigid thought patterns compared to the general population. Another common problem is impaired impulse inhibition [3]. Cognitive failures in patients with AN are manifested in various areas of daily life. One of them is forgetfulness, which is related to reduced attention and memory problems caused by malnutrition [14,25,26]. Patients with AN show impaired selective and sustained attention compared to the general population. Compared to the general population, patients with AN show excessive focus on specific stimuli, such as food, weight, or body appearance. The healthy population, on the other hand, shows more flexible cognitive processing, allowing adaptive adjustment of attention to different tasks and environments [27]. Sustaining attention in healthy individuals is less influenced by emotionally significant stimuli, which supports the effective management of everyday tasks. At the same time, it has been shown that rigid thought patterns and selective attention, characteristic of AN, may be a consequence of altered functioning of the attentional system [24]. Semi-structured interviews allow capturing the subjective experiences of patients, which provide a deeper understanding of their cognitive failures in the context of their illness [14,28,29].

Research objectives and research questions

In Slovakia, but also abroad, the impact on cognitive abilities is poorly understood. Based on our pilot study, we would like to find out: To identify differences in cognitive processes in women with AN and women from the general population. To achieve the research goal, we defined the main research question: "Is there a difference between the performance of cognitive functions in women with AN and women in the general population?" In order to clearly achieve the main and partial goals, we decided to incorporate partial research questions (PRQ) serving to detect key data.

PRQ1: *Are there statistically significant differences in the frequency of cognitive failures between the group of general women and the group of women with anorexia nervosa?*

PRQ2: *What is the effect size of differences in cognitive failures between the group of general women and the group of women with anorexia nervosa?*

PRQ3: *Which cognitive area (total score, memory, attention) shows the greatest difference between the group of general women and the group of women with anorexia nervosa?*

PRQ4: *Are there any differences in performance in the group of general women and the group of women with anorexia nervosa on the TMT-A (psychomotor pace and attention) section?*

PRQ5: *Do women with anorexia nervosa perform worse on the TMT-B (executive functions) section compared to general women?*

PRQ6: *Is there a difference in the efficiency of switching between simple and complex tasks (TMT-B/A ratio) between the group of general women and the group of women with anorexia nervosa?*

PRQ7: *Are there any differences in TMT performance between respondents with anorexia nervosa and a BMI below 18.5 and respondents with anorexia nervosa with a BMI in the normal range?*

2. Methods

2.1. Research File

The set consists of two groups consisting exclusively of adolescent and young adult women (N=18) aged 16 to 25 years. The condition for inclusion in the research was the age of 15 to 25 years. We focused on this age based on developmental characteristics related to cognition. The group with AN includes 9 female individuals diagnosed with AN, restrictive type, F50.0. The age range of the respondents, from 15 to 25 years, corresponds to the critical period for the occurrence of the disorder under the study. The sample of women with anorexia is very small because we focused on women who were no longer on pharmacological treatment and had been CBT therapy for three months. We excluded women with associated diagnoses from the sample because this would have led to skewed results. Anorexia was diagnosed in women based on ICD 10 by a doctor. All respondents were hospitalized in a psychiatric hospital, none had been there for longer than 6 months. The group of women from the general population consists of 9 healthy women (general population) who do not have a history of or any other psychiatric diagnosis. This study aims to compare cognitive processes in women with AN with those in women from the general population. We selected the research set using the method of purposive selection, taking into the account several aspects for example age, social status. Data collection was analyzed from May to August 2025. The selection process focused on ethical aspects of the research, including informed consent and the protection of participants' personal data. The aim is to ensure relevant and comparable data that will enable valid and reliable answers to the research questions set out in this work (Table 1 and 2).

2.2. Materials and Apparatus

Given the research problem and goal, we decided to implement a qualitative-quantitative methodology consisting of the Cognitive Failures Questionnaire (CFQ), the Trail Making Test (TMT), and a semi-structured interview in order to gain a deeper understanding of the introspective data. Subsequently, we processed the respondents' stories through case studies.

Cognitive Failures Questionnaire (CFQ)

The Cognitive Failures Questionnaire (CFQ), developed by Broadbent, Cooper, FitzGerald, and Parkes in 1982 - the questionnaire contains 25 items, to which respondents respond on a scale from "never" to "very often" according to how often they experience the situations stated in the statements. We determined the value of Cronbach's alpha which reached a value of 0.85, indicating high internal consistency of the instrument. The questionnaire was translated by 2 translators and then re-translated into English. The psychological aspect was checked by 2 psychologists.

Trail Making Test (TMT)

The Trail Making Test (TMT) is a neuropsychological test aimed to measure multiple aspects of cognitive functions. It consists of two parts: TMT-A and TMT-B. The task of the respondent in the TMT-A part is to connect the numbers on the presented paper in order from 1 to the highest number with a straight line without error in the shortest possible time. In the second part of the TMT-B, the task is to connect the numbers and letters. Start with the number 1, connect with the letter A, then the number 2, the letter B and so on. The output of the test is two values, or times in seconds [30]. The TMT test is standardized to Slovak population. The results are compared with tables that provide normative values (percentiles) for different age groups to determine whether performance is normal or pathological.

Semi-structured interview

Semi-structured interviews are a qualitative method that allows for in-depth exploration of the subjective experiences of respondents. The interviews were conducted according to a pre-prepared list of topics, with an emphasis on flexibility and adaptation to the respondents' responses [31]. Key topics of our interviews:

1. Subjective perception of cognitive failures.

2. The impact of cognitive problems on everyday functioning (work, studies, relationships).
3. In the case of patients with AN, comparison of the current state with the state before the onset of AN.

Case study

A case study is a detailed analysis of an individual case in the context of applied expertise, where the emphasis is on elucidating broader principles or rules [32].

2.3. Procedure

In order to monitor cognitive failures in the respondents' daily activities, we selected the CFQ questionnaire translated from English to Slovak and then back-translated. We collected the questionnaires using the pen and paper method. In order to monitor attention and executive functions, we chose the TMT test. We supplemented the results with semi-structured interviews, which we subsequently processed into case reports.

2.4. Qualitative Research Analysis

Case study no. 1

- Name: RM
- Gender: female
- Age: 21 years old
- Residence: Priekopa
- Classification: first-year university student, abroad – Europe
- Research group: group with anorexia nervosa
- BMI: <18.5

Personal history: She attended an ordinary kindergarten, where her mother worked as a teacher, she was more tearful, she had no problems after starting elementary school. Later she attended grammar school for eight years with remarkable grades with an average grade of 1. During her studies at grammar school she devoted herself to professional gymnastics, later mainly to dancing. Her relationship to the aforementioned sports disciplines is described as positively interesting. She is currently studying international law in the Netherlands, she has adapted well, she is happy there, but she always looks forward to being home with her family and friends. Her current hobbies include reading books and various types of sport. Currently, she has positive ties with her friends without the presence of significant difficulties, but she admits that around the age of 18 she had a tendency to react impulsively.

Medical history: From the first pregnancy, without complications, natural birth, postpartum adaptation went well. Psychomotor development was normal. She overcame common childhood illnesses, surgeries: 0, injuries: 0, unconsciousness: 0, hospitalizations: 0, cardiology: murmur, gastroenterologist: abdominal pain in diff. dg., wheat allergy. She has been menstruating since the age of 13, at the age of 18 secondary amenorrhea for about a year, menstruation resumed with the help of gynecologically prescribed pharmacological treatment. Around the age of 18 she also had sleep problems, treatment with melatonin. At the beginning of 2020 she overcame covid-19 with a more severe course in terms of respiratory problems. In March 2020, she was diagnosed by a child psychiatrist with a non-specific eating disorder of the restrictive type. Due to the progression and clinical picture, she was diagnosed with F50.0 in June the same year.

Family history: RM comes from a dysfunctional environment, her biological parents separated when RM was 2.5 years old. RM lived with her mother, she was meeting her father, they had a good relationship, she always cried when saying goodbye. RM and her mother moved three times. Both parents started new families, RM tolerated both stepparents. She remembers problems in her relationship with her parents during adolescence, just before the onset of anorexia. Her mother is 45 years old, she was treated for psychogenic loss of appetite in childhood, currently healthy, she got a masters from university, she works as a kindergarten teacher. She is involved in various sports, such

as hiking and cycling. She has a favorable somatic condition. Her father is 48 years old, physically healthy, a university-educated businessman. In winter, he likes to go skiing, during the summer he likes to dive and try various extreme sports such as windsurfing. Like his mother, he has a favorable psychological state with a tendency to impulsive reactions. The relationship with his parents is described as neutral. The incidence of psychopathology in the family is negative. No siblings.

Course of the disease: The first symptoms of the disease appeared in the context of high expectations and pressure for perfection from childhood. The environment was performance-oriented, both in the fields of education, sports and the arts, while constant comparisons and feelings of inadequacy led to a distorted self-image. The idea of controlling one's own body and diet became an escape from emotional stress and a source of a false sense of success. Key triggers of the disease include a sense of failure and failure to meet parental expectations, the need for control in a world where everything else seemed uncontrollable, and self-punishment through food restriction.

With the gradual weight loss, physical and psychological consequences appeared, and the disease gradually took control of her life. The physical manifestations of RM included rapid weight loss, critical loss of muscle mass and subcutaneous fat, hair loss, cold fingertips and pale skin. The psychological consequences of the respondent included constant anxiety about food, remorse and self-hatred after eating, the development of depressive episodes and self-harm, social isolation and disruption of interpersonal relationships. Cognitive problems during the illness included the inability to concentrate on any activity that was not related to food, frequent forgetfulness, problems with planning the day, RM describes that everything happened only around food and exercise. She describes problems with coordinating her own body in space, crashing into door frames, objects falling from her hands, etc.

After being diagnosed with AN, the patient's condition was critical, and treatment required a comprehensive approach consisting pharmacological treatment, psychotherapy, nutritional therapy, support groups, and educational program in the organization named "Chuť žít" based in Slovakia.

She describes the treatment as a slow and difficult process full of challenges, where improvements alternated with falls. At first, it was difficult for RM to accept help and overcome distrust of the people around her. Gradually, however, she began to perceive support as essential for returning to life. Thanks to the help of professionals and the support of loved ones, the respondent gradually found the will to live and regained self-esteem.

Current status: RM currently weighs 47kg at a height of 160cm (BMI = 18.4 kg/m²). RM is currently studying abroad, dedicating herself to her studies. She has established friendly relationships. She continues to use the psychotherapy service in the online space. Relapse is negatively debatable. From a cognitive point of view, RM currently does not describe any significantly limiting phenomena, but she admits that she has "blur" memories of the most critical period of AN and cannot place it in time. She only remembers about two years very "vaguely".

Case study no. 2

- Name: AMT
- Gender: female
- Age: 16 years old
- Residence: Bystrička
- Classification: high school student
- Research group: group with anorexia nervosa
- BMI: within normal range

Personal history: She attended an ordinary kindergarten and elementary school in Prague. At the turn of the 2020/2021 school year, she moved to Martin with her family. Firstly, they lived at her grandmother's place, then they moved to their own house, where they currently live. She describes the adaptation from Czech Republic to Slovakia as difficult; when she arrived, she felt like an attraction because she was Czech. She also remembers the quarantine due to the COVID-19 pandemic, during which she also gained weight, and she perceives all of this as a turning point when "everything started to fall apart." Gradually, the symptoms of ED began to manifest. She began to

deal with her appearance, exercise, and food intake a lot. She is currently studying at high school - Business Academy, Martin, dual class.

Medical history: AMT is from the first pregnancy that went well. Psychomotor development was adequate. During the preschool period, she overcame ordinary childhood illnesses. Operations: 0, injuries: 0, unconsciousness: 0, hospitalizations: 1 – Psychiatric Clinic of the Faculty of Medicine, Charles University and Martin University Medical School. She has been menstruating since the age of 12. At the age of 15, she was diagnosed with AN, F50.0. Struggling with anemia due to diabetes. Secondary amenorrhea for four months, later irregularly, the last 3 months regularly.

Family history: She grew up in a complete family. At first, she describes the environment as positive, then her father began to behave aggressively, she went to bed crying every day. Her father was nervous and "took it out" on her, at that time she was still an only child, her mother just watched, did nothing about it. Then she got used to it, sometimes it was better, sometimes worse. At that time, she didn't take it badly, she didn't know that it should be different, she describes that she was satisfied. She experienced bullying at school, so she still felt safer at home, because her parents were interested in her despite everything. When they moved to Martin, things started to deteriorate rapidly, especially her relationship with her father, when he had nothing to reproach her with, he started telling her to lose weight, to eat less. Currently, her father doesn't really care about her appearance, the client said: "sometimes he makes some stupid remark, but he probably does not do it on purpose." Recalling the worst period of AN, she talks about a situation when she was crying in her room and her father came in, asking annoyingly what was going on again, AMT finally answered and he started to reproach her that she was just spoiled, that she shouldn't eat when she cries like that, that it was her fault. She says that her father first supported her to exercise and lose weight, then on the other hand, when he found her exercising at two in the morning, he started screaming. Her father only became a little aware of the problem when she was hospitalized. He only stopped dealing with it when she lost too much weight, and when she exercised excessively, he praised her.

Course of the disease: She had felt that she was so much bigger all her life, but the symptoms of the disease began at the beginning of the quarantine. They were also moving at that time. It started with an urge, or a voice in her head that told her to burn as many calories as possible, so that she would not be fat, and to eat less. She was hospitalized in the acute department of the children's psychiatric clinic in Martin, she sees a psychologist and uses nutritional therapy and a peer support program within the organization *Chuf' žit'*. In terms of pharmacological treatment, she was taking quetiapine, sertraline. She perceives the disease as affecting absolutely all aspects of life. She was unable to concentrate on ordinary things because she only thought about food and losing weight. Negative thoughts prevented her from doing everything. Since the beginning of AN, she observed changes in cognition, especially in terms of memory, she forgot about doctor's examinations, went from one room to another to take something and forgot what. She felt useless, her surroundings and friends at school told her so. The worst was before the hospitalization, when she was at her lowest weight. Then things like banging on doors and dropping everything would happen, except of being forgetful. Then it gradually started to ease after she returned from the hospitalization. She started to notice a more significant improvement in her attention over the past year, only a few months after she gained a healthy weight. Asking about the connection between food intake and cognition, she replied that it was definitely related, but at its worst, it didn't seem to bother her, even though things like the ones mentioned above were happening (e.g., difficulty getting through doors). Gradually, as she started to gain weight, she began to realize it. It was happening during the admissions period for the high school she wanted to go to. She found out that she was unable to do anything, prepare, study, the only thing she could focus on was losing as much weight as possible and eating little. She felt like she had to choose whether she wanted to go to high school or lose weight, and that was when things got a little better. She started eating more. At first, her problems with coordinating her own body subsided, her memory and attention only started to improve a few months after reaching a healthy weight, but she still has difficulty concentrating, for example at school, and thoughts about food persist. She forgets things now and then, but it is not as extreme anymore.

Current status: AMT is currently 173cm tall, she does not know her weight, nor does she want to know, but the doctor assesses his weight as normal. She perceives a big shift in treatment, including the cognitive aspect. Despite this, hse is often unable to fully concentrate on everyday things.

Case study no. 3

- Name: KK
- Gender: female
- Age: 21 years old
- Residence: Martin
- Classification: college student
- Research group: general population
- BMI: within normal range

Personal history: She currently lives in Prague, where she is studying biochemistry at university. She has built strong relationships with a few close friends and has been in a relationship for two years.

Medical history: KK is from the first pregnancy, which was normal. After giving birth, she underwent surgery due to a misplaced ovary. Psychomotor development was adequate. During her preschool years, she overcame common childhood illnesses. Surgeries: 5, injuries: 4x - broken ankle, broken thumb, broken clavicle and the following knee injuries, unconsciousness: 0, hospitalizations: 6 - dehydration, tonsil removal, three knee arthroscopies, one knee plastic surgery. She regularly visits a cardiologist for a genetically determined heart disease in the family. She has no allergies. She has had her period since the age of 13, always regularly. She does not take any medication. She overcame COVID-19 without serious problems or respiratory difficulties. Her mother is 43 years old, no diagnosed physical or mental illnesses, she works as a railway power manager in her place of residence. Respondent's father died in 2019 at the age of 48 from cardiac arrest while cycling down the Křačianská Magura. He had had long-term high blood pressure and a physiologically small heart chamber.

Family history: KK grew up in a complete family, comes from a harmonious, functional environment, had everything she needed. She has a sister who is a year and a half younger than her, with whom they have had a very good relationship from the beginning, they always had friends in common, the same interests, etc. At the age of 10, another sibling was born to, whom she did not want. At the time of the birth of her younger brother, her relationship with her mother deteriorated. She describes her relationship with her father, who died when KK was 16, very positively. Her relationship with her mother deteriorated again during that period. When she started college, KK moved to Prague, which had a positive impact on her relationship with her mother. They are currently very close and their communication has improved. Now, she tries to be like a "big sister" to her brother, taking him on trips, trying to spend time with him.

Current status: The respondent is 158 cm tall and does not know her weight, she does not weigh herself, last time at the doctor she weighed 55 kg. She is doing well. She does not feel anything significantly negative, nothing that would limit her in any way in her life. She does not subjectively describe any difficulties in the area of cognitive functions. What she is not sure she will remember, she writes down, for example, a shopping list.

3. Results

Quantitative Analysis of the Results of the Cognitive Failure Questionnaire (CFQ)

The CFQ questionnaire was used to assess the frequency of cognitive failures in two groups – a general population and population with AN.

The total score (max. 100 points) was on average higher in the group with AN (75.77 points) compared to the general population (55.11 points). The highest score in the general population was 73 (VAV, KK), while in the group with AN reached up to 93 points. The difference in the mean values (20.66 points) indicates a greater incidence of cognitive failures in the group with AN. In the memory

category (max. 40 points), the general population reached an average score of 19.33, with the highest score of 23 (multiple respondents) and the lowest score of 13 (TMV). In the group with AN the average score was higher (25.11 points), with the respondent NS reaching up to 32 points and the lowest score of 18 (NP). The difference of 5.78 points between the means indicates more frequent problems with remembering or forgetfulness in the group with AN. In the category of attention (max. 40 points), a higher average value was again found in the group with AN (26.88 points) compared to the general population (17.88 points). The highest score in the general population was 29 (VAV), while in the group with AN it was up to 34 (AMT). The difference of 9 points indicates more significant problems with maintaining attention or frequent distraction in respondents with AN. Overall findings show that the group with anorexia nervosa shows higher scores in all areas studied, which signals greater problems with cognitive failures. The most significant difference was identified in the attention category. The variability of scores in the general population was higher, suggesting a more heterogeneous distribution of cognitive abilities in this group compared to the group with AN.

Table 3 provides an overview of the Cognitive Failures Questionnaire (CFQ) results for a healthy group from the general population. The data are divided into three categories: Total score (maximum 100 points), Memory score (maximum 40 points), and Attention score (maximum 40 points). The table lists the initials of the respondents along with their respective scores in each category, thus providing the data necessary for the analysis of cognitive function within this group.

Table 4 shows the results of the Cognitive Failures Questionnaire (CFQ) for a group of respondents belonging to the anorexic population. As in the previous table, the data are broken down into categories: Total score, Memory score, and Attention score. Each row contains the initials of the respondents and their achieved score, allowing for a comparison of performance between the general and anorexic populations within these cognitive domains.

Inferential Statistical Tests

For group comparisons, we used the independent samples U-test to compare means between populations, which revealed statistically significant differences in all categories. We also used the Mann-Whitney U-test to examine the small sample size.

The results of the Mann-Whitney U test confirmed statistically significant differences between the two study groups in all areas studied. In the total score category, the U value was 11.5 with a p-value of 0.011, indicating that the group with AN achieved a significantly higher score compared to the general population. Similarly, in the memory category, the U value was 14.0 and a p-value of 0.021, indicating a statistically significant difference in favor of the group with AN. The most significant difference was observed in the attention category, where the U value was 9.0 and a p-value of 0.006, indicating the largest differences between the groups (Table 5). The group with AN showed significantly higher scores in all three categories, with the largest difference being recorded in the attention domain. The findings indicate statistically significant differences in cognitive domains between the study groups.

Effect Size

Differences between populations were quantified using Cohen's d (values above 0.8 indicate a large effect), which showed a large effect in all categories studied. The values of all examined categories significantly exceed the threshold of 0.8, and therefore the question (PQ2) we can answer that there are very large differences between the groups. The largest difference was recorded in the attention category ($d=1.65$), while the lowest, but also significant, was in the memory category ($d=1.29$). The total score reached a value of $d=1.61$, indicating a very high effect and a significant impact of the factors studied. In the area of memory, an effect of $d=1.29$ was recorded, representing a high impact on memory-related abilities. The most significant effect was observed in the area of attention with a value of $d=1.65$, indicating an extremely strong impact. The results highlight the

significance of changes or interventions in individual areas and point to their practical impact (Table 6).

Quantitative Analysis of Trail Making Test (TMT) Results

In the following chapter, we present the results obtained from the Trail Making Test (TMT), conducted on two groups of participants: healthy women (general population) and women diagnosed with AN, who were subsequently divided according to BMI. Then the results were analyzed and compared. The results provide an overview of the respondents' individual performance on each task and their ability to switch between simple and complex mental processes.

Table 1. Individual performance of respondents in each task.

Respondent	Group	BMI	TMT-A (s)	TMT-B (s)	B/A ratio
KK	general	18.5-25	29.3	60.07	2,050
VAV	general	18.5-25	26.35	39.07	1,482
EN	general	18.5-25	48.21	70.09	1,453
VO	general	18.5-25	34.96	48.8	1,395
TMV	general	18.5-25	27.45	49.34	1,797
RM	Anorexic	<18.5	45.1	71.48	1,584
MG	Anorexic	<18.5	47.9	86.64	1,808
LP	Anorexic	18.5-25	73.32	60.44	0.824
AMT	Anorexic	18.5-25	20.36	38.62	1,896
NP	Anorexic	<18.5	37.12	82.48	2,221

According to the results of the TMT, the best performance in the TMT-A part was achieved by respondent AMT from the group with AN, who completed the task in 20.36 seconds, which indicates excellent visual-motor coordination and the ability to maintain attention. On the contrary, the worst performance in this part of the test was achieved by respondent LP from the same group with a time of 73.32 seconds, which indicates a significant weakening of basic cognitive functions. In the TMT-B part, the best performance was achieved by respondent VAV from the general group with a time of 39.07 seconds, which reflects high cognitive flexibility and the ability to adapt to complex tasks. The slowest time in this part of the test was achieved by respondent MG from the group with AN (86.64 seconds), which indicates problems with cognitive switching. The TMT-B/A ratio was the lowest in respondent LP (0.824), which may, however, be a consequence of the very poor performance on TMT-A. The highest ratio (2.221) was achieved by the NP respondent from the group with AN, indicating significantly impaired efficiency in switching between simple and complex tasks. The results show significant differences between respondents not only between groups, but also within individual groups, highlighting individual variability in cognitive performance. The highest ratio (2.221) was achieved by the NP respondent from the group with AN, indicating significantly impaired efficiency in switching between simple and complex tasks. The results show significant differences between respondents not only between groups, but also within individual groups, highlighting individual variability in cognitive performance (Table 7).

According to (PQ4) and (PQ5), the mean values of the Trail Making Test (TMT) showed differences between the general group and the group with AN. In the TMT-A part, which measures the ability to concentrate on simple tasks and psychomotor speed, the general group achieved a mean time of 33.25 seconds, while the group with AN showed a significantly longer time of 44.76 seconds. This difference indicates impaired psychomotor speed and reduced attention in patients with AN. In the TMT-B part, which tests executive functions, the mean value in the general group was 53.47 seconds, while the group with AN achieved a time of 67.93 seconds. Although the differences are not significant, they suggest subtle cognitive deficits associated with AN. TMT-B/A is an important indicator in neuropsychological research because it provides information about cognitive flexibility and the efficiency of processing complex tasks. By comparing the time spent on a more complex task (TMT-B) with a simpler one (TMT-A), this ratio allows us to identify how well an individual is able

to adapt their mental processes to increased difficulty. A higher ratio usually indicates greater difficulty in switching between simple and complex tasks, while a lower ratio indicates smoother processing. TMT-B/A ratio was similar in both groups (general: 1.6354, anorexic: 1.6666), indicating a relatively consistent difference between simple and complex tasks. However, the higher ratio in the group with AN may indicate a slightly reduced efficiency in processing complex tasks. The results support the conclusion that AN negatively affects attention and executive functions. The TMT-B/A ratio between the general group and group with AN was slightly higher in the group with AN (1.6666) compared to the general group (1.6354). This ratio reflects the efficiency of the transition from simple tasks (TMT-A) to more complex tasks (TMT-B). In relation to (PQ6), the higher ratio in the group with AN indicates slightly greater difficulties in processing more complex tasks compared to the general group. Despite the difference, the results of the statistical analysis (Mann-Whitney U-test) showed that the differences were not statistically significant (p -value = 0.548). It is not possible to say with certainty that the difference in the TMT-B/A ratio between the groups is directly related to differences in cognitive abilities. It may be due to natural variability or small sample size. Although this difference is not significant, the higher ratio in the group with AN indicates a greater time lag between the simple and the more complex task, indicating greater mental effort required to process complex stimuli (Table 8).

Responding to (PQ7) respondents with a BMI below 18.5 performed worse in all categories compared to respondents with a normal BMI. The average time in the TMT-A section, which assesses psychomotor speed and ability to maintain attention, was 43.37 seconds for respondents with a BMI below 18.5, which is slower performance than for respondents with a normal BMI (37.14 seconds). These results indicate impaired psychomotor speed and reduced ability to concentrate in the low BMI group.

In the TMT-B section, which assesses executive function and cognitive flexibility, the average time of respondents with a BMI below 18.5 ranged from 80.20 seconds, a worse performance compared to the group with a normal BMI (52.35 seconds). This difference indicates a significant weakening of executive function and greater mental effort when processing complex tasks in respondents with a low BMI (Table 9). The TMT-B/A ratio, which reflects the efficiency of switching between simple and complex tasks, was 1.87 in respondents with a BMI below 18.5, a worse result compared to respondents with a normal BMI (1.56). A higher ratio indicates greater difficulty adapting to more complex tasks and reduced efficiency of mental processing in respondents with a low BMI. Respondents from the general group (BMI 18.5–25) showed stable performances in both TMT-A and TMT-B. In TMT-A, the results ranged from $-2.36SD$ – $-2.36SD$ (SK) to $-0.23SD$ – $-0.23SD$ (VAV), with most respondents achieving slightly below-average values. The best performance was achieved by VAV, while SK showed the worst performance in this group. In TMT-B, the results were more consistent, ranging from $-0.49SD$ – $-0.49SD$ (KK) to $0.44SD$ – $0.44SD$ (VAV). The best results were achieved by VAV and VO respondents ($0.39SD$, $0.39SD$), with the general group generally achieving values close to the norm. The group with AN showed greater variability in results, with their distribution corresponding to BMI categories. In the subgroup with a BMI below 18.5, TMT-A results were predominantly below average, ranging from $-1.28SD$ – $-1.28SD$ (NP) to $-3.15SD$ – $-3.15SD$ (MG). MG showed the worst performance, indicating a significant impairment of psychomotor speed. In TMT-B, results ranged from $-0.86SD$ – $-0.86SD$ (NP) to $-1.64SD$ – $-1.64SD$ (MG), with no respondent from this subgroup achieving values close to the norm. In the subgroup of respondents with AN and BMI in the normal range (18.5–25), the results differed significantly. The AMT respondent achieved above-average values in both tests ($0.47SD$ – $0.47SD$ in TMT-A and $0.76SD$ – $0.76SD$ in TMT-B), while the LP showed extreme impairments in both tests ($-4.81SD$ – $-4.81SD$ in TMT-A and $-1.185SD$ – $-1.185SD$ in TMT-B). When comparing the results between the groups, it is obvious that the general group shows stable results in both tests and most respondents achieve values close to the norm. On the contrary, the group with AN shows significant impairments, especially in TMT-A, where the results are significantly below the average. Respondents with a BMI below 18.5 show more pronounced negative deviations (lower SD values) in both TMT-A and TMT-B, indicating worse performance compared to

the norm. Healthy respondents (general group) show mixed results, with most achieving values close to the norm or slightly negative deviations. The most striking differences are observed in the LP respondent, who achieved extremely negative values for both TMT-A and TMT-B (Table 9).

Table 2. Research set - general population.

Respondents – healthy group									
Characteristics	KK	EN	VAV	TMV	NN	E.S.	VS	RS	VO
Age	21	18	18	21	20	20	25	24	21
Inclusion	University	Secondary school	Secondary school	University	University	University	University	University	University
Diagnosis	-	-	-	-	-	-	-	-	-
BMI status	18.5-25	18.5-25	18.5-25	18.5-25	18.5-25	18.5-25	18.5-25	18.5-25	18.5-25

Table 1. Research set – anorexic population.

Respondents – anorexic group									
Characteristics	RM	MG	AU	LP	NP	NS	AMT	BP	AD
Age	21	17	18	18	18	16	16	23	19
Inclusion	University	Secondary school	Secondary school	Secondary school	Secondary school	Secondary school	Secondary school	businesswoman	Secondary school
Diagnosis	F 50.0	F 50.0	F 50.0	F 50.0	F 50.0	F 50.0	F 50.0	F 50.0	F 50.0
Current status	Stabilized, after active treatment	Stabilized, after active treatment	Stabilized, after active treatment	Stabilized, after active treatment	Stabilized, after active treatment	Stabilized, after active treatment	Stabilized, after active treatment	Stabilized, after active treatment	Stabilized, after active treatment
BMI status	<18.5	<18.5	18.5-25	18.5-25	<18.5	18.5-25	18.5-25	18.5-25	18.5-25

Table 4. CFQ questionnaire – general population.

CFQ questionnaire – general population			
initials	Total score (100)	Memory (40)	Attention (40)
VAV	73	23	29
KK	73	23	24
EN	63	23	20
TMV	36	13	12
NN	62	22	20
VO	50	21	13
E.S.	45	17	11
VS	53	18	19
RS	41	14	13

Table 5. CFQ questionnaire – anorexic population.

CFQ questionnaire – anorexic population			
initials	Total score (100)	Memory (40)	Attention (40)
RM	79	25	28
AU	84	29	31
MG	79	26	26
LP	66	19	25
AD	61	22	21
NP	62	18	22
NS	93	32	32
AMT	91	31	34
BP	67	24	23

Table 6. At ap values.

Total score	U = 11.5	p = 0.011
Memory	U = 14.0	p = 0.021

Attention	U = 9.0	p = 0.006
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Table 7. Effect size.

Total score	d=1.61
Memory	d=1.29
Attention	d=1.65

Table 7. Average performance of respondents for individual parts of the test.

Group	TMT-A diameter (s)	TMT-B diameter (s)	TMT-B/A ratio
Anorectic population	44.76	67,932	1,667
general population	33,254	53,474	1,635

Table 8. Comparison of results of respondents with BMI below 18.5 and BMI within the normal range.

Group	TMT-A (s)	TMT-B (s)	TMT-B/A
BMI between 18.5-25	37.13	52.34	1.55
BMI <18.5	43.37	80.2	1.87

Table 9. Interpretation of standard deviation results for TMT-A,B.

Respondent.	Group	BMI	TMT-A (s)	TMT-B (s)
KK	General	18.5-25	-0.78SD	-0.49SD
VAV	General	18.5-25	-0.23SD	0.44SD
EN	General	18.5-25	-2.36SD	-0.48SD
VO	General	18.5-25	-1.72SD	0.39SD
TMV	General	18.5-25	-0.53SD	0.34SD
RM	Anorexic	<18.5	-1.99SD	-0.82SD
MG	Anorexic	<18.5	-3.15SD	-1.64SD
LP	Anorexic	18.5-25	-4.81SD	-1.185SD
AMT	Anorexic	18.5-25	0.47SD	0.76SD
NP	Anorexic	<18.5	-1.28SD	-0.86SD

4. Discussion

4.1. Interpretation of Results

Within the framework of partial research question (PRQ1) focused on the existence of statistically significant differences in the frequency of cognitive failures between the general population and population with AN, we based ourselves on the findings of previously conducted research studies [14,24], which demonstrated a deterioration in memory functions in women with AN. Long-term malnutrition has a negative impact on memory abilities and attention, which increases the frequency of everyday cognitive failures. The results of our research showed statistically significant differences in the frequency of cognitive failures between the population with AN and general population, which is consistent with previous findings [15].

In the framework of partial research question (PRQ2) focused on the effect size of differences in cognitive failures between general population and population with AN, we found that the population with AN showed, on average, higher scores in the CFQ questionnaire compared to the general population. This difference is significant and in line with previous research that individuals with ED are more prone to cognitive errors due to reduced executive functions [18]. The reason may be the lack of zinc, which plays a key role in brain functions, long-term malnutrition weakens the intestinal absorption of zinc, thereby further exacerbating its deficiency. This is the most common deficiency in terms of trace elements [15]. Vitamin B1 (thiamine) deficiency can affect psychomotor skills, which can lead to impaired coordination and reaction time. The greatest differences were observed in the area of attention, which supports the hypothesis that patients with anorexia nervosa tend to fixate on

certain thought patterns [27]. Increased selective attention to food stimuli is a central feature of hunger and its underlying psychological component, leading to cognitive failure.

Within the framework of partial research question (PRQ3) aimed at determining which cognitive area (total score, memory, attention) shows the greatest difference between the general population and population with AN, we observed the greatest difference in the area of attention between the average values of the groups. Our results are in line with the previous study, which confirms that patients with AN have an impaired ability to maintain attention on common everyday tasks, while their thinking is dominantly oriented towards issues related to body appearance and nutrition [33]. Respondent RM subjectively reported the following difficulties during an anorexic state: inability to concentrate on any activity that was not related to food, frequent forgetfulness, problems with planning the day, but also problems with coordinating one's own body in space, crashing into door frames, objects falling from hands, etc. Relapse is negatively debatable. The respondent AMT saw in the interview that negative thoughts actually prevented her from all normal activities, she could only think about food and losing weight. Since the beginning of AN, she had observed changes in cognition, mainly in terms of memory, she forgot about medical examinations, went from one room to another to take something and forgot what, she could not concentrate at school. It was very exhausting for her, she felt useless, and her surroundings and friends at school told her so. It was the worst before hospitalization, when she was at her lowest weight. Then things like banging on doors, dropping everything, and not just forgetting things, happened. Then it gradually began to ease after she returned from hospitalization. She began to notice a more significant improvement in attention over the past year, only a few months after she gained a healthy weight. When asked what she thinks about the connection between food intake and cognition, she answers that it is definitely related, but at worst she doesn't seem to mind, even though things like the ones mentioned above were happening (e.g., difficulty getting through doors). Gradually, as she started to gain weight, she began to realize it, she describes that at that time she began to perceive other things than just weight loss, she felt completely useless, her friends also told her this, it was during the admission period for the high school she wanted to go to. In terms of treatment, respondent AMT perceives a big shift, including the cognitive aspect. Despite this, she is often unable to fully concentrate on ordinary things. Respondent KK from the general group of women does not subjectively describe any difficulties in the area of cognitive functions. What she is not sure she will remember, she writes down, for example, a shopping list. She does not feel anything significantly negative that would limit her in life.

As part of partial research question (PRQ4) on the existence of differences in performance between general population and population with AN in the TMT-A section, examining psychomotor speed and attention, we found that the general group was able to process the findings faster. The difference between the groups is statistically significant and demonstrates a weakening of psychomotor speed and attention. The results correlate with the previous research, which draws attention to the weakening of cognitive abilities due to a long-term energy deficit, which occurs when the body does not consume enough calories to cover its metabolic needs [21]. In AN, this is often a chronic and very severe deficit, which has a direct impact on brain function, which subsequently leads to failure in terms of various aspects of cognition. Body stores of micronutrients decrease during the phase of chronic malnutrition in patients with AN, but the deficiency may remain asymptomatic during this phase, and the need for micronutrients remains limited due to physiological adaptation to the long-term state of restriction. According to findings the aforementioned deficiencies begin to manifest themselves mainly during the period of renutrition due to increased metabolic needs, which can explain the persistent cognitive failures in our respondents [34].

Within the framework of partial research question (PRQ5) aimed at identifying differences in performance in the TMT-B part, examining executive functions in women with anorexia nervosa compared to general women, we came to the results confirming rigid thinking and lower flexibility in information processing in women with AN. In the TMT-B part, the group with AN needed a longer time to perform the task. The measured difference points to weakened executive functions, which is

in line with the previous study, which demonstrated a higher rate of perseverative errors in patients with AN [24]. We assume that the weakening of executive functions in individuals with AN is the result of a complex interaction of neurobiological changes, metabolic deficits and rigid thinking. Impaired executive functions subsequently result in difficulties in managing everyday tasks and decision-making, which can lead to impaired functioning in social and academic environments.

Within the framework of partial research question no. 6 (PRQ6) oriented to the difference in the efficiency of switching between simple and complex tasks (TMT-B/A ratio) between the general group and group with AN, we noted a slightly higher ratio in the group with AN compared to the general group, which indicates a slightly weakened ability to switch between tasks, which indicates weakened cognitive flexibility. The difference was not statistically significant, but the results are in line with the previous research, which indicates rigidity of thinking and lower adaptability in patients with AN [25]. We believe that AN leads to rigidity of thinking, which makes switching between tasks more difficult. Long-term malnutrition negatively affects the function of the prefrontal cortex, which controls executive functions, including cognitive flexibility and the ability to switch between tasks effectively [21]. In addition to biological factors, perfectionism and anxious behavior, which lead to performance slowdown and error avoidance, may also contribute to impaired adaptability. As a result of the aforementioned mechanisms, individuals with AN show increased mental effort when solving complex tasks, which may negatively affect their daily functioning.

Within the framework of partial research question (PRQ7), we focused on the existence of differences in TMT performance between respondents with AN and BMI below 18.5 and respondents with AN and BMI in the normal range. We found that respondents with a BMI below 18.5 showed worse results in all monitored categories compared to respondents with a BMI in the normal range. In part TMT-A, they achieved an average time of 43.37 seconds compared to 37.14 seconds in the group with a BMI in the normal range. In TMT-B, the difference was even more significant (80.2 seconds vs. 52.34 seconds). Our results support the past research, which points to the negative impact of nutritional deprivation on executive functions [17]. This means that nutritional deprivation can induce impaired efficiency in the areas of cognitive flexibility, information processing and executive functions. Lack of necessary nutrients affects neuronal activity in the prefrontal cortex, which is fundamental for planning, decision-making, and adaptation to new tasks, which in turn causes rigid thought patterns in individuals, slowed switching between tasks, and higher rates of perseveration, which is consistent with previous research [25].

4.2. Research Limits

The dominant limitations are the limited number of respondents, which may limit the generalizability of the results to a wider population. A small sample size reduces the reliability of the conclusions.

Another limitation is the possible influence of comorbidities, such as depression and anxiety disorders, which were not explicitly controlled for.

Another limitation may be that respondents with AN varied in severity and duration of illness, as well as BMI. These individual differences may influence cognitive performance and bias the results.

Other limitations include the lack of long-term follow-up. The research only provides a snapshot of the cognitive function of the respondents. Long-term follow-up would allow us to assess whether cognitive function recovers after nutritional status improves and at what rate.

5. Conclusions

Future research would benefit from longitudinal studies examining changes in cognitive functions during treatment and recovery from anorexia nervosa. Expanding the scope to include emotional regulation and interpersonal bonding may provide a more comprehensive understanding of these processes. Neuroimaging techniques such as fMRI and EEG could help identify neurological correlates of cognitive deficits. Additionally, comparing self-report measures with objective

neuropsychological assessments may reduce subjective bias. Although preliminary, these findings may inform the development of therapeutic approaches and have potential applications in clinical psychology.

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