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Original Article

A Comparative Analysis of The Impact of Metabolic Syndrome on Cognitive Functions in Middle-Aged Adults According to NCEP ATP III and WHO Criteria

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ABSTRACT

Objective: Studies have highlighted the adverse effects of metabolic syndrome (MetS), a cluster of cardiovascular disease risk factors, on cognitive functions. This study aimed to explore early cognitive function changes in middle-aged patients recently diagnosed with MetS and to compare the sensitivity of the ATP III and World Health Organization (WHO) criteria in relation to cognitive functions.

Methods: This cross-sectional study included 64 participants, 39 patients with MetS according to ATP III criteria and 25 healthy controls matched for age, sex and education. Of the 39 MetS patients, 30 also met the WHO criteria. Metabolic parameters and neuropsychological assessments were compared between the MetS and control groups according to both criteria.

Results: According to ATP III criteria, central obesity is the most common criterion in MetS patients, while in WHO criteria, it comes after the mandatory criterion of insulin resistance. Control patients did not meet any MetS criteria. The findings showed that MetS patients classified according to ATP III had significant impairments in attention (digit span test, p=0.042), executive functions (Stroop color test, p=0.048; word fluency, p=0.024; similarity test, p=0.001), memory (logical memory, p=0.001; visual memory, p=0.001; immediate recall, p=0.001; delayed recall, p=0.011), and learning (p=0.001). In contrast, MetS patients classified according to WHO showed impairments mainly in executive functions (word fluency, p=0.022; similarity test, p=0.001), memory (logical memory, p=0.007; visual memory, p=0.002; immediate recall, p=0.003), and learning (p=0.001).

Conclusion: MetS is linked to impairments in attention, executive functions, memory, and learning abilities in middle-aged individuals, even at the early stages of the condition. Defining MetS according to the ATP III criteria might said to be more sensitive for assessing cognitive decline, as it identifies deficits across a wider range of cognitive domains compared to the WHO criteria.

INTRODUCTION

Metabolic syndrome (MetS) is characterized by various risk factors, such as abdominal adiposity, abnormalities in carbohydrate metabolism, abnormal lipid profiles and high blood pressure. The etiology of MetS is complex, involving multiple contributing factors.[1,2] Modern lifestyle habits, particularly insufficient exercise, and poor nutritional choices, significantly contribute to the rising incidence of this condition.

MetS is defined by several established criteria, with the NCEP ATP III and WHO guidelines being the most widely used. The ATP III criteria include central obesity, increased triglyceride concentrations, reduced HDL cholesterol, high blood pressure, and elevated fasting blood glucose

levels.[1] WHO criteria also recognize similar metabolic abnormalities but place a greater emphasis on insulin resistance as the key feature. These criteria are essential tools for assessing the increased risk of cardiovascular disease.[3]

Cognitive functions encompass the comprehensive processes engaged in acquiring, managing, integrating, storing, and recalling information. These functions are generally categorized into several areas, including perception, attention, memory, and executive functions. The latter includes higher-level processes such as planning and decision-making, essential for achieving effective cognitive performance.[4]

Decreased cognitive ability is a widespread concern within the aging population and a crucial determinant of dementia. With increasing life expectancy in developed countries, age-related cognitive decline, often progressing to dementia, is likely to become an increasingly serious clinical and public health challenge.[5] Various factors contribute to cognitive decline, and MetS is recognized as a potentially significant and modifiable contributor to cognitive dysfunction.[6,7] While previous research has identified associations between MetS and cognitive impairment, the findings remain debated. Most studies, however, have predominantly focused on older adult populations and the long-term cognitive effects of MetS experienced in young adulthood.[8-12]

This study aims to examine the relationship between MetS and cognitive abilities in middle-aged individuals and evaluate the sensitivity of the NCEP ATP III and WHO guidelines regarding cognitive functions. Identifying MetS as a contributor to cognitive decline in this relatively young population may allow for earlier interventions because numerous risk factors linked to MetS are modifiable.

MATERIALS AND METHODS

Study design

The study involving cross-sectional and case-control methods was approved by the Kocaeli University Faculty of Medicine Human Research Ethics Committee (project number 2007/53, decision number 9/7). Participants received both written and oral information before providing their consent. The study enrolled 64 participants aged 30 to 55 and with at least 5 years of education. This cohort included 39 patients with MetS as per ATP III criteria and 25 healthy controls who did not meet any of the criteria. The control group was matched to those with MetS for age, gender, education, smoking, and alcohol consumption. Exclusion criteria included a history of cardiac disease (other than hypertension), diabetes, recent medications within the past three months (antidiabetic, lipid-lowering, antihypertensive, and medications affecting central nervous system function), primary medical conditions (such as kidney, liver, or respiratory), nervous system diseases, previous strokes, confirmed or potential dementia, psychiatric disorders, major depression, excessive alcohol consumption (defined as more than 14 drinks per week), serious head trauma, and severe obesity (with a BMI greater than 40 kg/m^2).

Metabolic syndrome definition criteria

According to the NCEP ATP III criteria, MetS is diagnosed when at least three of the subsequent factors are present: central obesity (waist size greater than 102 cm for men and 88 cm for women), low HDL cholesterol (<1.03 mmol/l or <40 mg/dl for males and <1.29 mmol/l or <50 mg/dl for females), increased triglyceride levels (≥1.7 mmol/l or ≥150 mg/dl), hypertension (≥130/85 mmHg), and raised fasting glucose (≥6.1 mmol/l or ≥110 mg/dl).[1] The WHO criteria for MetS require the existence of glucose intolerance, or insulin resistance, alongside at least two of these criteria: obesity (BMI >30 kg/m2 or waist-to-hip ratio exceeding 0.90 for males, 0.85 for females), dyslipidemia (HDL-C <0.9 mmol/l or 35 mg/dl for men, <1.0 mmol/l or 39 mg/dl for women, or triglycerides ≥1.7 mmol/l or ≥150 mg/dl), elevated blood pressure (≥140/90 mmHg), and increased albumin excretion (≥20 µg/min or albumin-to-creatin ratio ≥30 mg/d). Additional factors like hyperuricemia and coagulation disorders are considered but not mandatory for diagnosis.[3]

Measurements and calculations

In the early morning, blood samples were gathered after fasting overnight. Blood pressure (BP) was recorded on the right arm using a standard mercury manometer, while the participant was seated and rested for at least 5 minutes before the measurement. Waist circumference (WC) was measured at the center point between the inferior rib margin and the iliac crest. Hip circumference refers to the measurement taken around the level of the greater trochanters. BMI was computed by dividing body weight (kg) by height squared (m^2). Insulin sensitivity was assessed using QUICKI and HOMA-IR indices. QUICKI:1/(log (fasting plasma insulin (microIu/ml) + log(fasting plasma glucose (mg/dl)). HOMA-IR: Fasting plasma insulin(microIu/ml) x fasting plasma glucose(mlmol/l)/22.5. An OGTT was carried out on subjects diagnosed with MetS.

Neuropsychological assessment

The neuropsychological test battery was performed by experienced interviewers following a structured sequence in one session in a calm environment. The validity and reliability of these tests have been established in Türkiye, specifically assessing attention, executive function, and memory.[13,14] Attention and working memory were evaluated using the Weschler Memory Scale and Digit Span tests (DST) (with the forward test focusing on attention and concentration, while the backward test measures attention, concentration, and working memory). In the forward Digit Span Test (DST), participants are presented with a series of mixed numbers in one-second intervals and are instructed to repeat them in the same order. The length of the sequence increases until the participant is unable to recall the entire series. The maximum score attainable for this section is eight. In the backward DST, participants were required to count backward from the last number presented, with a maximum score of seven. The final score

is calculated by summing the results from both sections.[15]

Executive function was assessed with the Stroop color-word test (SCWT), the word fluency test, and the similarities subtest of the Wechsler memory scale (WMS). The SCWT measures response suppression, a key aspect of executive functions. In this test, the time taken to complete five different cards is recorded separately. On card I, subjects are instructed to read the words as rapidly as they can; on card II, they are required to identify the colors quickly; and on card V, they must indicate the color of the ink in which the words are written, despite the word meaning being incongruent with the color (e.g., "blue" written in red). Prolonged response times are associated with a potential cognitive dysfunction.[16]

Memory was assessed using the verbal memory processes test (VMPT), created by Öktem and derived from the Rey Auditory Verbal Learning Test. The VMPT comprises 15 groups of unrelated terms, with participants required to recall all words correctly within 10 trials or until every term is correctly remembered. Key measurements included immediate recall (the number of words remembered on the first try), delayed recall (the words remembered after a 40-minute interval), highest learning point (the maximum number of words recalled in a single trial), total learning score (the sum of correct words across all trials), and recognition (the number of words correctly recognized from the list of unremembered words).[17] Additionally, the logical memory subtest of the WMS was used to evaluate verbal memory, and the visual reproductions subtest of the WMS was employed to assess nonverbal memory.[14]

Laboratory analysis

Glucose, total cholesterol (TC), HDL, and triglycerides (TG) were measured using the Aeroset analyzer with an Abbott Diagnostics kit (Wiesbaden, Germany). LDL was computed using the Friedewald equation. Insulin concentrations were determined through a chemiluminescent immunometric technique using the Cobas analyzer (Roche Diagnostics, Mannheim, Germany).

Statistical analysis

Statistical analysis was conducted using SPSS version 11.5 (SPSS Inc., Chicago, IL, USA). To assess the normality of the data distribution, the Shapiro-Wilk test was performed. The characteristics of the subjects are presented

Table 1. Demographic characteristics and metabolic risk parameters of metabolic syndrome (based on ATP III and WHO criteria) and control groups

	Metabolic Syndrome Group				
	ATP III (n=39)	WHO (n=30)	Control group (n=25)	P[1]	P[2]
Demographic variables					
Gender (F/M, n (%))	34(87%) /5(13%)	28(93%) / 2(7%)	23 (92%)/ 2 (8%)	0.547	0.851
Age, years	43.3±7.1	42.3±7.5	40.2±5.4	0.052	0.128
Education					
5 years (n, (%))	23 (59%)	19 (63%)	14 (56%)		
>5 years (n, (%))	16 (41%)	11 (37%)	11 (44%)	0.814	0.538
Smoking (%)	33%	30%	44%	0.390	0.287
Alcohol use (%)	5%	3%	0	0.250	0.361
Descriptive variables					
BMI (kg/m2)	33.3±5	34.1±4.6	22.6±2.8	0.001	0.001
Waist circumference(cm)	101.7±10	102.5±9.8	72.2±5.1	0.001	0.001
Waist-to-hip ratio	0.9±0.1	0.9±0.1	0.7±0.1	0.001	0.001
SBP (mmHg)	140.8±26.9	142.3±27.4	99.8±11.9	0.001	0.001
DBP (mmHg)	91.4±17	93.3±18.1	64.4±7.7	0.001	0.001
Fasting glucose (mg/dl)	103.5±14.5	105.4±14.7	87±8.4	0.001	0.001
HDL cholesterol (mg/dl)	45.9±13.6	47.2±15	62±12.2	0.001	0.001
Triglycerides (mg/dl)	196.4±80.8	191.3±87.6	73.8±21.7	0.001	0.001
HOMA-IR	3.3±2.8	3.7±3.0	0.5±0.1	0.001	0.001
QUICKI	0.35±0.05	0.34±0.05	0.44±0.02	0.001	0.001

F/M: female/male; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HOMA-IR, homeostasis model assessment of insulin resistance; QUICKI, quantitative insulin sensitivity check index; ATP III: Adult Treatment Panel III

P[1] Comparison of Patients with Metabolic Syndrome According to ATPIII Criteria and the Control Group

P[2] Comparison of Patients with Metabolic Syndrome According to WHO Criteria and the Control Group

Values are means±SD, or n (percent), and p-values are from the Independent Samples T-test, Mann Whitney U test or Fisher's exact test. Statistical significance $p<0.05$.

as frequencies (percentages) for categorical variables and as mean ± standard deviation (SD) for continuous variables. For comparisons between groups, the Pearson $\chi 2$ test or Fisher's exact test was used for categorical variables, the Independent Samples t-test was applied for parametric continuous variables, and the Mann-Whitney U test was used for nonparametric continuous variables. Statistical significance was considered at $p<0.05$.

RESULTS

The distribution of metabolic syndrome criteria in the patient group

The patient population determined to have MetS based on the ATP III showed the following distribution of criteria fulfillment: 15 patients (39%) fulfilled 3 criteria, 18 patients (46%) achieved 4 criteria, and 6 patients (15%) complied with all 5 criteria. The most frequently observed criterion was central obesity, present in 93% (36) of participants, followed by hypertriglyceridemia (80%), decreased HDL (77%), high arterial pressure (69%), and raised fasting blood glucose (67%).

Among 39 patients assessed, 30 (77%) were confirmed to have MetS based on WHO criteria. Within this subgroup, 14 patients fulfilled 2 criteria, 8 satisfied 3 criteria, 5 fulfilled 4 criteria, and 3 met all 5 criteria, along with exhibiting reduced insulin sensitivity. Central adiposity was the most prevalent factor, observed in 97% of participants, followed by hypertriglyceridemia (73%), hypertension (70%), microalbuminuria (30%), and low HDL cholesterol (23%).

Comparison of demographic characteristics and metabolic parameters of metabolic syndrome and control groups

No notable differences were found between the two groups concerning demographic variables, comprising age, gender, education level, smoking, and alcohol use. Both groups had more women than men (Table 1).

However, significant differences emerged between the metabolic syndrome group and controls in terms of metabolic parameters, including WC, waist-to-hip ratio, BMI, blood pressure, fasting glucose, HDL, TG levels, and measures of insulin resistance like HOMA-IR and QUICKI index (p: 0.001). These outcomes are in agreement with both definition criteria (Table 1).

Comparison of neuropsychological tests of metabolic syndrome and control groups

The findings revealed that MetS patients classified according to ATP III showed significant impairments across a broader range of cognitive domains compared to the control group. These impairments included attention (as measured by the digit span test, p=0.042), executive functions (Stroop color test; p=0.048, word fluency; p=0.024, similarity test; p=0.001), memory (logical memory; p=0.001, visual memory; p=0.001, immediate recall; p=0.001, delayed recall; p=0.011), as well as learning (p=0.001). In contrast, MetS patients classified according to WHO exhibited impairments primarily in executive functions (word fluency; p=0.022, similarity test; p=0.001), memory (logical memory; p=0.007, visual memory; p=0.002, immediate recall; p=0.003) and learning (p=0.001) (Table 2).

Table 2. Comparison of neuropsychological tests of metabolic syndrome and control groups

	Metabolic Syndrome Group				
	ATP III (n=39)	WHO (n=30)	Control group (n=25)	P[1]	P[2]
Neuropsychological Tests					
Stroop Test (time, sec)	29.7±8.8	28.9±8.3	25.5±6.5	0.048	0.089
Digit Span Test (score)	8.7±2	8.7±2	9.8±1.5	0.042	0.050
Backward recall of digits	3.5±1.4	3.6±1.4	4.2±0.8	0.047	0.201
Forward recall of digits	5.3±1.1	5.1±0.9	5.6±1.1	0.166	0.057
Logical memory (score)	15.8±5.6	16.9±5.3	21.1±5.9	0.001	0.007
Visual Memory	10±2.8	10.5±2.4	12.4±1.9	0.001	0.002
Immediate recall	5.8±1.6	6±1.5	7.3±1.4	0.001	0.003
Delayed recall	12±1.7	12.4±1.5	13.1±1.4	0.011	0.074
Word Fluency (score)	29.6±5.3	29.9±5	33.6±6.5	0.024	0.022
Similarity Test	5.8±2.2	5.9±2.3	7.8±1	0.001	0.001
Learning (score)	105.7±13.7	107.8±13.2	134.2±5	0.001	0.001
Recognition	2.4±1.4	2.2±1.3	1.6±1.3	0.019	0.092

ATP III: Adult Treatment Panel III

P[1] Comparison of Patients with Metabolic Syndrome According to ATP III Criteria and the Control Group

P[2] Comparison of Patients with Metabolic Syndrome According to WHO Criteria and the Control Group

Values are means ± SD, and p-values are from the Independent Samples T-test, Mann Whitney U test. Statistical significance $p<0.05$

DISCUSSION

The findings of this research demonstrated a decline in cognitive functions, including attention, executive function, memory, and learning, in patients with metabolic syndrome when compared to healthy controls matched for various covariates such as age, sex, education, smoking, and alcohol consumption. Additionally, the study concluded that defining MetS according to the ATP III criteria may be more sensitive in evaluating cognitive functions, as it detects impairments across a broader range of cognitive domains compared to the WHO criteria.

The literature highlights distinct differences in the relationships between metabolic syndrome and cognitive performance. These variations may be attributable to differing criteria for defining metabolic syndrome, the duration of exposure, which is often unreported, the neuropsychological test batteries used, and sociodemographic factors such as age, gender, and education level.

In the present study, the variation in criteria used to define metabolic syndrome appears to influence the results of cognitive assessment tests. Only 77% of patients diagnosed with MetS according to the ATP III criteria were also classified as having MetS according to the WHO criteria. Central obesity was the most prevalent criterion among individuals diagnosed with MetS according to the ATP III criteria, followed by hypertriglyceridemia, low HDL cholesterol, hypertension, and elevated fasting glucose. In patients diagnosed with MetS according to WHO criteria, the most common finding after insulin resistance, which is a mandatory criterion in all patients, was central obesity, followed by hypertriglyceridemia, hypertension, microalbuminuria, and low HDL cholesterol. The differences in metabolic risk factors between the patient groups defined by these two diagnostic criteria may account for the cognitive differences observed.

Various studies have examined the relationships between components of MetS and cognitive functions. For example, one study found an association between visceral adipose tissue, reduced hippocampal volume, and impaired verbal memory.[18] Another study highlighted cognitive decline in diabetic patients, even at the prediabetic stage.[19] Additionally, some studies have demonstrated the relationship between obesity, impaired glucose metabolism, hypertension, dyslipidemia, and cognitive decline.[20-25] However, due to the interconnections between these parameters, comprehensively assessing their individual effects can be challenging.

The combined effect of the components of MetS on cognitive functions exceeds the cumulative impact of each individual component. In the cross-sectional study by Alsuwaidi et al.,[26] individuals aged 40 to 80 with MetS, as defined by ATP III, showed lower memory performance compared to both those without MetS and those meeting only one or two criteria for the syndrome. However, the test battery used in this study focused only on memory performance and reaction speed, without evaluating other cognitive domains. To adequately evaluate the complex cognitive functions, which are challenging to assess clinically in relatively healthy and younger populations, should be employed detailed neuropsychological tests that provide objective scores.

Consistent with our study, the relationship between executive dysfunction and poor memory was also observed in individuals with MetS between the ages of 40 and 60 in the study conducted by Foret and colleagues. Although the cognitive tests, diagnostic criteria, and age range were comparable to those in our research, the participants in their cohort had a higher average education level (16±3 years) than both our study group and the general population. Furthermore, they found that patients with MetS who also had coexisting hypertension, central obesity, and dysglycaemia exhibited worse memory performance compared to those with other conditions.[27]

Alcorn et al.[28] conducted a review of cross-sectional studies examining the associations between MetS and cognitive performance. They concluded that MetS is linked to poorer executive functions. However, the relationship between MetS and other cognitive domains such as memory and attention, remains inconsistent. Notably, the studies included in the review varied significantly in their neuropsychological assessments, MetS diagnostic criteria, and the ages of the participants.

Research indicates that the risk of cognitive impairment may increase with the duration of exposure to MetS.[29] Although the exact duration of exposure in our study remains unclear, it is noteworthy that our cohort comprised middle-aged patients who had recently been diagnosed with MetS and were not receiving medical treatment. This distinction sets our study apart from other studies in the literature, as it focuses on the early stages of the disease.

In studies evaluating the longitudinal effects of MetS on cognitive functions, Kazlauskaite et al.[29] conducted cognitive assessments on middle-aged women with MetS over an 11-year follow-up period. Their study showed that women with MetS in middle age experienced a more pronounced decline in perceptual speed over time, while memory scores showed no significant change. In another study, Dearborn et al.[30] found no association between the six-year progression of MetS and cognitive status in people aged 45 to 64 years. However, the cross-sectional analysis of the same study identified associations between MetS and executive dysfunction, and word production deficits. The discrepancy between the cross-sectional and longitudinal findings has been attributed to the practice effect, resulting from the acquisition of experience through repeated cognitive assessments.[31]

Early diagnosis of cognitive disorders and implementation of preventive measures before a serious disorder develops are crucial for public health. Further research is needed to better understand longitudinal changes in cognitive performance among individuals with MetS and to identify underlying causes. In addition, future studies could evaluate the

impact of lifestyle changes and early therapeutic interventions on cognitive functions to reduce the severity of MetS.

One of the strengths of our study is the presence of a control group in which patients were matched for common variables such as age, gender, education level, smoking, and alcohol use, which are potential confounding factors affecting cognitive functions. Many studies use dementia screening tests such as the Mini-Mental State Examination (MMSE) for cognitive assessment; these tests may not be sensitive enough, especially in younger populations where cognitive effects may not be readily apparent in daily practice. An important advantage of our study is the use of comprehensive neuropsychological test batteries that are standardized for the Turkish population and are better suited to detect subtle cognitive changes.

This study has several limitations, including a small sample size and a single-center design. The cross-sectional nature of the study restricts the ability to establish causal inferences. Additionally, the lack of concurrent functional brain MRI imaging represents another limitation.

Conclusion

Metabolic Syndrome is associated with declines in attention, executive functions, memory, and learning abilities in middle-aged individuals, even at the early stages of the condition. Defining the MetS according to the ATP III criteria may be more sensitive in evaluating cognitive functions, as it identifies impairments across a broader range of cognitive domains compared to the WHO criteria.

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Ethics Committee Approval

The study was approved by the Kocaeli University Faculty of Medicine Human Research Ethics Committee (Date: 19.06.2007, Decision No: IAEK 9/7).

Informed Consent

Retrospective study.

Peer-review

Externally peer-reviewed.

Authorship Contributions

Concept: N.G., Z.C., B.C., I.T.; Design: N.G., Z.C., M.Y.; Supervision: N.G., Z.C., B.C., I.T., M.Y.; Fundings: N.G., Z.C.; Materials: N.G., Z.C., M.Y.; Data collection &/or processing: N.G., Z.C.; Analysis and/or interpretation: N.G., Z.C., B.C., I.T., M.Y.; Literature search: N.G., Z.C.; Writing: N.G., Z.C.; Critical review: N.G., Z.C., B.C., I.T., M.Y.

Conflict of Interest

None declared.

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Orta Yaşlı Yetişkinlerde Metabolik Sendromun Bilişsel İşlevler Üzerindeki Etkisinin NCEP ATP III ve DSÖ Kriterlerine göre Karşılaştırmalı Analizi

Amaç: Çalışmalar, bir kardiyovasküler hastalık risk faktörleri topluluğu olan metabolik sendromun (MetS) bilişsel işlevler üzerindeki olumsuz etkilerini vurgulamaktadır. Bu çalışmanın amacı, yakın zamanda MetS tanısı alan orta yaşlı hastalarda erken bilişsel işlev değişikliklerini araştırmak ve ATP III ve Dünya Sağlık Örgütü (DSÖ) kriterlerinin bilişsel işlevlerle ilgili duyarlılığını karşılaştırmaktır.

Gereç ve Yöntem: Bu kesitsel çalışmaya, ATP III kriterlerine göre MetS'li 39 hasta ve yaş, cinsiyet ve eğitim açısından eşleştirilmiş 25 sağlıklı kontrol olmak üzere 64 katılımcı dahil edilmiştir. 39 MetS hastasından 30'u DSÖ kriterlerini de karşılamıştır. Her iki kritere göre de MetS ile kontrol grupları arasında metabolik parametreler ve nöropsikolojik değerlendirmeler karşılaştırılmıştır.

Bulgular: ATP III kriterlerine göre MetS hastalarında en sık görülen kriter santral obezite iken, DSÖ kriterlerine göre zorunlu insülin direnci kriterinden sonra gelmektedir. Kontrol hastaları herhangi bir MetS kriterini taşımamaktadır. Bulgular, ATP III'e göre sınıflandırılan MetS hastalarının dikkat (sayı uzamı testi, p=0.042), yürütücü işlevler (Stroop renk testi, p=0.048; kelime akıcılığı, p=0.024; benzerlik testi, p=0.001), bellek (mantıksal bellek, p=0.001; görsel bellek, p=0.001; anlık hatırlama, p=0.001; gecikmiş hatırlama, p=0.011) ve öğrenmede (p=0.001) önemli bozulmalar olduğunu göstermiştir. Bunun aksine, DSÖ'ye göre sınıflandırılan MetS hastalarında temel olarak yürütücü işlevlerde (kelime akıcılığı, p=0.022; benzerlik testi, p=0.001), bellekte (mantıksal bellek, p=0.007; görsel bellek, p=0.002; anlık hatırlama, p=0.003) ve öğrenmede (p=0.001) bozulma olduğu gösterilmiştir.

Sonuç: MetS, hastalığın erken evrelerinde bile, orta yaşlı bireylerde dikkat, yürütücü işlevler, hafıza ve öğrenme becerilerindeki bozulmalarla bağlantılıdır. MetS'un ATP III kriterlerine göre tanımlanmasının, DSÖ kriterlerine kıyasla daha geniş bir bilişsel alan yelpazesindeki eksiklikleri tanımladığı için bilişsel gerilemenin değerlendirilmesinde daha hassas olduğu söylenebilir.

Anahtar Sözcükler: Bellek; bilişsel işlevler; metabolik sendrom; nöropsikolojik değerlendirmeler; yürütücü işlev.