

METABOLIC SYNDROME AND SLEEP APNEA: THE IMPACT OF LIFESTYLE INTERVENTIONS

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Abstract

Contemporary healthcare focuses on assessing the efficacy of dietary and exercise interventions in mitigating metabolic syndrome and its association with sleep apnea. Results demonstrate notable reductions in the HOMA Index and triglyceride levels among treated cohorts, indicating improved glycemic control and lipid profile. Additionally, intervention groups exhibit significant decreases in cholesterol levels, indicative of enhanced lipid profile. Marginal alterations in C-Reactive Protein imply limited impact on systemic inflammation, while consistent uric acid levels suggest potential autonomy from the interventions. Remarkable correlations between clinical parameters and sleep apnea risk underscore the pivotal role of lifestyle modifications in metabolic syndrome management, offering insights into underlying mechanisms.

The aim of this study is to further investigate the underlying mechanisms behind the observed improvements in metabolic parameters following dietary and exercise interventions, with a specific focus on elucidating the relationship between these interventions and the risk of sleep apnea in individuals with metabolic syndrome. These findings elucidate the intricate interplay between metabolic risk factors and sleep apnea susceptibility, thereby informing therapeutic and preventive approaches for individuals with metabolic syndrome.

Keywords: sleep apnea, metabolic syndrome, diet, exercise.

Rezumat

Asistența medicală contemporană se concentrează pe evaluarea eficacității intervențiilor dietetice și ale exercițiilor fizice în atenuarea sindromului metabolic și asocierea acestuia cu apneea în somn. Rezultatele demonstrează reduceri notabile ale indicelui HOMA și ale nivelurilor de trigliceride în rândul cohortelor tratate, indicând un control glicemic și un profil lipidic îmbunătățite. În plus, grupurile de intervenție prezintă scăderi semnificative ale nivelurilor de colesterol, ceea ce indică un profil lipidic îmbunătățit. Modificările marginale ale proteinei C-reactive implică un impact limitat asupra inflamației sistemice, în timp ce nivelurile constante ale acidului uric sugerează o autonomie potențială față de intervenții.



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Corelațiile remarcabile între parametrii clinici și riscul de apnee în somn indică rolul esențial al modificărilor stilului de viață în managementul sindromului metabolic, oferind perspective asupra mecanismelor de bază.

Scopul acestui studiu este de a investiga în continuare mecanismele care stau la baza îmbunătățirilor parametrilor metabolici observate în urma intervențiilor dietetice și prin exerciții fizice, punând un accent special pe elucidarea relației dintre aceste intervenții și riscul de apnee în somn la persoanele cu sindrom metabolic. Aceste descoperiri arată interacțiunea complicată dintre factorii de risc metabolic și susceptibilitatea la apneea în somn, ghidând abordările terapeutice și preventive pentru persoanele cu sindrom metabolic.

Cuvinte cheie: apnee în somn, sindrom metabolic, dietă, exerciții fizice.

Introduction

Metabolic Syndrome (MetS) represents a critical public health challenge, characterized by a multifaceted array of cardiovascular⁽¹⁾ risk factors including atherogenic dyslipidemia, hypertension, altered plasma glucose, and central obesity. This syndrome, manifesting clinically through compensatory hyperinsulinemia in response to peripheral insulin resistance and a proatherogenic lipid profile marked by hypertriglyceridemia and low high-density lipoprotein (HDL) levels, portends an elevated risk for type 2 diabetes mellitus (T2DM) and accelerated atherosclerosis^(2,3).

At the core of MetS pathogenesis lies adiposopathy, playing a pivotal role in metabolic deregulations through the production of pro-inflammatory adipokines and cytokines. These mediators drive insulin resistance and foster a prothrombotic and inflammatory state. The dysfunction of visceral adipocytes, coupled with altered adiponectin secretion, exacerbates dyslipidemia and augments atherosclerotic plaque vulnerability. The role of oxidative stress and endothelial dysfunction in MetS pathogenesis opens new therapeutic perspectives utilizing antioxidant agents and endothelial function modulators⁽⁴⁻⁶⁾.

The therapeutic approach to MetS

necessitates individualized risk stratification and early medical intervention to modify modifiable risk factors. Pharmacological management targets optimal glycemic control, lipid profile regulation, and blood pressure normalization, paralleled by non-pharmacological interventions such as dietary modification and increased physical activity. The synchronization of these therapeutic strategies, along with vigilant monitoring of inflammation and oxidative stress biomarkers, is essential for primary and secondary prevention of macrovascular and microvascular complications associated with MetS^(7,8).

A holistic perspective on MetS and interdisciplinary collaboration among endocrinology, cardiology, and nutrition are imperative to enhance clinical outcomes and reduce the global burden of metabolic pathology. Thus, MetS should not be viewed merely as a collection of individual risk factors but as a clarion call for heightened attention to metabolic health. An integrated, proactive healthcare approach prioritizing prevention and optimal risk management is crucial to improve quality of life and reduce the economic burden on healthcare systems worldwide⁽⁹⁾.

The objectives

Evaluate the specific dietary and exercise interventions that contribute to the observed decreases in the HOMA index and triglyceride levels, aiming to understand their effects on glycemic control and lipid profile in individuals with metabolic syndrome. Investigate the mechanisms responsible for the significant decrease in cholesterol levels in intervention groups, with the goal of identifying pathways leading to an overall improvement in lipid profile. Analyze the

extent of the influence of dietary and exercise interventions on systemic inflammation, as indicated by changes in C-Reactive Protein levels, to determine the impact on overall health. Explore the significant correlations between clinical and paraclinical parameters and the risk of sleep apnea, aiming to elucidate the role of lifestyle interventions in managing metabolic syndrome and mitigating the risk of sleep apnea.

The aim of this study is to further investigate the underlying mechanisms behind the observed improvements in metabolic parameters following dietary and exercise interventions, with a specific focus on elucidating the relationship between these interventions and the risk of sleep apnea in individuals with metabolic syndrome.

Materials and methods

Ethical considerations

The study was conducted in accordance with the approval of the research ethics committee at the Faculty of Medicine and Pharmacy, University of Oradea, under reference number 12/01.04.2019. Prior to their inclusion, all participants provided informed consent, consistent with prevailing legislation.

Formation of study groups

The study enrolled 48 participants, aged 18 or above, with an average age of 38.95 years (± 14.74), categorized into three groups:

- Control Group (CG) comprising 9 individuals
- Diet Therapy Group (DG) consisting of 19 individuals
- Diet and Physical Activity Group (DSG) comprising 20 individuals

All participants were diagnosed with Metabolic Syndrome (MS) and were under the



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care of an endocrinologist for controlled hypothyroid activity. The study spanned 12 months, with initial and final assessments conducted. Monthly follow-ups were conducted to adjust diet therapy. Exclusion criteria included individuals with type 1 or type 2 diabetes or other significant chronic conditions. Participants consented to data processing by signing a consent agreement.

Body composition analysis

We monitored variations in the three independent groups based on factors such as sex, age, and urban/rural environment, alongside clinical parameters including BMI, fat mass, and visceral fat compared to the three research groups.

Measurement of body composition (BMI, fat mass, visceral fat)

A cross-sectional study was conducted on MS patients enrolled in a cohort study aimed at obtaining clinical characteristics and tailored diet therapy. Clinical evaluation utilized the Tanita MC780MA bioelectric impedance body analyzer, with results analyzed using GMON 3.4.1 medical software. BIA type body analyzers, endorsed by WPHNA, were employed for accurate body composition assessment, with a margin of error of 0.1 kg. Affinity for diet therapy was tracked using the non-invasive medical device Cnoga MTX, monitoring changes in clinical parameters

including oxygen saturation, blood pressure, and blood pH.

Analysis of paraclinical parameters

Paraclinical parameters included the calculation of the Homeostasis Model Assessment (HOMA) index, assessing insulin resistance using the HOMA-IR model formula: (fasting insulin mU/L) × (fasting glucose mmol/L) / 22.5.

Evaluation of obstructive sleep apnea (OSA) risk

Risk assessment for OSA utilized adapted scales (Berlin Questionnaire Sleep Apnea combined with the Epworth Sleepiness Scale) during the intervention period.

Statistical analysis

With a study exit rate of 0.00%, statistical significance was determined using the Chi-Square test, where Asymp. Sig < 0.05 indicated significance. Statistical analysis was performed using SPSS Statistics 22, employing Student's t-test for parameter calculation, mean values, frequency intervals, and standard deviations. The Bravais-Pearson correlation coefficient was utilized to evaluate the relationship between variables, with $p < 0.05$ considered statistically significant for ANOVA, and $p < 0.01$ indicating high-level statistical significance. Bonferroni post-hoc analysis was employed for subgroup comparisons.



Figure 1. Graphic presentation of the initial and final evolution of the screening parameters such as cholesterol (A), BMI (B), Homa index (C), triglycerides (D), fat mass (E) and visceral fat (F)



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Results

Table 1 presents the descriptive and inferential statistics concerning the effectiveness of diet therapy and exercise on the average values of body composition parameters. The significance thresholds indicate the following trends:

In the control group (GC), a significant increase in fat mass is observed ($p=0.001$).

For the diet therapy group (GD), there is a significant decrease in fat mass ($p=0.001$).

Similarly, in the diet therapy combined with exercise group (GD+S), there is a significant decrease in fat mass ($p=0.001$). Regarding visceral fat, there is a slight but statistically insignificant increase observed in GC ($p=0.330$). However, in GD, there is a significant decrease in visceral fat ($p=0.001$), and in GD+S, the decrease in visceral fat is less pronounced but still statistically significant ($p=0.001$). The initial and final progress is depicted in Figure 1. The most favorable outcomes observed within the GD group were notably in cholesterol and triglyceride levels, as well as in the HOMA index and visceral fat. Furthermore, it's apparent that there were no statistically significant changes ($p>0.05$) in initial and final results for the CG. However, significant differences were observed between CG and GD ($p<0.05$), as well as between CG and GDsport ($p=0.001$). Additionally, significant differences persisted between GD and GDsport ($p<0.05$), except for BMI, where

the disparity did not meet the threshold for significance.

Apnea risk correlated with clinical parameters

The difference between pretest and posttest fat content and triglycerides yielded a Pearson's coefficient $r=0.265$, with $p<0.05$, indicating a strong positive relationship. The greater the difference in fat content, the greater the difference in triglycerides. A very slight deviation in GC indicates negligible change. In GD, it denotes a significant decrease in the difference between triglycerides, linked with a concurrent decrease in fat content. This might be elucidated by the implementation of a hypolipidemic diet in individuals with high fat content. At GD+S, the difference in triglycerides moderately decreases in relation to the difference in fat content, yet remains statistically significant. The mean difference in fat mass relative to the mean difference in triglycerides is lower in GD+S. This value can be attributed to the normolipidic diet of GD+S, influenced by the exerted effort, as depicted in table 2 and in Figure 2.

Discussion

The conclusion of the study underscores the potential efficacy of dietary and exercise

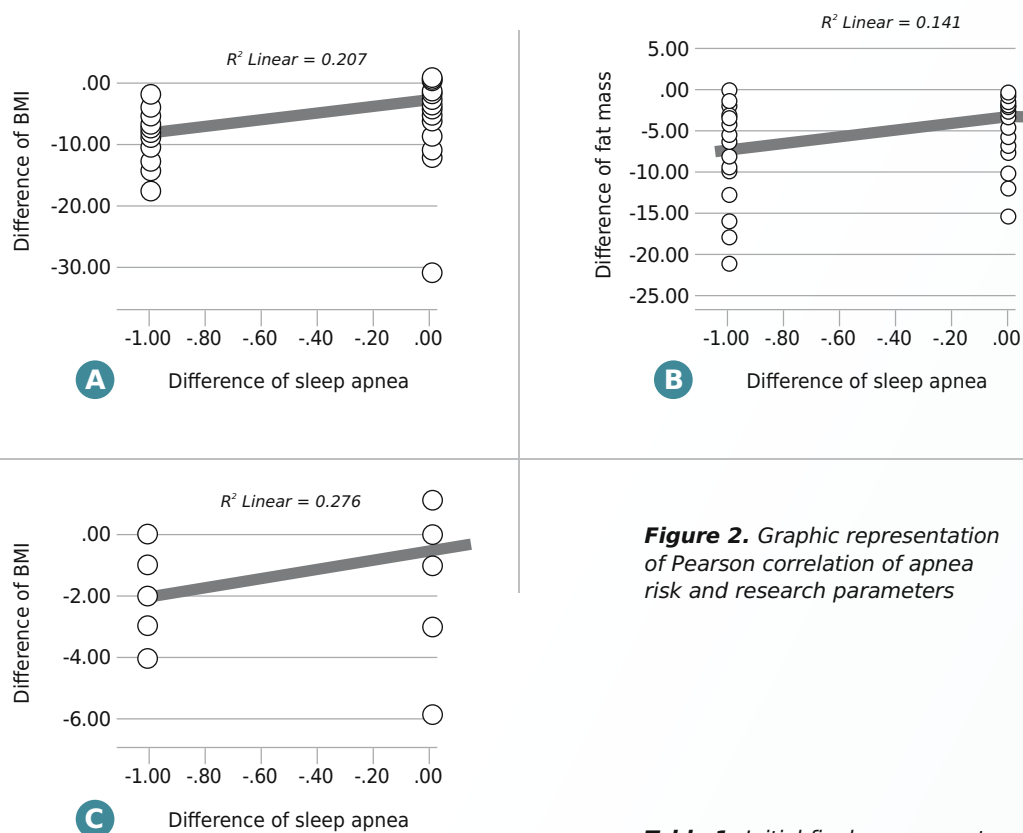


Figure 2. Graphic representation of Pearson correlation of apnea risk and research parameters

Table 1. Initial-final assessment of research parameters

Assessment	Parametri	Mean	Std. Dev.	Sig	t	p
Initial	BMI	30.70	7.66	0.001	11.48	0.001
Final		26.14	4.63			
Initial	Fat mass	30.48	9.24	0.001	11.33	0.001
Final		26.6	8.44			
Initial	Visceral fat	7.53	5.39	0.001	9.60	0.001
Final		6.63	5.01			
Initial	HOMA index	4.01	2.35	0.001	11.34	0.001
Final		2.68	1.31			
Initial	Cholesterol	0.67	0.46	0.001	6.80	0.001
Final		0.43	.049			
Initial	Triglycerides	0.54	0.49	0.001	7.62	0.001
Final		0.26	0.44			



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Pearson correlation		BMI	Fat mass	Visceral fat
Apnea risk difference	r	0.499**	0.425**	0.559**
	p	0.000	0.000	0.000
	N	220	220	220

Table 2. Pearson correlations regarding the difference in apnea risk and BMI, fat mass, and visceral fat, respectively

interventions in mitigating the adverse effects of metabolic syndrome. The observed reductions in the Homeostatic Model Assessment (HOMA) index and triglyceride levels suggest a positive influence on glycemic control and lipid profile, aligning with established strategies for managing metabolic syndrome⁽¹⁰⁻¹⁵⁾.

One notable aspect is the significant decrease in cholesterol levels within the intervention groups. This outcome not only highlights the positive impact of lifestyle modifications on lipid metabolism but also suggests a potential avenue for reducing cardiovascular risk in individuals with metabolic syndrome⁽¹⁶⁾.

The study's findings also shed light on the limited influence of dietary and exercise interventions on systemic inflammation, as indicated by minor changes in C-Reactive

Protein levels. While this suggests that inflammation may not be the primary target of these interventions in the sample studied, further exploration is needed to understand the nuanced relationship between lifestyle modifications and inflammatory markers⁽¹⁷⁻²¹⁾. Interestingly, the constancy of uric acid levels throughout the intervention period suggests that these particular interventions may not exert a substantial influence on uric acid metabolism⁽²²⁻²⁹⁾. This finding prompts additional inquiry into the potential independence of uric acid dynamics from the studied lifestyle modifications⁽³⁰⁻³²⁾.

Perhaps one of the most significant implications of the study is the identified correlations between clinical and paraclinical parameters and the risk of sleep apnea. This underscores the interconnected nature of metabolic syndrome and sleep apnea,

emphasizing the critical role of lifestyle interventions in managing not only metabolic health but also mitigating the associated risk of sleep apnea. Such correlations emphasize the importance of a holistic approach to health, recognizing the interplay between metabolic factors and sleep-related conditions⁽³³⁾. The demographics of the participant cohorts highlight a varied geodemographic distribution, with 93 individuals coming from urban environments, constituting 42.3% of the sample, and 127 from rural environments, representing 57.7%. The gender analysis revealed a male predominance, with 119 men (54.1%), compared to 101 women (45.9%).

The investigation included a series of clinical and paraclinical parameters essential in evaluating metabolic syndrome. The body mass index (BMI), a recognized marker of obesity, had an average value of 29.60, with a standard deviation of 5.85, indicating a tendency towards obesity in the studied population. Fat mass, a critical indicator of body composition and metabolic risk, had an average value of 32.18 and a standard deviation of 7.73. Notably, the average level of visceral fat was 8.81, with a standard deviation of 5.12, suggesting a significant accumulation of fat in the abdominal region. The lipid profile was also analyzed, noting an average cholesterol level of 0.59 and a standard deviation of 0.49, along with triglycerides, having an average value of 0.37 and a standard deviation of 0.48.

The correlations between metabolic syndrome parameters and obstructive sleep apnea syndrome (OSAS) were significant. A notable correlation between BMI and OSAS was observed, with a correlation coefficient (r) of 0.499 and a p -value < 0.001 , indicating a strong association between obesity and apnea. Fat mass also showed a significant

correlation with OSAS ($r = 0.425$, p -value < 0.001), highlighting the role of adiposity in the pathogenesis of OSAS. Interestingly, visceral fat showed the strongest correlation with OSAS ($r = 0.559$, p -value < 0.001), suggesting that abdominal fat deposits may have a significant impact on the development of apnea. Cholesterol and triglycerides presented weaker correlations with OSAS ($r = 0.151$, p -value $= 0.025$ for cholesterol and $r = 0.171$, p -value $= 0.011$ for triglycerides), which may reflect a lesser influence of the lipid profile on the risk of apnea.

These findings demonstrate a clear connection between metabolic risk factors and the prevalence of OSAS, with relevant implications for therapeutic and preventive approaches in managing patients with metabolic syndrome.

In conclusion, the study provides valuable insights into the multifaceted effects of dietary and exercise interventions on metabolic syndrome. While improvements in glycemic control and lipid profile are evident, the nuanced influences on inflammation and uric acid metabolism warrant further investigation⁽³⁴⁾.

Conclusions

Dietary and exercise interventions have led to significant decreases in the HOMA index and triglyceride levels, indicating a positive impact on glycemic control and lipid profile in metabolic syndrome.

Cholesterol levels have shown a significant decrease in the intervention groups, suggesting an overall improvement in the lipid profile. Minor changes in C-Reactive Protein indicate a limited influence of the interventions on systemic inflammation in this sample. Uric acid remained constant, suggesting a possible independence from the



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interventions applied in the study. Significant correlations between clinical and paraclinical parameters and the risk of sleep apnea underline the essential impact of lifestyle interventions in managing metabolic syndrome and the associated risk of apnea.

Institutional Review Board Statement:

The study was carried out in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board. The study was carried out in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (or Ethics Committee) of the University of Oradea (protocol code 12/01.04.2019 and date of approval).

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