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Impact of Lifestyle Interventions on Cardiovascular Risk Factors in Patients with Metabolic Syndrome

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ABSTRACT

Introduction: Metabolic syndrome is a growing public health concern, characterized by a cluster of cardiovascular risk factors including central obesity, hypertension, dyslipidemia, and impaired glucose regulation. Lifestyle interventions have shown promise in improving these parameters. **Objective:** To evaluate the impact of lifestyle interventions on cardiovascular risk factors in patients diagnosed with metabolic syndrome. **Materials and Method:** A six-month interventional study was conducted at Department of Cardiology, Hayatabad Medical Complex Peshawar, Pakistan from July, 2024 to December, 2024. One hundred adult patients with metabolic syndrome were enrolled. Lifestyle modifications included dietary counseling, physical activity, and behavioral support. Anthropometric and biochemical parameters were assessed at baseline and after intervention. **Results:** Participants showed significant reductions in waist circumference, blood pressure, fasting glucose, and triglycerides, along with an increase in HDL cholesterol. By study end, 36% of patients no longer met the criteria for metabolic syndrome. **Conclusion:** Structured lifestyle interventions effectively reduce cardiovascular risk factors and can reverse metabolic syndrome in a significant proportion of patients.

INTRODUCTION

Metabolic syndrome, understood as a group of factors that involve abdominal obesity, some disorders in lipid profiles, high blood pressure, and insulin resistance, enhances considerably the risk of CVD and type 2 diabetic mellitus. The population affected by the syndrome has increased, and the situation has even become a subject of concern around the world. Dietary, exercise and behavioral mail are now recommended as paramount for managing this syndrome and other risks associated with cardiovascular diseases. Marcos-Delgado et al. points out that lifestyle modifications positively influence the health-related quality of life in adults with metabolic syndrome, both regarding the physical and psychological aspects (1). Metabolic syndrome is especially important as it is associated with cardiovascular events, according to Rus et al., who described its prevalence and cardiac risk factors in this prospective study (2).

This paper seeks to establish that consistent exercise still ranks among the most effective behavioral changes when it comes to handling metabolic syndrome. Among the aerobic, resistance, and combined exercise interventions, the effects on the variables have been studied with fluctuating results for metabolic syndrome. Overall, Liang et al. establish that all three types of exercise are productive, and combined exercise has a broad benefit impact on those palpable cardiovascular risk factors (3). Besides physical activity, the dietary factor shows complex linkages with the risk. According to Wagner et al., reducing dietary and lifestyle factors in individuals with metabolic and cardiovascular diseases results in a positive cellular effect in terms of micronuclei frequency, which represents cellular genomic instability and overall health (4).

This indicates that metabolic syndrome impacts not only cardiac and vascular entities but also fields of medicine that are not clearly related to cardiovascular

diseases. For example, Targher et al. have pointed out that metabolic-associated steatotic liver disease (MASLD) could be systemic in many ways, and it had a strong association with cardiovascular and oncological complications, supporting the need for either lifestyle change. Moreover, the disorder is comorbid with hypertension and requires an individual comprehensive approach to treatment. Stanciu et al. note this and expand more on how metabolic dysfunction and the use of drugs in managing other chronic diseases, including diabetes and hypertension, interrelate. Migration and alterations of environmental stimuli also explain the prevalence and manifestation of metabolic syndrome, according to Rosenthal et al., which implies that future public health interventions should include sociocultural and geographical characteristics (7).

Metabolic syndrome does not have the same impact on all populations. For example, some autoimmune diseases like psoriasis are known to be related to metabolic syndromes. Wu et al. suggest that in the treatment and management of psoriasis, metabolic dysfunction should not be considered independent of the disease, stating that chronic inflammatory diseases are related to metabolic risk (8). Another emerging model is the Cardiovascular-Kidney-Metabolic (CKM) model, which is a complex approach that widely explains cardiovascular, renal, and metabolic diseases. According to Ndumele et al., they believe in a clinical view of this triad and stress the importance of the big-picture approach to targeting each of these illnesses as diseases working in tandem with one another (9). Technological solutions have also started to become instrumental in enhancing healthy lifestyles. Research on mHealth, or the use of mobile technology to deliver interventions promoting the improvement of lifestyle factors for cardiovascular risk reduction, has shown tremendous potential in post-cardiac-event patients.

Cruz-Cobo et al. present another meta-analysis to show that compliance with the mHealth-based interventions was significantly effective in enhancing the current health behaviors and outcomes (10). However, it is crucial to understand sex-related differences in modifiable cardiovascular risk by lifestyle interventions. Rajendran et al. also show that women have unique CV risk characteristics and may require targeted management interventions (11). The impacts of metabolic syndrome do not just end on overall health but even on reproductive health. For instance, women with polycystic ovarian syndrome (PCOS), which is often linked with insulin resistance, are at higher risk of developing metabolic syndrome and complications of cardiovascular diseases. Sangaraju et al. stress that these women should be given lifestyle practises in order to reduce the development of cardiometabolic disease (12). Diets rich in whole foods, like plant-based diets or traditional dietary patterns, including the Med diet, have been found to reduce such risks. Sotos-Prieto et al. reveal a lower incidence of overall metabolic syndrome and decreased mortality among persons following the Mediterranean diet, which supports its implementation in both clinical practice and health promotion (13).

However, metabolic syndrome negatively impacts the prognosis in patients with CVD as that of those without any CVD. Li et al., in a meta-analysis study, noted that patients with CVD and associated metabolic syndrome exhibit worse prognosis and stressed the need for changes in the lifestyle of patients with metabolic syndrome (14). Lastly, the issue of understanding the mechanisms and dysregulation of lipid metabolism for the purpose of introducing proper interventions remains paramount. The authors Natesan & Kim have provided an overview of current management strategies of lipid disorders, including a conclusion that lifestyle modification are effective when added to drug therapy for the management of the metabolic syndrome (15). Together, these studies establish the multifaceted benefits of lifestyle intervention, including physical activity, dietary changes, behavior modification, and the use of technological advances to reduce cardiovascular risk factors in the population with metabolic syndrome. As the incidence of this syndrome increases worldwide and particularly in low- and middle-income countries such as Pakistan, large-scale organized lifestyle intervention programs can help improve cardiovascular health outcomes at an affordable cost.

Objective

To assess the effectiveness of clinical management strategies, diet, and physical activity should be used as primary interventions in patients with metabolic syndrome to address cardiovascular risk factors to raise the quality of life.

MATERIALS AND METHODS

Design: Prospective Interventional Study.

Study setting: The study was conducted at the Department of Cardiology, Hayatabad Medical Complex Peshawar, Pakistan

Duration: The study was carried out over a six-month period, from July, 2024 to December, 2024.

Inclusion Criteria

The participants were patients between 30 and 65 years of age with a diagnosis of metabolic syndrome according to the IDF criteria. Patients had to meet at least three of the five metabolic syndrome criteria, which included central obesity, high triglycerides, low high-density lipoprotein, high blood pressure, or impaired fasting glucose. Participants had to provide informed consent and be willing to respond during the study duration.

Exclusion Criteria

Consequently, patients with a prior history of cardiovascular disease, chronic kidney or liver disease, cancer, or chronic corticosteroid medications were not

included in the study. Children, pregnant or lactating women, and people with disabilities or severe illnesses that prevent physical activity were also excluded from the study.

Methods

The participants considered for the study were selected based on the inclusion criteria after seeking their consent. Demographic information, medical history, and anthropometric parameters such as waist circumference, blood pressure, fasting blood glucose, as well as lipid profile, including HDL cholesterol and triglycerides. Lifestyle intervention was done with regard to diet, exercise sessions, and behavioral modification. Specifically, recommendations included avoiding foods high in saturated fats and sugars and increasing the consumption of fruits, vegetables, and whole grains. Physical activity counseling involves moderate-intensity aerobic exercise for at least 150 minutes a week, depending on capabilities. Trials of compliance and metabolic status were taken respectively after three and six months. People were also reminded and followed up on through telephone and group meetings once every month to ensure they complied. Data was analyzed using statistical analytical software, Statistical Package for Social Sciences (SPSS) version 25, and t-tests were used to compare between baseline and post-study measures. Therefore, a p-value below 0.05 was deemed statistically significant.

RESULTS

Patients included in this study were 100 in number, all of whom had been diagnosed with metabolic syndrome. The number of participants' mean age was 49.2 ± 8.6 years old, with 56% of the participants being females and the rest, 44% being males. Regarding the demographic and clinical parameters, the results depicted that central obesity and hypertension were significantly present in a large number of participants. Lifestyle intervention was well managed, with 87% of the patients attending all the sessions and follow-up appointments.

Patients with metabolic syndrome saw significant changes in a number of CV risk factors after three months of a more directed and focused lifestyle modification. Specifically, mean waist circumference lowered from 102.6 ± 8.3 cm to 97.1 ± 7.4 cm ($p < 0.001$). This was evidenced further by the decrease in both systolic and diastolic blood pressure. Furthermore, fasting blood glucose and plasma triglycerides were lowered significantly, and the concentration of plasma HDL cholesterol was significantly higher.

Table 1

Changes in Anthropometric and Blood Pressure Parameters Before and After Intervention

Parameter	Baseline Mean ± SD	6-Month Mean ± SD	p-value
Waist Circumference (cm)	102.6 ± 8.3	97.1 ± 7.4	<0.001
Systolic BP (mmHg)	142.5 ± 12.1	132.3 ± 10.4	<0.001
Diastolic BP (mmHg)	91.6 ± 8.5	84.7 ± 7.6	<0.001

Biochemical parameters also reflected substantial improvements. Fasting blood glucose levels declined from a mean of 113.4 ± 14.2 mg/dL to 101.7 ± 11.9 mg/dL. Triglyceride levels showed a mean decrease of 35 mg/dL, while HDL cholesterol improved by an average of 4.5 mg/dL.

Table 2

Changes in Metabolic Biochemical Parameters

Parameter	Baseline Mean ± SD	6-Month Mean ± SD	p-value
Fasting Glucose (mg/dL)	113.4 ± 14.2	101.7 ± 11.9	<0.001
Triglycerides (mg/dL)	186.3 ± 29.4	151.2 ± 26.8	<0.001
HDL Cholesterol (mg/dL)	38.6 ± 6.3	43.1 ± 6.9	<0.001

The number of patients meeting the criteria for metabolic syndrome decreased significantly after the intervention. At baseline, all 100 participants fulfilled at least three criteria. After six months, only 64 patients continued to meet the diagnostic threshold, while 36 were no longer classified as having metabolic syndrome.

Table 3

Prevalence of Metabolic Syndrome Components

Risk Factor	Baseline (%)	6 Months (%)	p-value
Central Obesity	100%	91%	0.01
Elevated Blood Pressure	88%	70%	0.002
High Triglycerides	85%	59%	<0.001
Low HDL Cholesterol	72%	49%	<0.001
Impaired Fasting Glucose	77%	60%	0.004

Overall, the lifestyle intervention program demonstrated significant effectiveness in improving both individual metabolic parameters and overall metabolic syndrome status.

DISCUSSION

Consequently, the results of this study indicate the various gains in patient outcomes of lifestyle interventions in patients with metabolic syndrome to counter cardiovascular risks. The results of clinical and biochemical tests focusing on such parameters as waist circumference, blood pressure, fasting glucose, triglycerides, and HDL cholesterol significantly changed for the better during the six-month intervention course. These findings are opportune with other literature in supporting non-pharmacologic interventions in managing metabolic syndrome. Many lifestyle intervention trials have demonstrated improvements in the health-related quality of life and delays in the advancement of chronic diseases that are related to metabolic syndrome. Marcos-Delgado et al. conducted a

meta-analysis study that aimed to establish that comprehensive lifestyle programs significantly impact both the physiological and psychological aspects of adults with Metabolic Syndrome (1). This can be explained in light of the present study's findings that a structured lifestyle intervention will help to mitigate the prevalence of the risk components so that several people no longer meet the criteria for metabolic syndrome diagnosis.

The high overall point prevalence of central obesity and hypertension seen in the current study participants is in agreement with findings from Russians presented by Rus et al. in this prospective study on cardiovascular health (2). The decrease in the mean value of and reduction in WC and BP over six months, as seen in the current study, supports the importance of modifying behaviors, including nutrition and physical activity. These decrease not only the cardiovascular risk in the short term but also in the long term. The authors of this systematic review have found that both aerobic, resistance and a combination of exercise programs are useful in metabolic syndrome, with the combined approaches offering the best results (3). The present study adopted moderate aerobic exercise training that can be performed by subjects most of the time, and this may have facilitated the changes in the subjects' anthropometric features, blood pressure, and lipid profiles. Therefore, it can be expected that future research studies might benefit from adding resistance training to achieve even more favorable results.

The other factor that needs to be considered is diet change. Wagner et al. pointed out that a change of diet to accommodate for less processed foods and shifting focus towards micronutrient-dense foods presents benefits at this systemic level, including decreasing genomic instability (4). This could explain why compliers in this study received dietary guidance on increasing vegetables, fruits, whole grains, and lean protein intake, which positively impacted lipid profile and glycemia. These outcomes are particularly relevant due to the systemic character of metabolic syndrome discussed by Targher and others, who pointed out its connection with liver disease and cancer through inflammatory and insulin resistance processes (5). Metabolic syndrome and hypertension show that integration of care is an excellent option. According to Stanciu et al., in hypertension-related patients diagnosed with metabolic syndrome, treatment remains a challenge, especially when dealing with drug interactions as well as the side effects of antidiabetic medications (6). Lifestyle intervention was used in this study as the non-pharmacological approach or adjunct to pharmacological treatment to minimize the use of drugs while improving clients 'cardiovascular health.

Rosenthal et al. further revealed how such aspects of lifestyle as migration and urbanization have enhanced cases of metabolic syndrome worldwide (7). The present research findings indicate the necessity for locally targeted, culturally sensitive procedures to reverse these trends. For instance, in the Pakistan setting, where dietary transitions and reduced physical activity levels are now emerging as increased concerns arise out of urbanization and changing lifestyles, community-level interventions can be highly effective modes of reversing those negative trends. In addition, Wu et al. examined the co-morbidity of metabolic syndrome with chronic inflammatory diseases, particularly psoriasis, and concluded that both shared the same inflammation system (8). More recently, Ndumele et al. defined the CKM syndrome of the cardiovascular-kidney-metabolic systems in which the three organ systems are interconnected (9). The reduction in blood pressure and improvement in glucose levels seen in this study back this notion that change to one component in lifestyle influences other aspects of the body. Controlling these changes through the use of mHealth and digital technologies also receives attention. Similarly, in a study by Cruz-Cobo et al., the long-term impacts of mobile-based interventions in achieving behavioral modifications after cardiac events were revealed (10).

Another dimension is the sex differences in cardiovascular risk and reactions to intervention. Rajendran et al. stated that there are genetic differences between women and men and pointed out that it is worth adopting gender-specific measures in order to decrease the risks (11). Despite the gender differences that this study considered, future studies will enhance precision by conducting mechanical analyses by gender. The results also have implications for certain population subgroups, including women with PCOS, a group that often has metabolic syndrome. Sangaraju et al. stated that while adults with problematic metabolic profiles are at risk of long-term cardiometabolic consequences, early lifestyle intervention for these populations can reduce such risks (12). Therefore, successful nutrition and lifestyle interventions might be conducted during screening and initial gynecological and primary health check-ups. Diets such as the Mediterranean style, in particular, have demonstrated a good record in improving metabolic risk indicators. Sotos-Prieto et al. also identified that individuals following this diet had a significantly lower mortality rate and metabolic syndrome (13). These aspects of the diet were incorporated into this study's nutritional advice, which could explain the observed metabolic benefits.

Notably, Li et al. demonstrated that the metabolic syndrome negatively affects prognosis in patients with cardiovascular disease (14). These findings indicate that lifestyle interventions have the potential for secondary risk reduction and perhaps primary prevention as well. Lastly, Natesan and Kim highlighted the importance of lipid metabolism and various treatment plans associated

with metabolic diseases (15). Finally, the results of the current study prove that, although pharmacological interventions are often crucial for certain patients, lifestyle modifications can be an efficacious addition/option. Lastly, this study offers powerful support for the use of structured lifestyle interventions aimed at enhancing cardiovascular risk factors in patients with metabolic syndrome. These findings are in concordance with the literature and underscore the need to adopt changes in dietary habits and increase physical activity and behavior modification. The completion of such practices in clinic services could open up the possibility of dealing with the increasing trend of cardiometabolic diseases at a lower cost and expansible manner, especially in developing countries, including Pakistan.

CONCLUSION

This study indicates that properly organized diets and programs to encourage exercise and better health behaviors reverse cardiovascular risk in patients with metabolic syndrome. During the research, participants recorded significant improvements in their waist circumference, blood pressure, fasting glucose, triglyceride levels, and HDL cholesterol levels. Furthermore, a significant number of patients failed to meet the criteria for metabolic syndrome at the final visit, which supports other approaches for improvement in metabolic syndrome. These outcomes are on par with similar studies pushing for the adaptation of lifestyle changes for the management and prevention of further cases of cardiometabolic diseases. Considering the increasing burden of metabolic syndrome and its relationship to cardiovascular disease and mortality across LMICs, including Pakistan, implementing lifestyle changes in primary care is feasible and warranted. Future activities should cover other areas of society and engage in the use of technology to improve the persistence of interventions.

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