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Original Research Article

To Study the Effect of Pranayama on Clinical Predictors of Metabolic Syndrome in Medical Students with Raised Body Mass Index and or Elevated Blood Pressure: A Prospective Interventional Trial

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Abstract:

Background: Metabolic syndrome (MS) involves several risk factors for cardiovascular disease (CVD) and is common among Indian medical students due to their sedentary lifestyle and poor dietary habits [1]. Yoga and Pranayama are becoming popular non-pharmacological strategies to prevent MS through lifestyle modifications.

Aim: To study the effect of pranayama on clinical predictors of metabolic syndrome in medical students with raised body mass index and/or elevated blood pressure.

Methods and Material: After screening 100 undergraduate medical students aged 17 to 20, 32 students with a Body Mass Index (BMI) of 25 or higher and/or elevated blood pressure (systolic BP >120 mm Hg and diastolic BP >80 mm Hg) were selected based on clearly defined inclusion and exclusion criteria. Using block randomization, these students were randomly assigned into two groups: the Interventional Group (N=16) and the Control Group (N=16). Both groups had statistically similar mean values for age, gender distribution, physical activity levels, BMI, waist-to-hip ratio (WHR), body mass composition, lipid profile, fasting blood sugar, and blood pressure. The Interventional Group practiced Pranayama for 25 minutes daily, six days a week, for eight weeks, while the Control Group continued their routine activities. After eight weeks, the parameters previously measured in both groups were reassessed, and the results were analyzed statistically.

Results: The Interventional Group experienced a notable reduction in BMI, waist-to-hip ratio (WHR), fat weight, fat percentage, blood pressure (both systolic and diastolic), serum cholesterol, low-density lipoprotein (LDL) levels, and fasting blood sugar. Additionally, this group experienced a significant increase in lean mass percentage and total body water percentage. In contrast, the Control Group showed no significant changes in these parameters.

Conclusions: Regular practice of Pranayama can serve as an effective non-pharmacological tool for preventing obesity, hypertension, and diabetes, while also optimizing lipid profile, thereby significantly reducing the risk factors associated with metabolic syndrome.

Keywords: Pranayama, Metabolic Syndrome, Obesity, Blood Pressure, Lipid Profile.

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Introduction

Being a young adult can come with its fair share of stress. Many young adults deal with the pressure of choosing a career and striving to meet their goals. These time constraints often result in poor dietary choices and insufficient sleep, which can elevate their risk of metabolic syndrome.

Metabolic syndrome, also known as Syndrome X, is characterized by a cluster of risk factors that increase the likelihood of cardiovascular disease. These risk factors include abdominal obesity (waist circumference > 35 inches for women and 40 inches for men), high blood pressure (≥130/80 mm Hg), impaired fasting blood glucose (≥100 mg/dL), high triglycerides (>150 mg/dL), and low HDL cholesterol (< 40 mg/dL for men and <50 mg/dL for women). According to the NHLBI (National Heart, Lung, and Blood Institute) and the AHA (American Heart Association), a diagnosis of metabolic syndrome is made when a person has at least three of these factors. [2]

Nearly a quarter of the global adult population is affected by metabolic syndrome, which significantly heightens the risk of mortality, heart attack, stroke, and type 2 diabetes. [3] Those afflicted with metabolic syndrome face twice the risk of dying prematurely, triple the chance of experiencing a heart attack or stroke, and are five times more likely to develop type 2 diabetes compared to the general population.[4] Indian medical students often lead stressful and sedentary lives due to extended study hours, demanding schedules, irregular eating habits, and limited opportunities for physical activity.

Recent research highlights the potential of non-pharmacological interventions, such as yoga and pranayama, in managing metabolic syndrome effectively. Pranayama, a practice involving deep breathing exercises, combines the Sanskrit terms 'Prana' (referring to breath or life force) and 'Ayama' (denoting extension or control).[5] Essentially, pranayama focuses on the art of extending and regulating the breath.

Given the alarming rates of overweight and obesity among medical students and the limited research on the effects of pranayama in Northern India, this study set out to investigate how pranayama—one of the core practices in yoga—can influence clinical indicators of metabolic syndrome in students with elevated BMI and/or high blood pressure.

Material and Methods

Study design: Following approval from the Institutional Ethical Committee (Endorsement No. HFW(MS)G-5(Ethic)/2019), this study was conducted in the Department of Physiology at I.G.M.C. Shimla. Based on the findings of a previous study by Kekan DR et al [6], assuming a mean BMI value of 25.28 +/- 1.16 in the experimental group and 26.95 +/- 1.31 in the control group, a sample size of 24 subjects with 12 participants in each group was calculated to find the difference with a confidence interval of 95% and with the power of 90%.

Experimental Protocol: To identify students with raised BMI (≥ 25) and or elevated BP (SBP >120 mmHg and DBP >80 mmHg), informed consent was taken from 100 first-year medical students and their height and weight were measured using the standard protocol. Height was measured without shoes to the nearest 0.1 cm by using a portable stadiometer. Weight was measured in light clothing and bare feet to the nearest 0.5 kg using an Excell simplified digital weighing scale calibrated against a set of standard weights. BMI was calculated by Quetelet's Index as weight in kilograms divided by height in meters squared. Blood Pressure was measured according to the Eighth Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure guidelines [7].

The level of physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ) [8] developed by the WHO for physical activity surveillance. We excluded participants with a history of smoking and alcohol consumption, prior experience in active sports or yoga training, and the use of medications known to affect cardiovascular autonomic functions, such as phenylephrine, clonidine, or metoprolol. Additionally, we excluded students with histories of major surgery, musculoskeletal disorders, bronchial asthma, other respiratory conditions, effort intolerance, exertional chest pain, or palpitations. Out of the initial 100 MBBS students, 32 students who fulfilled the inclusion and exclusion criteria were identified. The enrolled medical students were evenly divided into Interventional and Control groups using the Block Randomization method, and their fasting blood samples were analysed for serum lipid profile and blood sugar.

Body Composition Analysis: The enrolled students were instructed to arrive at the Research Lab in the Department of Physiology by 8:30 AM. They were advised to fast for at least four hours before the test, abstain from exercise for 12 hours, and avoid coffee, tea, chocolate, or alcoholic beverages for 24 hours before the assessment. Waist circumference was measured around the abdomen at the midpoint between the lowest rib and the highest point of the iliac crest, at the end of a gentle exhalation, using a one-inch-wide measuring tape in centimeters. Hip circumference was recorded at the level of the greater trochanter in centimeters, and the waist-to-hip ratio was calculated.

Body Mass Composition was assessed by multi-frequency bioelectrical impedance analysis using Body Stat, Quad Scan 4000 according to the recommendations in the NIH (National Institute of Health) Technology Assessment Statement. [9] The results displayed on the equipment's screen were meticulously recorded. To ensure measurement accuracy, a specific body stat calibrator (500 ohms) was used daily to verify the equipment's reproducibility.

Intervention: For 8 weeks, students in the Interventional group engaged in Pranayama practice six days a week, under the guidance of a qualified Yoga Instructor. These sessions took place from 8:30 to 9:00 AM in the Clinical Laboratory of the Department of Physiology. During each session, participants practiced four types of Pranayama: Kapalbhati, Bhramari, Anulom-Vilom, and Udgeeth Pranayama, performing each technique for a total of 25 minutes with 1-minute rest between each type. The Control group carried out their routine activities and were asked to avoid exercise or practice yoga.

At the end of 8 weeks, subjects in both the groups were reassessed to measure changes in anthropometric parameters, body mass composition, blood pressure, fasting blood sugar, and lipid profile. The collected data was then subjected to statistical analysis.

Statistical Analysis: Mean +/- SD (Standard Deviation) of continuous variables were analysed by paired and unpaired T-test using SPSS software, version 26. Categorical variables such as gender, socio-demographic status, and family history of Hypertension / Diabetes were analysed using percentages and proportions and their association was analysed using the chi-square test. P<0.05 was considered as statistically significant. Two-tailed significance tests were used for all analyses.

Results:

The current study was conducted on 32 undergraduate medical students having BMI (≥25) and or elevated BP. There were 17 males (53.12%) and 15 females (46.88%).

By block randomization, students were divided into the Interventional group (n =16) having mean age of 19.13 ± 0.96 years and Control group (n=16) having mean age 19.00 ± 0.82 years respectively (p= 0.694). Gender distribution (p= 0.480), socioeconomic status (p= 0.999) and physical activity (p= 0.999) were similar in both the groups.

Also, the mean of all baseline anthropometric parameters like WC, HC, WHR, BMI, body mass composition parameters, blood pressure, fasting blood sugar, and lipid profile were statistically similar in both groups as shown in Table 1.

Table 1: Comparison of Baseline parameters in the two groups

Variables	Interventional Group (n=16)	Control Group (n=16)	P-Value
BMI (kg/m^2)	27.18 ± 3.37	27.24 ± 5.02	0.969
WC (cm)	92.44 ± 8.60	94.75 ± 16.06	0.615
HC (cm)	101.66 ± 5.78	103.00 ± 11.97	0.689
WHR	0.91 ± 0.05	0.92 ± 0.05	0.714
Fat Wt. (kg)	21.21 ± 7.43	20.23 ± 11.59	0.776
Fat %	28.64 ± 8.16	25.29 ± 10.24	0.315
Lean Wt. (kg)	52.57 ± 10.70	56.91 ± 10.23	0.249
Lean %	71.36 ± 8.16	74.71 ± 10.25	0.315
TBW (litre)	35.46 ± 6.05	38.34 ± 6.08	0.189
TBW %	48.36 ± 5.01	50.34 ± 6.58	0.346
ECW (litre)	15.93 ± 2.01	16.83 ± 2.27	0.245
ECW %	21.78 ± 1.60	22.04 ± 2.03	0.688
ICW (litre)	20.06 ± 4.26	22.19 ± 4.18	0.163
ICW %	27.28 ± 3.28	28.97± 3.77	0.183
Fasting blood sugar	88.8 ± 11.0	89.4±13	0.617
Cholesterol (mg/dl)	166.00 ± 21.69	159.94 ± 39.82	0.597
TG (mg/dl)	91.50 ± 30.35	116.06 ± 91.79	0.318
HDL (mg/dl)	55.13 ± 11.78	51.00 ± 16.54	0.423
LDL (mg/dl)	92.19 ± 21.36	82.07 ± 28.26	0.268
VLDL (mg/dl)	18.14 ± 6.39	21.93 ± 18.17	0.467
SBP (mm of Hg)	123.75 ± 5.60	123.00 ± 5.11	0.695
DBP (mm of Hg)	82.75 ± 3.64	81.50 ± 3.46	0.328

As depicted in Table 2, after 8 weeks of Pranayama practice, the Interventional Group showed a significant reduction in the mean values of BMI, WC, HC, WHR, Fat weight, Fat %, SBP, DBP, FBS, Serum Cholesterol and LDL. A statistically significant increase was observed in the mean values of Lean Body %, Total Body Water % (TBW %), Extracellular Water % (ECW %), and Intracellular Water % (ICW%).

Table 2: Comparison of Various Study Parameters after 8 Weeks in the Study Group

Variables	Baseline (n=16)	After 8 Weeks (n=16)	P-Value
BMI (kg/m^2)	27.18 ± 3.37	24.6 ± 2.94	0.000
WC (cm)	92.44 ± 8.60	87.38 ± 9.22	0.000
HC (cm)	101.66 ± 5.78	99.00 ± 5.09	0.009
WHR	0.91 ± 0.05	0.88 ± 0.07	0.006
Fat Wt. (kg)	21.21 ± 7.43	15.56 ± 5.11	0.000
Fat %	28.64 ± 8.16	23.74 ± 7.14	0.000
Lean Wt. (kg)	52.57 ± 10.70	50.56 ± 9.84	0.001
Lean %	71.36 ± 8.16	76.26 ± 7.14	0.000
TBW (litre)	35.46 ± 6.05	34.56 ± 5.94	0.014
TBW %	48.36 ± 5.01	52.33 ± 4.67	0.000

ECW (litre)	15.93 ± 2.01	15.53 ± 1.89	0.002
ECW %	21.78 ± 1.60	23.61 ± 1.41	0.000
ICW (litre)	20.06 ± 4.26	19.00 ± 4.06	0.000
ICW %	27.28 ± 3.28	28.61 ± 3.22	0.004
Fasting blood sugar	88.8 ± 11.0	83.4 ± 9.5	0.007
Cholesterol (mg/dl)	166.00 ± 21.69	140.56 ± 25.58	0.001
TG (mg/dl)	91.50 ± 30.35	95.88 ± 35.91	0.714
HDL (mg/dl)	55.13 ± 11.78	54.00 ± 10.54	0.148
LDL (mg/dl)	92.19 ± 21.36	71.31 ± 18.93	0.001
VLDL (mg/dl)	18.14 ± 6.39	18.78 ± 8.83	0.913
SBP (mm of Hg)	123.75 ± 5.60	117.50± 3.14	0.000
DBP (mm of Hg)	82.75 ± 3.64	78.38 ± 2.75	0.001

No statistically significant change was observed in any parameter in the control group after 8 weeks as shown in table 3.

Table 3: Comparison of Various Study Parameters after 8 Weeks in Control Group

Variables	Baseline (n=16)	After 8 Weeks (n=16)	P-Value
BMI (kg/m^2)	27.2 ± 5.02	27.40 ± 5.57	0.770
WC (cm)	94.75 ± 16.06	95.19 ± 14.86	0.635
HC (cm)	103.00 ± 11.97	101.81 ± 10.33	0.07
WHR	0.92 ± 0.05	0.93 ± 0.05	0.06
Fat Wt. (kg)	20.23 ± 11.59	20.00 ± 12.60	0.843
Fat %	25.29 ± 10.25	25.06 ± 10.95	0.799
Lean Wt. (kg)	56.91 ± 10.23	56.32 ± 10.47	0.426
Lean %	74.71 ± 10.25	74.94 ± 10.95	0.799
TBW (litre)	38.34 ± 6.08	37.96 ± 6.38	0.473
TBW %	50.34 ± 6.58	50.72 ± 6.99	0.644
ECW (litre)	16.83 ± 2.27	16.68 ± 2.27	0.489
ECW %	22.04 ± 2.03	22.29 ± 2.31	0.461
ICW (litre)	22.19 ± 4.18	21.75 ± 4.17	0.153
ICW %	28.98 ± 3.77	28.87 ± 3.68	0.749
Fasting blood sugar (mg)	89.4±13	90.01 ± 9.5	0.899
Cholesterol (mg/dl)	159.94 ± 39.82	143.13± 29.84	0.067
TG (mg/dl)	116.06 ± 91.79	100.31± 43.35	0.476
HDL (mg/dl)	51.00 ± 16.54	52.81± 10.63	0.663
LDL (mg/dl)	82.07 ± 28.26	73.40± 26.58	0.113
VLDL (mg/dl)	21.93 ± 18.17	21.79± 9.19	0.833
SBP (mm of Hg)	123.00 ± 5.11	123.00 ± 5.29	0.432
DBP (mm of Hg)	81.50 ± 3.46	82.13 ± 3.96	0.312

Discussion

Metabolic syndrome, also referred to as Syndrome X or insulin resistance, is a condition defined by the World Health Organization as a complex cluster of health issues including abdominal obesity, insulin resistance, hypertension, and hyperlipidemia. Medical students face intense pressures that lead to poor habits, lack of sleep, and stress, combined with fierce competition, increases their risk of developing metabolic syndrome.

Fortunately, accessible and cost-effective lifestyle modifications, such as Yoga asanas and Pranayama, offer promising strategies for both preventing and potentially reversing metabolic syndrome.

Effect of Pranayama on BMI and BMC: After eight weeks of practicing Pranayama, participants in the Interventional Group demonstrated a statistically significant reduction in BMI, waist-to-hip ratio (WHR), body fat weight, and body fat percentage, coupled with a notable increase in lean body mass percentage. In contrast, the Control Group, which did not receive any intervention, showed no significant changes in these parameters. These results align with previous studies, [6,10,11] which observed similar benefits from practices like Kapalbhati, Udgheet, Anulom Vilom, etc. often combined with various Yoga asanas over periods ranging from one to twelve weeks.

Pranayama or yogic breathing, is recognized as a form of abdomino-respiratory-autonomic exercise that stimulates the respiratory, abdominal, and gastrointestinal receptors. The vital areas of the brainstem, cortex, and their efferent pathways are influenced stimulating the effector organs. This results in the synchronous discharge from the autonomic nervous system, pineal gland, and hypothalamus that regulate the endocrine system. The metabolic processes are also triggered which accelerates fat metabolism. [6] All these factors eventually reduce fat deposition and result in weight reduction.

In the present study, Body Composition analysis revealed a statistically significant increase in total body water percentage, extracellular water percentage, and intracellular water percentage (p=0.000). Since adipose tissue contains less water compared to other tissues [12], the reduction in fat mass resulted in a higher proportion of body water. This increase in body water compartments underscores the potential of Pranayama as an effective tool for managing high BMI and promoting cardiovascular health.

Effect of Pranayama on Biochemical Parameters: In the Interventional Group, a significant reduction in fasting blood sugar levels was observed compared to the Control Group, which showed no noteworthy changes. This decline may be attributed to Pranayama, which involves abdominal breathing and potentially revitalizes pancreatic cells. This rejuvenation could enhance the utilization and metabolism of glucose in peripheral tissues, the liver, and adipose tissues through enzymatic processes [13]. Improved insulin kinetics may result from increased sensitivity of target tissues, thereby reducing insulin resistance and boosting peripheral glucose utilization [14].

After eight weeks of Pranayama, the Interventional Group experienced a statistically significant decrease in the mean values of Serum Cholesterol and LDL (from 166.00 ± 21.69 mg/dl to 140.56 ± 25.58 mg/dl, p= 0.001 and from 92.19 ± 21.36 mg/dl to 71.31 ± 18.93 mg/dl, p= 0.001 respectively) with no significant alterations seen in the Control Group. Psychological stress activates the sympathetic nervous system, leading to increased production of serum lipids and lipoproteins due to alterations in lipid metabolism. Catecholamines trigger lipolysis, releasing free fatty acids into circulation. These free fatty acids then serve as a substrate for the resynthesize of triglycerides and the subsequent production of VLDL by the liver. [15] Pranayama, by modulating the autonomic nervous system towards parasympathetic dominance, fosters a relaxed state. [16] This reduction in sympathetic drive may be responsible for the observed improvements in lipid profile parameters.

Effect of Pranayama on Blood Pressure: In the Interventional Group, systolic blood pressure (SBP) decreased from 123.75 ± 5.60 mm Hg to 117.50 ± 3.14 mm Hg, and diastolic blood pressure (DBP) fell from 82.75 ± 3.64 mm Hg to 78.38 ± 2.75 mm Hg. Changes seen after 8 weeks in the Control Group were statically insignificant. Voluntary slow, deep breathing effectively resets the autonomic nervous system through stretch-induced inhibitory signals and hyperpolarization currents that travel through both neural and non-neural tissues. This process synchronizes neural elements across the heart, lungs, limbic system, and cortex, contributing to a shift toward parasympathetic dominance. [16]

Conclusion: This study postulates that mind-body exercises such as Pranayama couples sustained muscular activity with internally directed focus, producing a temporary self-contemplative mental state. It may reduce adiposity and ameliorate blood pressure, biochemical parameters along with body mass composition. Pranayama, as a form of yogic breathing exercise, shows promise as a cost-effective, safe, and beneficial therapeutic approach for preventing metabolic syndrome and its associated complications.

Limitations

We acknowledge some limitations in the present study. It was conducted with a relatively small sample size and over a brief period at a single center. To validate these findings more robustly, future research should involve longer-duration, multicentric studies with larger samples of overweight or obese populations, and should be conducted in fully controlled environments.

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