

ORIGINAL RESEARCH

Effect of Yoga and Naturopathy-Based Lifestyle Intervention on Inflammatory Markers on Obese Individuals: A Prospective Randomized Controlled Trial

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ABSTRACT

Background • Obesity is characterized by abnormal accumulation of fat in adipose tissue. It is a major risk factor for metabolic syndrome caused by chronic inflammatory changes. Naturopathy and yogic intervention are a holistic approach. So, the present study aims to assess the effect of naturopathy and yogic intervention on inflammatory markers among obese individuals.

Methods: In this randomized controlled trial, 262 subjects were recruited and randomized into either an experimental or control group with 131 subjects in each group aged 35 ± 9.6 years in experimental and 39.3 ± 9.6 years in control group. The experimental group received 10 days of naturopathy and yogic treatment. The control group didn't receive any naturopathy or yogic treatment. Complete blood count (CBC) was tested at baseline and after 10 days of intervention.

Results • The study showed a significant reduction in white blood cells (WBC), Neutrophils, and Lymphocytes with mean values of 1.63 ± 0.38 , 1.14 ± 0.25 , 0.4 ± 0.09 and an increase in Platelet lymphocyte ratio (PLR) with mean value 19.84 ± 4.97 respectively with a $P < .001$ in experiment group when compared to the control group. The experimental group also showed a reduction in Platelet and Neutrophil lymphocyte ratio (NLR) with a mean value of 11.28 ± 3.5 & 0.18 ± 0.03 with a $P = .01$ when compared to the control group.

Conclusion • Obesity being a major risk factor for metabolic syndrome could be safely and effectively treated with naturopathy and yogic intervention by alleviating the inflammatory markers. (*Adv Mind Body Med.* 2024;38(3):##-##.)

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INTRODUCTION

Obesity is a condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health is impaired. It has become a major epidemic and is linked to diseases such as metabolic syndrome, type 2 diabetes, and

atherosclerotic cardiovascular disease.¹ World Health Organization (WHO) classifies having a Body Mass Index (BMI) greater than or equal to 25 as overweight, and obesity for a BMI ≥ 30 .² The prevalence of obesity has increased worldwide to pandemic proportions over the past 50 years. Currently over half a billion adults are obese. The documented global epidemic of obesity has been increasing at an alarming rate, particularly in developing countries.³ Obesity exacerbates the age-related decline in physical function and causes frailty in older adults.⁴ It causes various psychological, social, and economic implications, which lead to increased morbidity, mortality, and economic losses.⁵ It has a negative impact on many tissues and systems in the body that are associated with various mechanisms, especially inflammation. Obesity-induced low-grade inflammation is attributed to various non-communicable diseases and is studied using different biomarkers.⁷

Complete blood count (CBC) is a cost-effective and simple blood test. Neutrophils and lymphocytes constitute the first line of defense against infection and play a major role in inflammation. The neutrophil-to-lymphocyte ratio (NLR), is a novel inflammatory biomarker used as a prognostic marker in various diseases.⁸ Similarly, White blood cells (WBC) in particular are also considered as a systemic

inflammatory marker in Obesity. A recent report from by the American College of Sports Medicine reported that Yoga got the popularity in the field of wellness and fitness.⁹

Due to the complex and multi-factorial nature of obesity, a holistic approach is often identified as best practice. Lack of awareness, emotional triggers, hormone imbalance, stress & neurotransmitter imbalances are the most common cause of obesity. Long-term sustainable health optimization requires a planned lifestyle change.¹⁰ In obese adults, mind-body fitness mostly consists of sessions that integrate body postures, effective breathing patterns, meditation, and relaxation to reduce physical limits, chronic pain, and stress while promoting muscular control, body functioning, flexibility, and balance. A body movement-based strategy like this might lead to better mental and cardiometabolic health as well as enhanced physical performance.¹¹ Based on the benefits of psychophysiological adaptations to Yoga practice in obese individuals has a multisystem effects by improving various anthropometric and body composition variables, cardiovascular disease risk factors, physical fitness parameters, quality of life, and stress.¹² Yoga is a simple and economical therapeutic modality that may be considered as a beneficial adjuvant for many health problems.¹³ A brief guide from the Department of Physical Education and Sport Science, University of Thessaly, Trikala, Greece stated that A comprehensive diabetes care strategy that includes both aerobic and resistance exercise can be quite effective in combating this chronic metabolic illness. For a successful and pleasurable workout in a gym setting, progression and customized exercise programming are essential.¹⁴ It is a kind of low-intensity physical activity and is used for therapeutic purposes.¹⁵ Yoga plays a significant role in weight reduction and weight management.¹⁶ The current study aims at evaluating the effects of yoga and naturopathy treatments on inflammatory markers in obesity.

LITERATURE OF REVIEW

Since obesity affects about one in three persons in the world and is a complicated metabolic condition with several comorbidities, it is seen as a serious public health concern. Notably, obese people are more likely to have low levels of physical activity, poor mental health, and limited functional ability.¹⁷ By enhancing mindfulness and the mind-body connection, lowering stress, and enhancing mood, yoga may improve lower energy intake.¹⁸ Regular yoga practice is linked to higher dietary quality and better emotional eating management in people who are not obese.¹⁹ People who used yoga to lose weight reported better self-esteem, more awareness and focus, and a shift in mentality away from weight loss and toward health in a qualitative study.²⁰ Additionally, since yoga can improve physical function, isometric strength, cardiorespiratory fitness, and balance in addition to reducing back and joint pain, some of the barriers to adopting and sustaining PA may be lessened by practicing particular yoga postures.²¹ Additionally, since yoga can improve physical function, isometric strength, cardiorespiratory fitness, and

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Along with this mind-body medicine naturopathy interventions Naturopathic medicine, which is one of the alternative medical systems focus on correcting the underlying imbalances occurred due to sedentary lifestyle and requires a proper plan of care to support for a long-term sustainable health.²³ Naturopathy treatments consist of diet therapy, mud therapy, hydrotherapy, manipulative therapy, acupuncture and chromotherapy.²⁴ Hydrotherapy is a modality of naturopathy treatments that uses water in different forms for treating various health conditions in varying temperature as in hot and cold baths, packs, vapor, steam, internally and externally.²⁵

Hydrotherapy modalities like cold immersion, alternate compresses also showed their effect in reducing the anthropometric parameters through the influence of cold by the activation of brown adipose tissue which helps in the fat mobilization.²⁶ Another study has shown that hydro kinesitherapy in thermal sitting in patients with obesity, have reduced pain, improvement in their joint function and walking speed has increased. The positive effects of balneotherapy on biochemical parameters and adipokines were noted among obese individuals. There was decreased triglycerides, total cholesterol; low-density lipoprotein, glycaemia and serum levels of leptin and high sensitivity C-reactive protein.^{27,28}

Balneotherapy has been used in treating musculoskeletal diseases. A study has shown that balneotherapy decrease the amount of body fat and BMI, where the effect lasted for 1 year.^{29,30} The adipocytes or adipose tissue macrophages produce adipokines that induce a low grade chronic inflammatory state which is considered to have a major role in obesity related cardiovascular complications and insulin resistance.³¹ Other studies have shown that leptin that acts as a signalling molecule of metabolic status and which mediates some metabolic processes that includes energy homeostasis, neuroendocrine functions, etc. hyper leptinemia and leptin resistance are associated with type2 diabetes mellitus, hence lowering these circulating leptin levels improve the insulin sensitivity and inflammation.^{32,33} In obese individuals, the concentration of leptin in plasma is increased and it correlates with body fat mass. leptin is considered to be an important mediator between obesity and the development of CVDs.³⁴⁻³⁶ namely white, brown, and beige, that reside in various specific anatomical locations throughout the body. The cellular composition, secretome, and location of these adipose depots define their function in health and metabolic disease. In obesity, adipose tissue becomes dysfunctional, promoting a pro-inflammatory, hyperlipidemic and insulin resistant environment that contributes to type 2 diabetes mellitus (T2DM). A repeated application of therapeutic peloids reduces the severity of the inflammatory process in the adipose tissue as evidenced by a decrease in the levels of proinflammatory cytokine NMF-alpha and adiponectin hyperproduction.³⁷

Figure 1. Illustration of trail profile

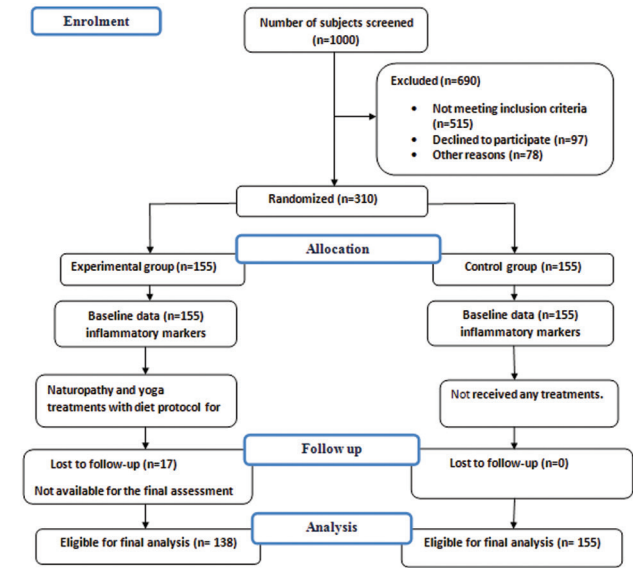


Table 1. treatment protocol of experimental group for 10 days

Days	Morning Treatment	Afternoon Treatment	Night Treatment
Day 1	Steam Bath	Cold Hip Bath	Cold Abdominal Pack
Day 2	Full Body Massage	Gastro Hepatic Pack	Cold Abdominal Pack
Day 3	Sauna Bath	Cold Hip Bath	Cold Abdominal Pack
Day 4	Cold Circular Jet	Gastro Hepatic Pack	Cold Abdominal Pack
Day 5	Salt Glow Oil Massage	Cold Hip Bath	Cold Abdominal Pack
Day 6	Colon Hydro Therapy	Cold Hip Bath	Cold Abdominal Pack
Day 7	Full Mud Bath	Gastro Hepatic Pack	Cold Abdominal Pack
Day 8	Cold Douche To Whole Body	Cold Hip Bath	Cold Abdominal Pack
Day 9	Cold Under Water Massage	Cold Hip Bath	Cold Abdominal Pack
DAY 10	Reclining Steam Bath	Cold Immersion Bath	Cold Abdominal Pack

Table 2. Detailed food composition of experimental group for 10 days

DAY	7:30 AM	9:00 AM	11-12:30 PM	2:00 PM	4:00 PM	6:30-7:30 PM
Day 1	AGJ-250ml	BW-250ml	100 BV+ 100 Rice+100 Papaya+200BM	LHJ-250ml	BW-250ml	100 RV + 50 sprouts + 100gm papaya+200ml BM
Day 2	AGJ-250ml	BW-250ml	200 Papaya + 200BM	LHJ-250ml	BW-250ml	200 Papaya + 200BM
Day 3	AGJ-250ml	BW-250ml	LHJ-250ml	LHJ-250ml	BW-250ml	LHJ-250ml
Day 4	AGJ-250ml	BW-250ml	LHJ-250ml	LHJ-250ml	BW-250ml	LHJ-250ml
Day 5	AGJ-250ml	BW-250ml	LHJ-250ml	LHJ-250ml	BW-250ml	LHJ-250ml
Day 6	AGJ-250ml	BW-250ml	LHJ-250ml	LHJ-250ml	BW-250ml	LHJ-250ml
Day 7	AGJ-250ml	BW-250ml	MJ-250ml	LHJ-250ml	BW-250ml	LHJ-250ml
Day 8	AGJ-250ml	BW-250ml	200 gm Papaya + 200BM	LHJ-250ml	BW-250ml	200gm Papaya+200BM
Day 9	AGJ-250ml	BW-250ml	100 RV + 50 sprouts +100gm papaya+200ml BM	LHJ-250ml	BW-250ml	100 RV + 50 sprouts +100gm papaya + 200ml BM
Day 10	AGJ-250ml	BW-250ml	100 BV+ 100 Rice+ 100 Papaya+200BM	LHJ-250ml	BW-250ml	200ml mixed vegetables + 100gm boiled vegetable + 2 chapathis + 100 gm papaya

Visfatin is an adipokine that is responsible for the endothelial dysfunction that causes progression of atherosclerosis and is a risk factor for CVDs, that increases in obesity, insulin resistance, type 2 diabetes mellitus and other pro-inflammatory states. Balneotherapy decreases the levels of leptin and visfatin among obese individuals.^{35,38} Sleep plays a major role in healthy lifestyle, as sleep affects the individual's quality of life and well-being. A poor sleep quality causes an increase in the body weight and obesity due to impaired neurohormonal functions.³⁹ Balneotherapy has shown to relieve mental stress, fatigue and improvement in quality of sleep among obese individuals.⁴⁰

Table 3. Yoga Protocol For Obesity - 10 Days

SL. No	Yoga practice		Rounds	Duration
1	Kriyas	Jala neti Sutra neti Vamana douthi	1 on each side 1 on each side 1 (Day 3 & Day 7)	20 minutes
2	Sukhasana + prarthana mantra		1	1 min
3	Loosening exercises and stretching	Neck movements	5	30 sec
		Arm, shoulder and wrist movements	5	30 sec
		Hip rotation and stretch	5	30 sec
		Spinal twist and stretch	5	30 sec
		Jogging	--	1 min
		Jumping	5	1 min
4	Suryanamaskara		6	10 min
5	Standing series	Ardhachakrasana	1	1 min
		Trikonasana	1	1 min
		Padahasthasana	1	1 min
6	Supine series	Utthithapadasana	1	1 min
		Naukasana	1	1 min
		Pawanamuktasana	1	1 min
7	Prone series	Bhujangasana	1	1 min
		Shalabasana	1	1 min
		Dhanurasana	1	1 min
8	Sitting series	Paschimottanasana	1	1 min
		vakrasana	1	1 min
9	Instant relaxation technique		1	2 min
10	Pranayama	Bhastrika (bellows breathing)	50 strokes	2 min
		Kapalabhati	120 strokes	3 min
		Nadishodhana (alternate nostril breathing)	6	6 min
		Surya anulomaviloma	12	6 min
11	Deep relaxation technique		1	15 min
Total				60 minutes

MATERIALS AND METHODS

Total of 1000 subjects from a Naturopathy hospital in Karnataka, South India were screened and 262 subjects were included in the study. Prior to the enrolment, informed consent was obtained. Consent form explained the procedure, study objectives and all the rights of the subject pertaining to the conduct of the study both orally and in writing. The data was collected at baseline (Day 1) and post-intervention (Day 11) which is shown in Figure 1. Individuals who have been diagnosed with a body mass index (BMI) ≥ 25 kg/m² as per the criteria of World Health Organization, aged between 20-65 years, with Waist circumference 90 cm for men and 80 cm for women were included in the study. Morbid obesity (BMI > 40 kg/m²), Obesity secondary to hormonal imbalances and drug therapy, individuals with Thyroid disorder and other comorbid medical conditions such as uncontrolled hypertension, hypercholesterolemia, type I and II diabetes mellitus, pregnant, and lactating females, were excluded for the study.

Design of the study

This study is a single-centered, single-blinded (parallel-arm), prospective randomized controlled trial, approved by the Institutional Ethical Committee. Individuals were allocated into either the experimental group or the control group by simple randomization by computer-generated method. The randomization was maintained by a naturopathy and yoga medical professional, who was not involved in the individual's recruitment or data collection.

Intervention

Individuals admitted to the sri Dharmasthala Manjunatheshwara (SDM) Yoga and Nature Cure Hospital, Ujire, Karnataka were given naturopathy and yoga treatments for 10 days along with the naturopathic diet protocol shown in Table 1-3. Individuals were kept away from their daily routines.

They had to maintain complete physical and mental rest during the study period with minimal activity. The individuals were instructed to drink approximately 3 L of water per day during the time of intervention. Throughout the intervention period; individuals were under the supervision of a trained naturopathy and yoga physician for 10 days.

Outcome measures

All the individuals in experimental group and control group were assessed by a naturopathy and yoga physician with the following parameters obtained from the complete blood count test at the baseline and after 10 days treatment. The outcome assessment was conducted by a doctor who was blind to the study.

Complete Blood Count

Venous blood (7 ml) was drawn into evacuated, serum separator tubes after 12 h fasting. Complete blood cell count was performed. It includes the assessment of RBC, differential count, hemoglobin, platelets by using Erba Mannheim EM-360 auto analyzer following the instructions provided in the manual.

Statistical Analysis:

The data was analyzed in SPSS v 20. Depending on the distribution of the variables, the results are expressed as proportions (number or percentage), mean standard deviation (SD) or median and interquartile range. The pre-post comparison was done using paired *t* test. Descriptive analysis was done using appropriate tests. *P* < .05 is considered significant.

Sample size has been calculated using G* power version 3.1.9 by considering 1:1 allocation ratio for a parallel arm design with 0.25 effect size, 80% power, 5% level of significance and an expected attrition rate of 25% for paired *t* test assumptions, it was found to be 131 per group, 262 subjects in total.

RESULTS

All the subjects of the case group underwent the interventions according to the designed protocol for 10 days. The data obtained were analysed for normality using the Kolmogorov Smirnov test. The data of both groups were analysed within group by dependant *t* test and between groups by independent *t* test.

In the test group, there were 52% females and 47% males with a mean age of 35.03 years. In the control group, 48% were females and 53% were males with a mean age of 39.32 years. The demographic variables at baseline are shown in Table 4.

Experimental group after 10 days of intervention showed statistically significant reduction in mean values of WBC, Neutrophil, Lymphocytes with mean value of 1.63±0.38, 1.14±0.25, 0.4±0.09 and increase in PLR with mean value 19.84±4.97 respectively with *P* < .001. Experimental group also showed considerable reduction in Platelet and NLR with mean value of 11.28± 3.5 & 0.18± 0.03 with *P* = .01. RBC's and haemoglobin showed reduction with mean value of

Table 4. Demographic Variables at Baseline of Two Groups

	Test Group	Control Group
Age	35 ± 9.6	39.3 ± 9.6
Height	163.7 ± 9	171.7 ± 110.2
Weight	83.28 ± 11.87	79.91 ± 12.68

Table 5. Change in inflammatory markers in the Experiment Group

Variables	Baseline	After 10 days	P value	Difference (Mean ± SD)
WBC (10 ⁹ /UL)	7.60 ± 1.84	5.97 ± 1.46	<.001*	1.63 ± 0.38
RBC (10 ⁹ /UL)	4.88 ± 0.63	4.85 ± 0.56	.370	0.03 ± 0.07
HB (g/dL)	13.82 ± 1.90	13.70 ± 1.71	.160	0.12 ± 0.19
PLT (10 ⁹ /UL)	285.45 ± 58.10	274.17 ± 61.60	.010*	11.28 ± 3.50
Neutrophil (10 ⁹ /UL)	4.36 ± 1.37	3.22 ± 1.12	<.001*	1.14 ± 0.25
Lymphocyte (10 ⁹ /UL)	2.38 ± 0.64	1.98 ± 0.55	<.001*	0.40 ± 0.09
NLR	1.90 ± 0.67	1.72 ± 0.70	<.010*	0.18 ± 0.03
PLR	127.66 ± 42.50	147.50 ± 47.44	<.001*	19.84 ± 4.97

**P* < .05 is considered significant

Abbreviations: WBC, White blood cells; RBC, Red blood cells; HB, Haemoglobin; NLR, Neutrophil lymphocyte ratio; PLR, Platelet lymphocyte ratio.

Table 6. Change in inflammatory markers in the Control Group

Variables	Baseline	After 10 days	P value	Difference (Mean ± SD)
WBC (10 ⁹ /UL)	7.03 ± 1.48	6.82 ± 1.55	.19	0.21 ± 0.07
RBC (10 ⁹ /UL)	5.06 ± 0.80	4.93 ± 0.57	.05	0.13 ± 0.23
HB (g/dL)	14.00 ± 2.33	13.65 ± 1.90	.04	0.35 ± 0.43
PLT (10 ⁹ /UL)	260.80 ± 56.61	256.90 ± 59.90	.50	3.90 ± 3.29
Neutrophil (10 ⁹ /UL)	3.64 ± 1.02	3.47 ± 1.14	.17	0.17 ± 0.12
Lymphocyte (10 ⁹ /UL)	2.42 ± 0.59	2.35 ± 0.56	.18	0.07 ± 0.03
NLR	1.56 ± 0.52	1.53 ± 0.58	.53	1.03 ± 0.06
PLR	113.00 ± 35.79	114.98 ± 37.83	.58	1.98 ± 2.04

Abbreviations: WBC, White blood cells; RBC, Red blood cells; HB, Haemoglobin; NLR, Neutrophil lymphocyte ratio, PLR, Platelet lymphocyte ratio.

Table 7. Between groups (independent *t* test)

Variables	Experiment group (post)	control group (post)	P value	Effect size
WBC (10 ⁹ /UL)	5.97 ± 1.46	6.82±1.55	<.001	0.2888
RBC (10 ⁹ /UL)	4.85 ± 0.56	4.93±0.57	.322	0.0673
HB (g/dL)	13.7 ± 1.71	13.65±1.90	.769	0.0200
PLT (10 ⁹ /UL)	274.17 ± 61.6	256.9±59.9	.022	0.1560
Neutrophil (10 ⁹ /UL)	3.22 ±1.12	3.47±1.14	.048	0.1343
Lymphocyte (10 ⁹ /UL)	1.98 ± 0.55	2.35±0.56	<.001	0.3176
NLR	1.72 ± 0.7	1.53±0.58	<.001	0.3311
PLR	147.5 ± 47.44	114.98±37.83	<.001	0.3986

Abbreviations: WBC, White blood cells; RBC, Red blood cells; HB, Haemoglobin; NLR, Neutrophil lymphocyte ratio, PLR, Platelet lymphocyte ratio.

0.03±0.07, 0.12±0.19 was not significant which is shown in Table 5. Control group results showed almost comparable changes at baseline and after the follow up in the complete blood count including WBC, RBC, Platelets, neutrophils and lymphocytes which is shown in Table 6.

DISCUSSION

A significant improvement in the Neutrophil Lymphocyte Ratio, Platelet Lymphocyte Ratio and WBC with the yoga and naturopathy intervention group when compared to the control group.

The result of the present study showed significant decrease in inflammatory markers which is found to interact with leptin hormone and modulate its function.⁴¹ Leptin plays a role in hematopoiesis, inflammation and immunologic reaction in humans, and that the increased WBC counts often observed in obese people may be mediated by an

increased leptin concentration.⁴¹ Leptin has the capability to modulate C-Reactive Protein (CRP) expression levels indirectly through other proinflammatory molecules like IL-6 and directly through promoting the production of CRP via hepatic and vascular mode.⁴² The extracellular availability of CRP and leptin leads to coprecipitation, which in turn impairs leptin ability to bind to the leptin receptor and activate intercellular signaling.⁴³

Obesity is considered as a major risk factor for cardiovascular diseases because of increased neutrophil count. Increased neutrophils migrate through bloodstream into the ischemic myocardial tissue before other inflammatory cells causing destructive change by releasing proteolytic enzymes and reactive oxygen species.⁴⁴ This might be the leading cause along with the development of atherosclerotic changes for the development of cardiovascular diseases. Meanwhile inappropriate activation of circulating neutrophil in obese adolescents suggest continuous activation of innate immunity which results in higher neutrophil count and acute inflammation on the microvasculature leading to pathological manifestation of various liver diseases.⁴⁵⁻⁴⁷ Lymphocytes beside leukocytes are correlated with anthropometric parameters of obesity and high-density lipoprotein (HDL) concentration, and lymphocytes alone is correlated with increased insulin level. Hence neutrophil and lymphocyte count makes NLR a strong inflammatory marker in metabolic syndrome,⁴⁸ NLR is an ideal factor to evaluate the balance between the innate and adaptive immunity,⁴⁹ and it can be used to predict the development of metabolic syndrome in early stage.

Leptin also plays a role in platelet function which is indeed modulated in various condition associated with obesity such as low grade pro-inflammatory state, insulin resistance, change in leptin and adiponectin level, oxidative stress or endothelial function.⁵⁰ Platelets are described as hyperactive, mainly based on increased platelet size and presence of pro-thrombotic plasmatic molecules. We explored platelet functions, including calcium signalling in obesity, and the effect of weight loss. We included 40 obese patients (women with body mass index [BMI] of ≥ 35 kg/m²). The leptin receptor expressed in platelets potentiates the aggregation of platelets induced by antagonists.⁵¹

Platelet lymphocyte ratio (PLR) which is calculated by dividing the platelet count by the lymphocytes has been identified as a biomarker of inflammation and proved to be significant marker for prognosis.⁵² PLR or PCT (Plateletcrit) may be more useful as a marker in determining an increased thrombotic state and inflammatory response in morbidly obese patients.⁵³ Hence based on the above literature, reduction of fat percentage results in inhibiting inflammatory reaction in obese individuals by regulating leptin levels which in turn is beneficial in reducing WBC, Neutrophil, Platelet, etc.

Intensive styles of yoga lead to higher energy consumption, observed to impact anthropometric measures along with reduction in proportion of body fat and BMI.⁵⁴

Yoga not only focuses on weight loss but also has beneficial effect on improving cardio-respiratory fitness.⁵⁵ A recent systematic review and network meta-analysis shown that multicomponent exercise treatments are more effective than single-component modalities these gave the literature for the integration of other treatment modalities which includes yoga, physical exercise, and mind body modalities for better outcome.⁵⁶⁻⁵⁸ the most effective exercise type for improving cardiometabolic health in individuals with overweight/obesity remains largely undecided. This network meta-analysis aimed to evaluate and rank the comparative efficacy of 5 exercise modalities on cardiometabolic health measures in individuals with overweight/obesity. \nMETHODS: A database search was conducted in MEDLINE, Embase, Scopus, and Web of Science from inception up to September 2020. The review focused on randomized controlled trials involving exercise interventions consisting of continuous endurance training, interval training, resistance training, combined aerobic and resistance training (combined training also the favourable results were observed when it is combined with the diet.⁵⁹ Previous literature shows that Naturopathic treatment including hydrotherapy, diet, fasting therapies, and massage therapy has shown beneficial effect on weight loss along with reduction in target organ damage.^{60,61} Hydrotherapy treatments with application of cold temperature (18-24°C) is proven to be effective in treating obesity as it increases energy expenditure by increasing fuel uptake through cold activated brown adipose tissue⁶² whereas sauna baths, not only increase the metabolism but also has an influence on CRP which helps to reduce systemic inflammation,⁶³ which, in turn, may affect leptin level. A healthy diet plays multifactorial action on obesity which focus on low energy intake through low calorie diet which results in meaningful weight loss regardless of which macronutrients focused in the diet.⁶⁴ addition of dietary fibers improves satiety and helps to improve digestion and absorption through enhancing gut microbiota.⁶⁵ Along with effect on serum lipid, specific component like Coumaric acid and ferulic acid in barley inhibits adipogenesis.⁶⁶ Short-term juice fasting with lemon honey juice and other vegetable juice not only reduces BMI and fat percentage but helps to provide necessary antioxidants and phytonutrients as it is supplied in concentrated form, which helps to combat inflammatory markers.⁶⁸ Hence multidimensional approach is necessary to treat obesity and reduce its risk factors.

Further research is needed on potent inflammatory markers like C-reactive protein (CRP), tumor necrosis factor [TNF]- α and interleukins with long-term studies needed to prove the effect of naturopathy and yogic interventions on ameliorating inflammation in obese individuals.

Limitations of the present study are, that since the criteria for defining obesity in Asian Indians were applied, the results of this study cannot be applied to other demographic groups. The studies' short-term effect is one of the limitations.

CONCLUSION

Obesity being the major risk factor for metabolic syndrome can be treated and controlled through various naturopathic and yogic interventions along with a specific diet focusing on a low-calorie vegetarian diet. Naturopathy and yogic intervention being non-invasive, cost-effective, and easily available treatments, the clinical implication of the present findings shows that these integrated approach helps to reduce the low-grade inflammation in obesity, with the early awareness of obesity can help to prevent late-stage negative impacts on the body and organ tissues.

AUTHOR DISCLOSURE STATEMENT

The authors declare that they have no competing interests.

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REFERENCES

- Ofei F. Obesity - a preventable disease. *Ghana Med J*. 2005;39(3):98-101.
- Lin X, Li H. Obesity: Epidemiology, Pathophysiology, and Therapeutics. *Front Endocrinol (Lausanne)*. 2021;12:706978. doi:10.3389/fendo.2021.706978
- Blüher M. Obesity: global epidemiology and pathogenesis. *Nat Rev Endocrinol*. 2019;15(5):288-298. doi:10.1038/s41574-019-0176-8
- Villareal DT, Chode S, Parimi N, et al. Weight loss, exercise, or both and physical function in obese older adults. *N Engl J Med*. 2011;364(13):1218-1229. doi:10.1056/NEJMoa1008234
- Lemamsha H, Papadopoulos C, Randhawa G. Understanding the risk and protective factors associated with obesity amongst Libyan adults - a qualitative study. *BMC Public Health*. 2018;18(1):493. doi:10.1186/s12889-018-5411-z
- Bertakis KD, Azari R. Obesity and the use of health care services. *Obes Res*. 2005;13(2):372-379. doi:10.1038/oby.2005.49
- Karakaya S, Altay M, Kaplan Efe F, et al. The neutrophil-lymphocyte ratio and its relationship with insulin resistance in obesity. *Turk J Med Sci*. 2019;49(1):245-248. doi:10.3906/sag-1804-68
- Zahorec R. Ratio of neutrophil to lymphocyte counts--rapid and simple parameter of systemic inflammation and stress in critically ill. *Bratisl Lek Listy*. 2001;102(1):5-14.
- Newsome AM, Reed R, Sansone J, Batrakoulis A, McAvoy C, W. Parrott M. 2024 ACSM Worldwide Fitness Trends: Future Directions of the Health and Fitness Industry. *ACSM's Health Fit J*. 2024;28(1):14-26. doi:10.1249/FIT.0000000000000933
- Koithan M, Sutherland E. Naturopathic Treatment of Obesity. *J Nurse Pract*. 2009;5(9):693-694. doi:10.1016/j.nurpra.2009.07.019
- Batrakoulis A. Role of Mind-Body Fitness in Obesity. *Diseases*. 2022;11(1):1. doi:10.3390/diseases11010001
- Batrakoulis A. Psychophysiological Adaptations to Yoga Practice in Overweight and Obese Individuals: A Topical Review. *Diseases*. 2022;10(4):107. doi:10.3390/diseases10040107
- Ross A, Thomas S. The health benefits of yoga and exercise: a review of comparison studies. *J Altern Complement Med*. 2010;16(1):3-12. doi:10.1089/acm.2009.0044
- Batrakoulis A, Jamurtas AZ, Fatouros IG. Exercise and Type II Diabetes Mellitus: A Brief Guide for Exercise Professionals. *Strength Condit J*. 2022;44(6):64-72. doi:10.1519/SSC.0000000000000731
- Bull FC, Al-Ansari SS, Biddle S, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med*. 2020;54(24):1451-1462. doi:10.1136/bjsports-2020-102955
- Guarracino JL, Savino S, Edelstein S. Yoga Participation Is Beneficial to Obesity Prevention, Hypertension Control, and Positive Quality of Life. *Top Clin Nutr*. 2006;21(2):108-113. doi:10.1097/00008486-200604000-00006
- Fruh SM. Obesity: risk factors, complications, and strategies for sustainable long-term weight management. *J Am Assoc Nurse Pract*. 2017;29(S1):S3-S14. doi:10.1002/2327-6924.12510
- Alert MD, Rastegar S, Foret M, et al. The effectiveness of a comprehensive mind body weight loss intervention for overweight and obese adults: a pilot study. *Complement Ther Med*. 2013;21(4):286-293. doi:10.1016/j.ctim.2013.05.005
- Watts AW, Rydell SA, Eisenberg ME, Laska MN, Neumark-Sztainer D. Yoga's potential for promoting healthy eating and physical activity behaviors among young adults: a mixed-methods study. *Int J Behav Nutr Phys Act*. 2018;15(1):42. doi:10.1186/s12966-018-0674-4
- Ross A, Brooks A, Touchton-Leonard K, Wallen G. A Different Weight Loss Experience: A Qualitative Study Exploring the Behavioral, Physical, and Psychosocial Changes Associated with Yoga That Promote Weight Loss. *Evid Based Complement Alternat Med*. 2016;2016:2914745. doi:10.1155/2016/2914745
- Boraczynski MT, Boraczynski TW, Wójcik Z, Gajewski J, Laskin JJ. The effects of a 6-month moderate-intensity Hatha yoga-based training program on health-related fitness in middle-aged sedentary women: a randomized controlled study. *J Sports Med Phys Fitness*. 2020;60(8):1148-1158. doi:10.23736/S0022-4707.20.10549-8
- Carr KA, Epstein LH. Choice is relative: reinforcing value of food and activity in obesity treatment. *Am Psychol*. 2020;75(2):139-151. doi:10.1037/amp0000521
- Astin JA. Why patients use alternative medicine: results of a national study. *JAMA*. 1998;279(19):1548-1553. doi:10.1001/jama.279.19.1548
- Koithan M, Sutherland E. Naturopathic Treatment of Obesity. *J Nurse Pract*. 2009;5(9):693-694. doi:10.1016/j.nurpra.2009.07.019
- Dower, C., O'Neil, E. H. & Hough, H. J. *Profile of a Profession: Naturopathic Practice*. (2001).
- Ouellet V, Labbé SM, Blondin DP, et al. Brown adipose tissue oxidative metabolism contributes to energy expenditure during acute cold exposure in humans. *J Clin Invest*. 2012;122(2):545-552. doi:10.1172/JCI60433
- Fioravanti A, Adamczyk P, Pascarelli NA, et al. Clinical and biochemical effects of a 3-week program of diet combined with spa therapy in obese and diabetic patients: a pilot open study. *Int J Biometeorol*. 2015;59(7):783-789. doi:10.1007/s00484-014-0894-5
- Oláh M, Koncz A, Fehér J, et al. The effect of balneotherapy on C-reactive protein, serum cholesterol, triglyceride, total antioxidant status and HSP-60 levels. *Int J Biometeorol*. 2010;54(3):249-254. doi:10.1007/s00484-009-0276-6
- Hanh T, Serog P, Fauconnier J, et al. One-year effectiveness of a 3-week balneotherapy program for the treatment of overweight or obesity. *Evid Based Complement Alternat Med*. 2012;2012:150839. doi:10.1155/2012/150839
- Rapolienė L, Razbadauskas A, Salyga J, Martinkėnas A. Stress and Fatigue Management Using Balneotherapy in a Short-Time Randomized Controlled Trial. *Evid Based Complement Alternat Med*. 2016;2016:9631684. doi:10.1155/2016/9631684
- Antuna-Puente B, Feve B, Fellahi S, Bastard J-P. Adipokines: the missing link between insulin resistance and obesity. *Diabetes Metab*. 2008;34(1):2-11. doi:10.1016/j.diabet.2007.09.004
- Ghadge AA, Khaire AA. Leptin as a predictive marker for metabolic syndrome. *Cytokine*. 2019;121:154735. doi:10.1016/j.cyto.2019.154735
- Ragino YI, Stakhneva EM, Polonskaya YV, Kashtanova EV. The Role of Secretory Activity Molecules of Visceral Adipocytes in Abdominal Obesity in the Development of Cardiovascular Disease: A Review. *Biomolecules*. 2020;10(3):374. doi:10.3390/biom10030374
- Chait A, den Hartigh LJ. Adipose Tissue Distribution, Inflammation and Its Metabolic Consequences, Including Diabetes and Cardiovascular Disease. *Front Cardiovasc Med*. 2020;7:22. doi:10.3389/fcvm.2020.00022
- Landeche MF, Tuero C, Valentí V, Bilbao I, de la Higuera M, Frühbeck G. Relevance of Leptin and Other Adipokines in Obesity-Associated Cardiovascular Risk. *Nutrients*. 2019;11(11):2664. doi:10.3390/nu11112664
- Matarese G, Mantzoros C, La Cava A. Leptin and adipocytokines: bridging the gap between immunity and atherosclerosis. *Curr Pharm Des*. 2007;13(36):3676-3680. doi:10.2174/138161207783018635
- Fotina ON, et al. The Influence Of Peloid Applications On Adipokine Secretion In The Obese Patients. *Russian Journal of Physiotherapy. Balneology and Rehabilitation*. 2012;11:41-44.
- Liang W, Ye DD. The potential of adipokines as biomarkers and therapeutic agents for vascular complications in type 2 diabetes mellitus. *Cytokine Growth Factor Rev*. 2019;48:32-39. doi:10.1016/j.cytogr.2019.06.002
- Noh J. The Effect of Circadian and Sleep Disruptions on Obesity Risk. *J Obes Metab Syndr*. 2018;27(2):78-83. doi:10.7570/jomes.2018.27.278
- Yang B, Qin Q-Z, Han L-L, Lin J, Chen Y. Spa therapy (balneotherapy) relieves mental stress, sleep disorder, and general health problems in sub-healthy people. *Int J Biometeorol*. 2018;62(2):261-272. doi:10.1007/s00484-017-1447-5
- Pérez-Pérez A, Sánchez-Jiménez F, Vilarinho-García T, Sánchez-Margalet V. Role of Leptin in Inflammation and Vice Versa. *Int J Mol Sci*. 2020;21(16):5887. doi:10.3390/ijms21165887
- Chen K, Li F, Li J, et al. Induction of leptin resistance through direct interaction of C-reactive protein with leptin. *Nat Med*. 2006;12(4):425-432. doi:10.1038/nm1372
- Procopio C, Andreozzi F, Laratta E, et al. Leptin-stimulated endothelial nitric-oxide synthase via an adenosine 5'-monophosphate-activated protein kinase/Akt signaling pathway is attenuated by interaction with C-reactive protein. *Endocrinology*. 2009;150(8):3584-3593. doi:10.1210/en.2008-0921
- Williams BA, Merhige ME. Association between neutrophil-lymphocyte ratio and impaired myocardial perfusion in patients with known or suspected coronary disease. *Heart Lung*. 2013;42(6):436-441. doi:10.1016/j.hrtlung.2013.07.013
- Nijhuis J, Rensen SS, Slaats Y, van Dielen FM, Buurman WA, Greve JW. Neutrophil activation in morbid obesity, chronic activation of acute inflammation. *Obesity (Silver Spring)*. 2009;17(11):2014-2018. doi:10.1038/oby.2009.113
- Reyes M, Quintanilla C, Burrows R, Blanco E, Cifuentes M, Gahagan S. Obesity is associated with acute inflammation in a sample of adolescents. *Pediatr Diabetes*. 2015;16(2):109-116. doi:10.1111/pedi.12129

47. Xu R, Huang H, Zhang Z, Wang F-S. The role of neutrophils in the development of liver diseases. *Cell Mol Immunol*. 2014;11(3):224-231. doi:10.1038/cmi.2014.2
48. Ryder E, Diez-Ewald M, Mosquera J, et al. Association of obesity with leukocyte count in obese individuals without metabolic syndrome. *Diabetes Metab Syndr*. 2014;8(4):197-204. doi:10.1016/j.dsx.2014.09.002
49. Zhao P, Xia N, Zhang H, Deng T. The Metabolic Syndrome Is a Risk Factor for Breast Cancer: A Systematic Review and Meta-Analysis. *Obes Facts*. 2020;13(4):384-396. doi:10.1159/000507554
50. Elaib Z, Lopez JJ, Coupaye M, et al. Platelet Functions are Decreased in Obesity and Restored after Weight Loss: Evidence for a Role of the SERCA3-Dependent ADP Secretion Pathway. *Thromb Haemost*. 2019;119(3):384-396. doi:10.1055/s-0038-1677033
51. Nakata M, Yada T, Soejima N, Maruyama I. Leptin promotes aggregation of human platelets via the long form of its receptor. *Diabetes*. 1999;48(2):426-429. doi:10.2337/diabetes.48.2.426
52. Gunaldi M, Goksu S, Erdem D, et al. Prognostic impact of platelet/lymphocyte and neutrophil/lymphocyte ratios in patients with gastric cancer: a multicenter study. *Int J Clin Exp Med*. 2015;8(4):5937-5942.
53. Erdal, E. & Inanir, M. Platelet-to-lymphocyte ratio (PLR) and Plateletcrit (PCT) in young patients with morbid obesity. *Rev Assoc Med Bras (1992)* **65**, 1182–1187 (2019).
54. Cramer H, Thoms MS, Anheyer D, Lauche R, Dobos G. Yoga in Women With Abdominal Obesity: a Randomized Controlled Trial. *Dtsch Arztebl Int*. 2016;113(39):645-652.
55. Mody BS. Acute effects of Surya Namaskar on the cardiovascular & metabolic system. *J Bodyw Mov Ther*. 2011;15(3):343-347. doi:10.1016/j.jbmt.2010.05.001
56. Batrakoulis A, Jamurtas AZ, Metsios GS, et al. Comparative Efficacy of 5 Exercise Types on Cardiometabolic Health in Overweight and Obese Adults: A Systematic Review and Network Meta-Analysis of 81 Randomized Controlled Trials. *Circ Cardiovasc Qual Outcomes*. 2022;15(6):e008243. doi:10.1161/CIRCOUTCOMES.121.008243
57. Batrakoulis A, Jamurtas AZ, Fatouros IG. High-Intensity Interval Training in Metabolic Diseases: physiological Adaptations. *ACSM's Health Fit J*. 2021;25(5):54-59. doi:10.1249/FIT.0000000000000703
58. Batrakoulis A. Psychophysiological Adaptations to Pilates Training in Overweight and Obese Individuals: A Topical Review. *Diseases*. 2022;10(4):71. doi:10.3390/diseases10040071
59. Al-Mhanna SB, Rocha-Rodrigues S, Mohamed M, et al. Effects of combined aerobic exercise and diet on cardiometabolic health in patients with obesity and type 2 diabetes: a systematic review and meta-analysis. *BMC Sports Sci Med Rehabil*. 2023;15(1):165. doi:10.1186/s13102-023-00766-5
60. Kadyrova RKh, Shakieva RA, Salkhanov BA. [Role of modern diet therapy in the prevention of visceral complications in patients with dietary obesity]. *Vopr Pitan*. 1987;•••(1):16-20.
61. Shetty G, Moovenanthan A. Effect of Naturopathy and Yogic Intervention, Over 6 Years on Weight Management in a Patient with Obesity. *Journal of Obesity and Metabolic Research*. 2015;2(2):114-114. doi:10.4103/2347-9906.154261
62. Peres Valgas da Silva C, Hernández-Saavedra D, White JD, Stanford KI. Cold and Exercise: Therapeutic Tools to Activate Brown Adipose Tissue and Combat Obesity. *Biology (Basel)*. 2019;8(1):9. doi:10.3390/biology8010009
63. Laukkanen JA, Laukkanen T. Sauna bathing and systemic inflammation. *Eur J Epidemiol*. 2018;33(3):351-353. doi:10.1007/s10654-017-0335-y
64. Sacks FM, Bray GA, Carey VJ, et al. Comparison of weight-loss diets with different compositions of fat, protein, and carbohydrates. *N Engl J Med*. 2009;360(9):859-873. doi:10.1056/NEJMoa0804748
65. Dayib M, Larson J, Slavin J. Dietary fibers reduce obesity-related disorders: mechanisms of action. *Curr Opin Clin Nutr Metab Care*. 2020;23(6):445-450. doi:10.1097/MCO.0000000000000696
66. Lee S, Kim M-B, Kim C, Hwang J-K. Whole grain cereal attenuates obesity-induced muscle atrophy by activating the PI3K/Akt pathway in obese C57BL/6N mice. *Food Sci Biotechnol*. 2017;27(1):159-168. doi:10.1007/s10068-017-0277-x
67. Gupta P, Chikkala S, Kundu P. Ash gourd and its applications in the food, pharmacological and biomedical industries. *Int J Veg Sci*. 2021;27(1):44-53. doi:10.1080/19315260.2019.1699222
68. Shetty P, Moovenanthan A, Nagendra HR. Does short-term lemon honey juice fasting have effect on lipid profile and body composition in healthy individuals? *J Ayurveda Integr Med*. 2016;7(1):11-13. doi:10.1016/j.jaim.2016.03.001