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Effect of yoga training on inflammatory cytokines and C-reactive protein in employees of small-scale industries

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Abstract:

OBJECTIVE: The present study intends to see the effect of yoga practices on lipid profile, interleukin (IL)-6, tumor necrosis factor (TNF)-α, and high-sensitivity-C-reactive protein (hs-CRP) among apparently healthy adults exposed to occupational hazards.

MATERIALS AND METHODS: In the present study, 48 participants aged 30–58 years (41.5 ± 5.2) who were exposed to occupational hazards were randomized into two groups, that is, experimental and wait-list control. All the participants were assessed for lipid profile, IL-6, TNF-α, and hs-CRP at the baseline and after completion of 3 months of yoga training intervention. The experimental group underwent yoga training intervention for 1 h for 6 days a week for 3 months, whereas control group continued with their daily activities except yoga training. Data analysis was done using statistical software SPSS Version 20.0. Data were analyzed using paired *t*-tests and independent *t*-test.

RESULTS: The results of within group comparison revealed highly significant changes in cholesterol ($P < 0.001$), high-density lipoprotein ($P < 0.001$), low-density lipoprotein (LDL)($P < 0.01$), hs-CRP ($P < 0.01$), IL-6 ($P < 0.001$), and TNF-α ($P < 0.001$) in experimental group. Comparison between experimental and control group revealed significant changes in cholesterol ($P < 0.01$), LDL ($P < 0.05$), IL-6 ($P < 0.01$), TNF-α ($P < 0.01$), and hs-CRP ($P < 0.01$).

CONCLUSION: A yoga-based lifestyle intervention seems to be a highly promising alternative therapy which favorably alters inflammatory markers and metabolic risk factors.

Keywords:

High-sensitivity-C-reactive protein, inflammatory markers, interleukin-6, yoga

Introduction

Inflammation plays a major role in the defense mechanism of the body. In chronic metabolic disorders such as diabetes mellitus (DM),[1] hypertension,[2] obesity,[3] insulin resistance syndrome,[4] and coronary artery disease[5] inflammation becomes an important contributing factor for disease progression. Cytokines such as tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6) plays a major role in body's inflammatory response. These are released by adipose tissues and can initiate atherogenetic process.[6] Further, inflammatory marker such as high-sensitivity-C-reactive protein (hs-CRP), the synthesis of which is mostly under the control of IL-6,[7] predicts the future cardiovascular events in healthy participants.[8] This indicates that these inflammatory markers play an important role in the initiation of atherosclerosis in healthy adults. Moreover, the elevated levels of cytokines, such as IL-6, IL-18, and TNF-α, as well as hs-CRP have been found to be associated with elevated levels of body fat and BMI.[9-11] Even the clinically normal ranges of these markers are risk factors for cardiovascular disease in both

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middle aged[12-17] and older[18-23] people. In addition, lipid abnormalities contribute significantly toward increased risk of cardiovascular disease and morbidity in patients with diabetes.[24] It has been demonstrated in previous studies that higher levels of serum cholesterol, triglycerides, low-density lipoprotein (LDL), very low density lipoprotein (VLDL), HbA1c, high-density lipoprotein (HDL), and high body mass index (BMI) are associated significantly with coronary heart disease.[25-29]

Nevertheless, it is evident that the physical activity or exercise plays an important role in inflammation.[30] Earlier studies showed that the treatments, such as weight loss and exercise, which are used to improve glucose metabolism,[31-33] can also decrease inflammatory markers. It has been found that dietary-induced weight loss results in decrease of CRP, IL-6, and TNF-α concentration in obese women.[10,34-36] More active individuals involved in regular exercise have lower concentrations of IL-6 and CRP.[37] Further, it has been observed that physical exercise decreases several markers of inflammation.[38,39] The research findings reveal that inflammatory markers are associated with several metabolic disorders and regular physical activity can prevent the risk of developing these disorders in healthy adults.

The past studies have demonstrated positive effect of physical exercise on IL-6, hs-CRP, and body composition.[40] Physical exercise significantly improves lean muscle mass, BMI, fitness, resting heart rate, systolic blood pressure, and triglycerides to produce benefits in the management of obesity in adolescents.[41] DM and chronic inflammation are strongly related to increased cardiovascular risk. Physical exercise in patients with diabetes improves metabolic profile and exerts anti-inflammatory effects, that is, reduction in IL-6, hs-CRP, and TNF-α without weight loss.[42] Increased serum levels of inflammatory mediators have been associated with numerous disorders such as atherosclerosis, Type II diabetes, hypertension, depression, and overall mortality, but intervention of aerobic exercise training can significantly reduce inflammatory mediators.[43] Thus, it can be considered that the interventions that would help to reduce inflammatory markers could contribute to the prevention of various metabolic disorders and future cardiovascular events. Yogic literature and yogic research amply indicate the utility of yoga practices for achieving a holistic health. Yoga practice has substantial health benefits due to its ability to reduce inflammatory responses.[30] More so, yoga practices can be helpful to people of all ages, even to the persons of weak psychophysiological constitution. Hence, perceiving this aspect, it has been considered that ancient Indian traditional yoga practice might be helpful in reducing inflammatory markers such as IL-6, TNF-α, and hs-CRP. However, there is dearth of research studies exploring the effect of yoga practice on inflammatory markers in industrial workers exposed to occupational hazards. Therefore, the objective of this study was to assess the effect of yoga practices on inflammatory markers and hs-CRP among apparently healthy adults exposed to occupational hazards in small-scale industries of India.

Materials and Methods

Research design

This study considered parallel group design where two groups (experimental group and wait-list control group) were formed. The participants of both the groups were randomly divided considering Fisher's random table method.

Setting and participants

This was a 3-month parallel group study conducted in apparently healthy male adults aged 30–58 years (41.5 ± 5.2) at Kaivalyadhama Yoga Institute, Lonavla. The study protocol was approved by the Institutional Research Advisory Board and Institutional Ethics Committee, Kaivalyadhama, Lonavla, Pune. The Institutional Ethical Clearance number is kdham/SRD/RAC/IEC-03/2013.

The employees from an industrial estate located at Lonavla city were briefed about the study and were invited to participate. These study participants were at high risk of occupational hazards as they worked in factories manufacturing paint, chemical, steel, etc. The participants were initially screened through telephone interviews and personal visits for major eligibility criteria. Prospective study participants were screened for major health problems along with the past medical history, physical examination, and blood pressure to exclude serious underlying medical illnesses and to ensure the safety of participants while undergoing yoga intervention. The participants were excluded due to any of the following health problems: uncontrolled hypertension, insulin-dependent diabetes, kidney failure, lung disease, smoking, alcoholism, and heart disease. The participants who practiced yoga regularly or had participated in yoga class in the past 3 months were also excluded from the study. Written informed consent was obtained from all the participants participating in this study.

The recruitment and retention process for this study is illustrated in Figure 1. Out of sixty study participants, 48 participants fulfilled inclusion criteria for this study. The baseline clinical characteristics of study participants are presented in Table 1. The participants were randomized to one of the two groups, that is, experimental and wait-list control by employing Fisher's random number

table. Initially, there were 24 study participants in each experimental and wait-list control group. However, one study participant of experimental group and two study participants of wait-list control group did not undergo pretesting of selected parameters. The participants of wait-list control group were informed that they can enroll in yoga class after the completion of 3-month study duration at no cost to ensure acceptance of the protocol. However, after the completion of 3-month yoga intervention, there were 19 and 18 participants in the experimental and wait-list control group, respectively, due to 11 dropouts. Dropouts were due to various reasons such as absenteeism, scarcity of time, lack of interest, and acute illnesses.

Intervention

Yoga training was conducted by a certified yoga teacher from Kaivalyadhama Yoga Institute. The yoga training protocol was based on the principles of classical yoga.[44] Experimental group was given selected yoga practices for 6 days a week for 3 months at the ground provided by the industrial estate at Lonavla. Each yoga session comprised 1 h of yoga training from 5.30 to 6.30 pm which included warm up, asanas, and pranayama [Table 2]. The yoga training duration was divided into three stages, that is, an adaptation stage with no maintenance time in asanas and pranayama without kumbhaka (3 weeks), a gradual advancement in yoga practice (6 weeks), and continuation stage (3 weeks). This division of yoga training program helped the participants to gradually adapt yoga practices. However, they were instructed to maintain each posture according to their comfort throughout the yoga training. As well, they were asked to practice pranayama gradually in an experiential way.

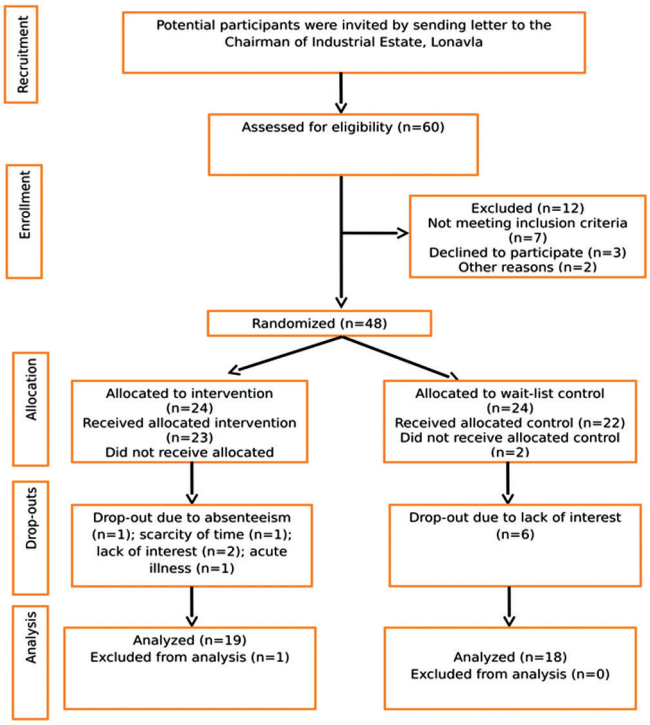

Figure 1: Flow chart illustrating recruitment, enrollment, allocation, drop-outs, and data analysis of the research study

Assessment

Overnight fasting venous blood sample (5 mL) was collected in Vacutainer from the antecubital vein of the arm. The collected blood samples were centrifuged at 1500 ×g for 20 min and the separated serum was stored frozen at −40°C until assayed. Serum cholesterol, triglyceride, and HDL were measured using clinical chemistry analyzer (Vector, Vchem) using enzymatic techniques, whereas LDL and VLDL were determined

Table 1: Baseline characteristics of the study population

Variables	Participants (*n*=48)
Age (years)	41.5 (5.2)
Height (cm)	165.5 (5.0)
Weight (kg)	60.2 (9.8)
BMI (kg/m^2)	21.1 (3.6)
Systolic blood pressure (mmHg)	127.06 (12.0)
Diastolic blood pressure (mmHg)	84.14 (9.1)

BMI=Body mass index

Table 2: Yoga training protocol

Position	Asana
Supine pose	Shavasana
	Ardha halasana (half plough pose)
	Halasana (plough pose)
	Viparita karani (inverted pose)
	Pawanmuktasana (wind-release pose)
	Matsyasana (fish pose)
	Naukasana (boat pose)
	Setubandhasana (bridge pose)
Prone pose	Bhujanasana (cobra pose)
	Ardha shalabhasana (half locust pose)
	Shalabhasana (locust pose)
	Dhanurasana (bow pose)
Sitting pose	Vajrasana (thunderbolt pose)
	Supta Vajrasana (reclining adamant pose)
	Gomukhasana (cow face pose)
	Vakrasana (twisted pose)
	Paschimatanasana (forward bending pose)
	Ushtrasana (camel pose)
	Parvatasana (mountain pose)
	Chakrasana (wheel pose)
Standing pose	Tadasana (mountain pose)
	Padahastasana (feet to hands pose)
	Vrikshasana (tree pose)
	Utkatasana (chair pose)
	Veerbhadrasana (warrior pose)
Pranayama	Anulom Vilom
	Bhramari
	Ujjayi
	Kapalabhati

using Friedewald's equation.[45] Serum IL-6, TNF-α, and hs-CRP were assessed using commercially available solid-phase sandwich ELISAs (Diaclone SAS; France and Diagnostics Biochem, Canada Inc.) on an ELISA plate reader (Bio-Rad 680, Bio-Rad PW 40, USA). The intra-assay coefficient of variation for IL-6, TNF-α, and hs-CRP was 4.2%, 3.3%, and 9.5%, whereas interassay coefficient of variation was 7.7%, 9.0%, and 9.0%, respectively.

Statistical analysis

Data analysis was done using statistical software (IBM SPSS, Statistical Package for the Social Sciences, Version 20.0). Data were analyzed using paired *t*-tests, independent *t*-test, and descriptive statistical method. The mean values ± standard deviation of pre- and post-variables are presented in Table 3.

Results

This study included 48 Indian healthy male adults aged 30–58 years (41.5 ± 5.2). No significant differences in all parameters were observed between experimental and wait-list control group at the baseline [Table 1]. Changes in lipoproteins and inflammatory markers before and after 12 weeks of yoga training are summarized in Table 3.

The results of within group comparison revealed highly significant changes in cholesterol ($P < 0.001$), HDL ($P < 0.001$), LDL ($P < 0.01$), hs-CRP ($P < 0.01$), IL-6 ($P < 0.001$), and TNF-α ($P < 0.001$), whereas no significant improvement was observed in triglyceride ($P = 0.17$) and VLDL ($P = 0.17$) in experimental group. The results of within group comparison in wait-list control group revealed no statistically significant change in triglyceride ($P = 0.23$), HDL ($P = 0.89$), hs-CRP ($P = 0.79$), IL-6 ($P = 0.71$), and TNF-α ($P = 0.15$), however, significant change was observed in cholesterol ($P < 0.05$) and LDL ($P < 0.05$).

Further, comparison between experimental and wait-list control group revealed significant changes in cholesterol ($P < 0.01$), LDL ($P < 0.05$), IL-6 ($P < 0.01$), and TNF-α ($P < 0.01$). Although statistically nonsignificant, a decrease was observed in triglyceride ($P = 0.16$), HDL ($P = 0.83$), VLDL ($P = 0.16$), and hs-CRP ($P = 0.13$).

Discussion

This 3-month yoga training intervention in adults of average health exposed to occupational hazards demonstrated significant improvement in inflammatory markers such as IL-6, TNF-α, and hs-CRP. Further, improvement in lipoproteins was also observed.

In the present study, the participants were employees of small-scale industries who were exposed to various occupational hazards as they worked in paint, chemical, and steel manufacturing industries.[46-49] The level of inflammatory markers, lipoproteins, and hs-CRP in industrial workers increases due to prolonged stress.[50] Further, previous studies[51-53] showed that occupational hazards are associated with various health problems such as cardiovascular diseases,[54,55] hypertension,[56,57] respiratory disorders,[58,59] and metabolic disorders such as diabetes and obesity.[60,61] According to a recent study, pro-inflammatory cytokines IL-8 and TNF-α are significantly associated with respiratory symptoms in hazardous waste workers of Karnataka.[58]

The past research studies have demonstrated that weight loss, physical activity, and lifestyle changes can lower pro-inflammatory markers, lipoproteins, and hs-CRP levels.[43,62,63] In this context, Indian traditional yoga practices were found to be beneficial in protecting an individual against inflammatory diseases by favorably altering inflammatory markers and metabolic risk factors.[64,65]

Previous research studies showed positive effects of yoga-based lifestyle modification in combating stress and reducing inflammation.[30,66] In the present study, 3 months of traditional yoga practices showed significant reduction in inflammatory markers and hs-CRP, which is consistent with previous research findings.[25,26,67] Yoga training intervention in the present study comprised

Table 3: Pre- and post-test values of selected variables after 12 weeks of yoga training

Outcome measures	Experimental group		*P*	Control group		*P*	Experimental versus control
	Baseline	3 months		Baseline	3 months		
Cholesterol (mg/dl)	170.0 (23.6)	157.7 (19.1)	0.000***	180.4 (26.0)	175.7 (23.3)	0.017*	0.006**
Triglyceride (mg/dl)	123.6 (69.7)	110.5 (43.6)	0.17	134.8 (58.2)	131.3 (54.4)	0.23	0.16
HDL (mg/dl)	39.1 (3.8)	40.8 (3.15)	0.000***	41.0 (2.9)	41.0 (2.4)	0.89	0.83
LDL (mg/dl)	106.1 (18.9)	96.4 (14.8)	0.002**	112.6 (18.1)	108.4 (16.9)	0.035*	0.015*
VLDL (mg/dl)	24.7 (13.7)	22.0 (8.7)	0.17	26.8 (11.7)	26.2 (10.9)	0.32	0.16
hs-CRP (μg/ml)	2.9 (0.7)	2.2 (0.6)	0.003**	2.8 (0.8)	2.9 (0.6)	0.79	0.13
IL-6 (pg/ml)	1.9 (0.8)	1.3 (0.8)	0.000***	2.0 (0.9)	2.1 (0.9)	0.71	0.003**
TNF-α (pg/ml)	34.0 (13.8)	27.1 (11.7)	0.000***	35.2 (7.6)	36.9 (7.1)	0.15	0.001**

*$P<0.05$, **$P<0.01$, ***$P<0.001$. HDL=High-density lipoprotein, LDL=Low-density lipoprotein, VLDL=Very low-density lipoprotein, hs-CRP=High-sensitivity C-reactive protein, IL-6=Interleukin-6, TNF=Tumor necrosis factor

asanas and pranayama which might have resulted in lowering stress levels, and hence caused a decrease in systemic inflammation. However, despite the apparent beneficial effects of yoga for reduction in inflammatory markers and hs-CRP, systematic and rigorous studies based on the effects of yoga on anthropometric, physiological and psychological variables in industrial workers with occupational hazards are quite meager in India. Interpretation of the current study is limited by selection bias, small sample size, lack of adjustment for baseline anthropometric characteristics, lifestyle factors, multiple intervention exposure, and methodological limitations. Furthermore, undefined age range and significant dropout rate are important limitations of the present study. Other well-established risk factors such as alcohol intake, parental history of diseases, and levels of physical activity were not included in this study.

Specifically, high quality, rigorous, and randomized controlled trials are needed to clarify and further elucidate the effects of yoga-based lifestyle intervention in industrial workers exposed to occupational hazards, especially in India and other Eastern populations that remain underrepresented in the current research study.

Conclusion

A yoga-based lifestyle intervention seems to be a highly promising alternative therapy which favorably alters inflammatory markers and metabolic risk factors. It also helps in the management of chronic diseases caused due to occupational hazards as it is cost-effective and easy to follow with good compliance. Thus, the efficacy of yoga-based lifestyle program is multifaceted and is achieved through reduction in weight, occupation-related inflammation, and stress, thereby, is helpful in reducing several associated chronic diseases.

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Conflicts of interest

There are no conflicts of interest.

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