High-density lipoprotein cholesterol increases following a short-term yoga-based lifestyle intervention: a non-pharmacological modulation

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Objectives The objective of the study was to assess the effect of a brief but comprehensive yoga-based lifestyle intervention on high-density lipoprotein cholesterol (HDL-c).

Methods This prospective interventional study was performed at the Integral Health Clinic (IHC), an outpatient facility at All India Institute of Medical Sciences, New Delhi, a tertiary health care centre, conducting yoga-based lifestyle intervention programmes for prevention and management of chronic diseases. The study included apparently healthy normal weight, overweight and obese subjects who underwent a pretested 10-day yoga-based programme including asanas (postures), pranayama (breathing exercises), meditation, group discussions, lectures and individualized advice on stress management and healthy diet. The primary outcome measure was change in serum HDL-c at day 10 versus day 0.

Results 238 participants (147 women, 91 men, 38.81 ± 11.40 years) were included in the study. There was a significant increase in HDL-c levels from baseline to day 10 (42.93 ± 5.00 vs 43.52 ± 5.07 mg/dL, $P = 0.043$). Notably, HDL-c was significantly improved in those for whom the baseline HDL-c levels were lower than the recommended values. Also, there was a reduction in blood pressure, fasting blood glucose, and improvement in other lipid profile variables.

Conclusion This yoga-based lifestyle intervention significantly increased HDL-c levels in a short duration of 10 days. This has additional clinical relevance as HDL-c is suggested to be one of the strongest statistically independent predictors of major cardiovascular events.

Keywords *HDL-cholesterol – yoga-based lifestyle intervention – lipid profile.*

INTRODUCTION

Cardiovascular events are a leading cause of death and disability worldwide[1,2]. High-density lipoprotein cholesterol (HDL-c) has emerged as one of the strongest statistically independent predictors of major cardiovascular events[3,4]. The Framingham study showed that the risk for coronary artery disease (CAD) increases steadily with HDL levels below 40 mg/dL[5]. Similarly, the Prospective Cardiovascular Munster (PROCAM) study demonstrated a significant relationship between low HDL-c and elevated cardiovascular risk[6]. The quantum of this risk was high, and for every 10% reduction in HDL, risk for CAD increased by 13% as shown in the Quebec Cardiovascular Study[7], and each 1 mg/dL increase in HDL-c resulted in a 2-3% decrease in cardiovascular disease (CVD) risk[8]. Recent studies have shown that increased levels of HDL-c are associated with lower cardiovascular risk irrespective of reduction in low-density lipoprotein cholesterol (LDL-c)[9]. A pooled analysis including over 302,430 patients showed that each unit increase of standard deviation in HDL-c was associated with 22% reduction in CAD risk[10]. Another

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pooled data analysis showed that a reduction of LDL-c to less than 87.5 mg/dL and a 7.5% increase in HDL-C resulted in regression of atherosclerosis[11]. Therefore, increasing the levels of HDL-c is now being explored as a way to reduce the risk of cardiovascular events[12].

Despite the availability of a multitude of pharmacotherapies for increasing HDL-c, CVD risk reduction remains inadequate, and has further worsened with increasing prevalence of overweight and obesity[13]. There is a strong evidence that lifestyle programmes have a beneficial effect on recurrent cardiovascular events[14], mainly by increase in HDL-c[15-17], in day-to-day practice[18]. It is evident that one of the key reasons for such benefit is weight loss as there is an inverse relation between obesity and HDL-c as shown in the Framingham Offspring study[19]. The importance of lifestyle intervention has now been emphasized in various guidelines on primary prevention/treatment for cardiovascular diseases[20,21]. A yoga-based lifestyle intervention is one such programme that includes lifestyle modification and increased physical activity, and has been shown to be efficacious in weight-loss and improvement of lipid profile across different populations[22-24], though increase in HDL-c was shown only in a few studies[23,25,26]. Yoga combines a healthy lifestyle with reduced stress[27,28], and works on the principles of mind-body-medicine or psychoneuroimmunology[29]. Further, yoga improves clinical profile of patients with various pathologies[24,30], and this benefit was independent of the type of clinical diagnosis[31]. Therefore, we conducted this study to see the efficacy of a brief but comprehensive yoga-based lifestyle intervention in improving HDL-c in a larger cohort of a mixed population.

METHODS

Subjects

This study was conducted between November 2008 and June 2013, and included a total of 238 subjects. The study population included apparently healthy normal weight, overweight and obese subjects. There were no stringent inclusion and exclusion criteria for the intervention programme, except that the participants undergoing intervention were interested and were able to attend the 10-day course at the Integral Health Clinic (IHC) while physically challenged subjects who were unable to perform the yogic exercises and those on other extensive dietary and/or exercise intervention programmes or regimens were excluded from the study.

Study design

This was a prospective study with the primary aim of orienting the participants towards a yoga-based healthy lifestyle, and written informed consent was obtained from all the participants. The total duration of subject participation was only 10 days, spread over two weeks. The participants were encouraged to accommodate these modest changes in their lifestyle for long-term and were explained the long-term benefits of this modest changes in lifestyle. They were also motivated to return to the IHC whenever they wished even after completing the study.

Lipid profile, weight, BMI, blood pressure, and fasting blood glucose were assessed at baseline, and at the end of intervention, i.e. day 10. Serum lipid profile was estimated using an automated analyzer (Konnelab 20) and fasting blood glucose was estimated using the glucose oxidase-peroxidase method. All the assessments were done while the subjects were relaxed, and between 8:30 hours and 9:30 hours to avoid any biases.

Study intervention

This intervention programme is outpatient-based, two hours each day for 10 days. It consists of an integrated and pretested yoga-based intervention comprising of theory and practice sessions[23]. A typical day in the programme starts with a set of simple physical postures (*asanas*) and breathing exercises (*pranayama*) for approximately one hour. This is followed by an interactive lecture/discussion on stress management, and nutrition. Though participants were educated about benefits of healthy diet and nutrition, no specific diet or meals were provided at IHC as part of the programme, so making dietary changes in light of what participants learned from the programme was left to the individuals. The diet advised was predominantly vegetarian, consisting of a combination of cereals and pulses, preferably unrefined, as the staple food; moderate amounts of judiciously chosen fat; about 400 to 500 g of vegetables and fruits daily; moderate amounts of milk and milk products; and spices in moderation.

Questions and unstructured discussions are encouraged among the participants. Each day's programme ends with relaxation through either a relaxation technique (*shavasana*) or meditation. Spouse and other members of the participant's family are motivated to attend the programme in order to facilitate compliance.

Statistical analysis

Descriptive statistics are provided for the demographic data and baseline clinical profile. The components of serum lipid profile, blood pressure, and fasting blood glucose at baseline and day 10, were compared using the paired sample *t*-test. The response variables were assessed in gender and HDL-c subgroups also.

RESULTS

The study included 238 (91 male and 147 female) subjects with a mean age of 38.81 ± 11.40 years, of whom 40 subjects were normal weight (BMI < 23 kg/m^2), 38 subjects were overweight (BMI 23-24.9 kg/m^2), and 156 were obese (BMI > 25 kg/m^2) as per WHO cut-off values for Asians. The baseline and clinical characteristics of the study subjects are summarized in table 1.

There was a significant increase from baseline to day 10 in HDL-c levels (42.93 ± 5.00 vs 43.52 ± 5.07 mg/dL, respectively, $P = 0.043$), and the mean change in HDL-c was 0.59 mg/dL in 10 days (table 2). There was a significant increase in HDL-c in men for whom baseline HDL-c was < 40 mg/dL, with a mean increase of 3.5 mg/dL. Similarly, there was a significant increase in HDL-c in women for whom baseline HDL-c was < 50 mg/dL, with a mean increase of 1.03 mg/dL at day 10 vs baseline (table 3 and figure 1).

Other components of serum lipid profile also showed a notable improvement. A significant reduction was observed in systolic and diastolic blood pressures at day 10 vs baseline. Also, there was a significant reduction in weight, which was reflected in a significant reduction in BMI from baseline to day 10 ($P < 0.0001$). Fasting blood glucose also showed a significant decrease from baseline to day 10 ($P < 0.0001$) (table 2).

In gender subgroups, weight, BMI, systolic and diastolic blood pressure, all decreased significantly from baseline to day 10 in both male and female subgroups. Interestingly, the lipid profile improved significantly only in the female subgroup while fasting blood glucose reduced in both gender subgroups (table 4).

DISCUSSION

Recent data shows that HDL-c is a potential target for reducing the risk for cardiovascular events substantially[8,32] which may be over and above to that achieved by reducing LDL-c[9]. Hitherto, it was believed that reducing LDL-c would significantly reduce CVD risk and

Table 1 Baseline characteristics of the study population

	Males (n = 91)	Females (n = 147)	*P*-value[1]	Total (n = 238)
Age, years	40.77 ± 12.83	37.59 ± 10.28	0.036	38.81 ± 11.40
Weight, kg	72.38 ± 8.79	66.90 ± 12.62	< 0.001	69.00 ± 11.60
Body mass index, kg/m^2	25.70 ± 3.10	27.87 ± 5.62	0.001	27.04 ± 4.92
Systolic blood pressure, mmHg	123.95 ± 10.96	115.27 ± 14.91	< 0.001	118.58 ± 14.16
Diastolic blood pressure, mmHg	92.70 ± 18.82	88.48 ± 20.99	0.124	90.09 ± 20.61
Total cholesterol, mg/dL	175.27 ± 32.72	176.01 ± 30.88	0.862	175.73 ± 31.53
LDL, mg/dL	107.64 ± 27.89	108.33 ± 25.12	0.842	108.07 ± 26.16
HDL, mg/dL	42.26 ± 5.36	43.34 ± 4.74	0.106	42.92 ± 5.00
Triglycerides, mg/dL	134.26 ± 76.24	122.35 ± 63.55	0.195	126.91 ± 68.76
Fasting blood glucose, mg/dL	104.28 ± 15.77	105.07 ± 16.30	0.724	104.75 ± 16.04

All data expressed as mean ± SD.
[1]Males vs females.

Table 2 Change in clinical and laboratory variables following lifestyle intervention in the total study population (n = 238)

	Pre	Post	*P*-value[1]
Weight, kg	69.00 ± 11.60	68.31 ± 11.40	< 0.001
Body mass index, kg/m^2	27.04 ± 4.92	26.76 ± 4.86	< 0.001
Systolic blood pressure, mmHg	118.58 ± 14.16	103.42 ± 22.58	< 0.001
Diastolic blood pressure, mmHg	90.09 ± 20.62	76.27 ± 9.16	< 0.001
Total cholesterol, mg/dL	175.73 ± 31.53	172.16 ± 32.71	0.017
LDL-c, mg/dL	108.07 ± 26.16	105.74 ± 26.21	0.056
HDL-c, mg/dL	42.93 ± 5.00	43.52 ± 5.07	0.043
Triglycerides, mg/dL	127.00 ± 68.90	117.53 ± 61.48	0.004
Fasting blood glucose, mg/dL	104.80 ± 16.16	101.31 ± 14.21	< 0.001

All data expressed as mean ± SD.
[1]*P*-value is from paired sample '*t*' tests.

Table 3 Changes in HDL-c following short-term yoga-based lifestyle intervention programme

	Males		Females	
	HDL < 40 mg/dL	HDL ≥ 40 mg/dL	HDL < 50 mg/dL	HDL ≥ 50 mg/dL
N	26	65	138	9
HDL, mg/dL				
Pre	36.07 ± 3.5	44.73 ± 3.72	42.76 ± 4.27	52.22 ± 1.48
Post	39.62 ± 5.74	43.57 ± 4.62	43.79 ± 4.63	50.22 ± 4.14
Change	3.50	−1.17	1.03	-2.00
% Mean change from baseline	9.63%	−2.57%	3.02%	-3.89%
P-value	0.000	0.004	0.012	0.115

All data expressed as mean ± SD.

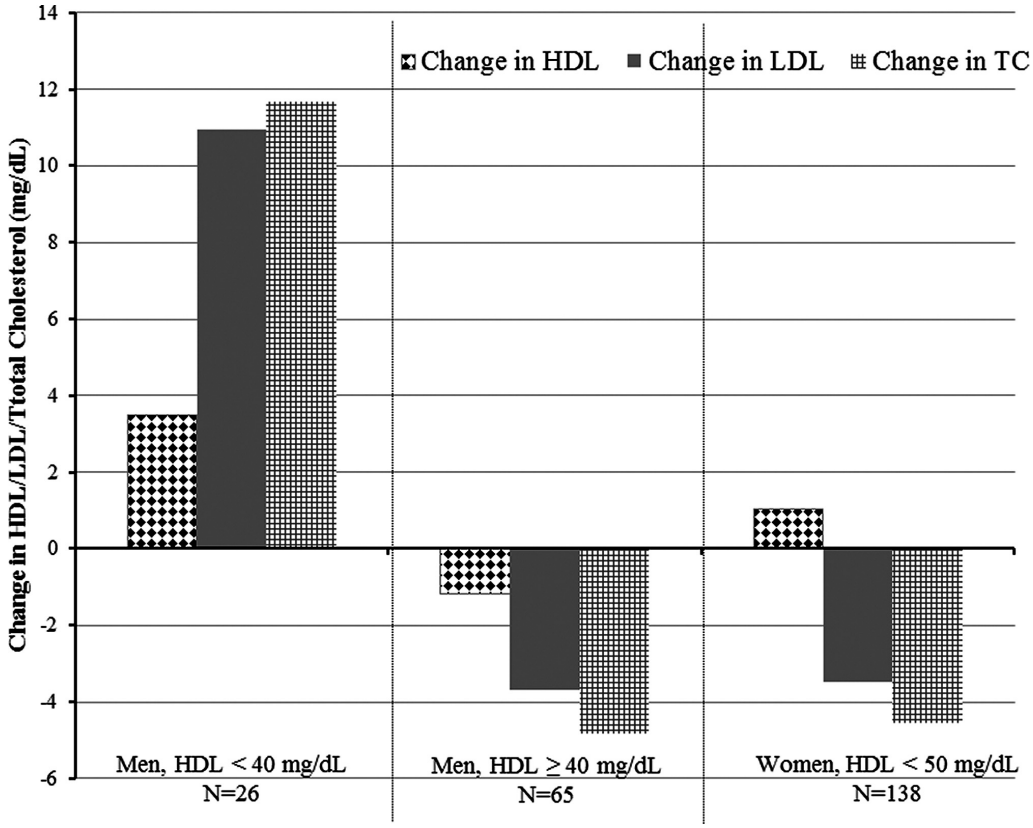

Fig. 1 Change in HDL, LDL and total cholesterol following a short-term yoga-based lifestyle intervention.

mortality; however, accumulating data suggests that there is still a substantial risk even in those who achieve recommended LDL-c targets as defined by the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III). Thence, the protective role of HDL-c is substantiated, and an HDL-c level < 40 mg/dL is now defined as a categorical risk factor for CAD per NCEP guidelines[33]. Further, an expert group on HDL-c has recommended that HDL-c be raised to 40 mg/dL in patients with CVD, metabolic syndrome, or CAD risk equivalents[34,35]. Therefore, there is a need to look beyond LDL-c targets, and focus on increasing the levels of HDL-c so as to lower the CVD risk.

The current study evaluated the efficacy of a simple yet comprehensive yoga-based lifestyle intervention in increasing HDL-c, and it was observed that there was a significant increase in HDL-c with a mean increase of 0.59 mg/dL (0.015 mmol/L) in the total study population. A notable finding of this study was that HDL-c was significantly improved in those for whom the baseline

Table 4 Change in clinical and laboratory variables following a short-term yoga-based lifestyle intervention in the gender subgroup

	Males (n = 91)		Females (n = 147)	
	Pre	Post	Pre	Post
Weight, kg	72.39 ± 8.79	71.43 ± 8.70	66.90 ± 12.62	66.39 ± 12.43
P-value	< 0.001		< 0.001	
Body mass index, kg/m^2	25.71 ± 3.10	25.32 ± 3.07	27.87 ± 5.62	27.66 ± 5.52
P-value	< 0.001		< 0.001	
HDL, mg/dL	42.26 ± 5.36	42.44 ± 5.25	43.34 ± 4.74	44.18 ± 4.85
P-value	0.678		0.032	
LDL, mg/dL	107.64 ± 27.89	108.14 ± 27.04	108.33 ± 25.12	104.25 ± 25.67
P-value	0.782		0.011	
Total cholesterol, mg/dL	175.27 ± 32.72	175.16 ± 34.18	176.01 ± 30.88	170.31 ± 31.74
P-value	0.962		0.004	
Triglycerides, mg/dL	134.26 ± 76.24	126.15 ± 67.89	122.47 ± 63.75	112.16 ± 56.70
P-value	0.146		0.011	
Fasting blood glucose, mg/dL	104.28 ± 15.77	100.70 ± 13.66	105.17 ± 16.48	101.75 ± 14.63
P-value	0.006		< 0.001	
Systolic blood pressure, mmHg	123.95 ± 10.96	107.27 ± 21.27	115.27 ± 14.91	101.03 ± 23.10
P-value	< 0.001		< 0.001	
Diastolic blood pressure, mmHg	92.70 ± 19.82	78.76 ± 7.62	88.48 ± 21.00	74.73 ± 9.71
P-value	< 0.001		< 0.001	

HDL-c levels were lower than the recommended values. In a subgroup of men with HDL-c less than 40 mg/dL, it was observed that there was a mean increase of 3.5 mg/dL. Similarly, in women with HDL-c levels less than the recommended values of 50 mg/dL, there was an increase of 1.03 mg/dL following this yoga-based lifestyle intervention. These findings suggest that patients with HDL-c lower than the recommended levels especially benefited from this yoga-based lifestyle intervention, and such a benefit in this short duration of 10 days is of additional clinical relevance when used as a complementary therapy. Increase in HDL-c contributes towards cardioprotection by cholesterol efflux, anti-inflammatory actions, protection of LDL-c against oxidation, increasing nitric oxide production, and decreasing endothelial cell apoptosis[36]. The increase in HDL-c along with reduction in LDL-c observed in a subgroup of women (HDL < 50 mg/dL) in our study is remarkable. A pooled analysis of two trials demonstrated an increase in HDL-c (0.1 mmol/L), and a decrease in triglycerides (0.2 mmol/L) after 1 year of treatment[37]. In view of these findings, the results of the current study are encouraging as not only HDL-c increased but there was a reduction in levels of LDL-c by about 3 mg/dL in the total study population. This is relevant even when compared to pharmacotherapy. Fibrates and nicotinic acid may take about 12-18 months to raise the HDL by 6%[38] to 11%[39] while initial trials with cholesteryl ester transfer protein inhibitors showed that these may increase HDL-c by 100%, however, these are associated with adverse safety profile, including mortality. In contrast to this, yoga is a more natural and safer way to raise HDL-c, and has no relative associated adverse events.

Another important observation in this study was that increase in HDL-c was parallel to the weight loss, and both were achieved side-by-side. This is in contrast to previous studies, where the initial response to weight loss and caloric restriction is a decrease in HDL-c, and HDL-c increases gradually after weight loss is sustained for over a period of time[40].

Despite these benefits, the importance of complementary and alternative therapies such as this yoga-based lifestyle intervention remains understated. This can be attributed to an emerging competitive pharmacotherapy market, where new pharmacotherapies are being explored for increasing HDL-c levels[18,41], which needs to be emphasized in clinical practice. Needless to say, some patients might still require pharmacotherapy and a more aggressive lifestyle modification to achieve desirable HDL-c levels. However, the results of the current study are promising, and suggest that modest and sustained yoga-based lifestyle changes can substantially help to reduce the risk of cardiovascular events when used as a complementary therapy as shown previously[42].

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CONFLICT OF INTEREST: none.

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