European Journal of Integrative Medicine 28 (2019) 47–51

Contents lists available at ScienceDirect

European Journal of Integrative Medicine

journal homepage: www.elsevier.com/locate/eujim

Research paper

Detection of serum high-density lipoprotein cholesterol high levels in monks practicing *Samatha and Vipassana* meditation

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ARTICLE INFO

Keywords:
Samatha and *Vipassana* meditation
Buddhist monks
HDL cholesterol and total cholesterol: HDL ratio

ABSTRACT

Introduction: Associations between psychological stress and the development of cardiovascular events and stroke have been established. Meditation is recognized as a method to reduce the stress. The aim of this study was to investigate the anthropometry, serum glucose and serum cholesterol status in monks practicing *Samatha* and *Vipassana* meditation living in forest hermitages.

Methods: This cross-sectional study compared 115 meditating Buddhist monks (71 meditating > 6 months, 45 meditating < 6 months) to 137 non-meditating subjects (36 non-meditating monks and 101 laymen). Body mass index, systolic and diastolic blood pressure, fasting blood sugar and lipid profile were measured. Meditation duration and dietary assessment was evaluated using an investigator administered questionnaire.

Results: From parameters tested, the HDL cholesterol level was higher (53.8 ± 5.3 mg/dL) ($P < 0.001$) while total cholesterol: HDL ratio was (3.57 ± 0.52) significantly ($P < 0.0036$) lower in monks meditating for > 6 months compared with naïve (< 6 months) meditating monks (4.1 ± 0.53), non-meditating monks (4.6 ± 0.93) and non-meditating laymen (5.5 ± 1.6). Systolic and diastolic blood pressures, pulse rate, serum glucose and non- HDL cholesterol did not vary significantly among these groups and were within normal limits.

Conclusion: Meditating monks had a higher HDL cholesterol, lowest total cholesterol: HDL ratio and the other parameters tested had mean levels closer to the lower limit of the normal range, indicating a possible protective effect of meditation on cardiovascular diseases and stroke. These results may be related to the duration of practicing *Samatha* and *Vipassana* meditation but require confirmation using appropriate clinical trial methodology.

1. Introduction

In Sri Lanka, the form of meditation practiced by Buddhists monks includes *Samatha* and *Vipassana*. Many kinds of *Samatha* meditation techniques exist. The common form is based on focusing the attention towards the breath with the aim to produce a serene state in which the highs and lows of excitation and laxity are reduced [1]. Other hand *Vipassana* is a gentle technique. It is an ancient and codified system and involves training the mind and provides an insight to meditation [2,3]. In both forms the mode of attention is directed and maintained by mind concentration. The instructions about how the meditator should handle the spontaneous thoughts and images in the state of a wandering mind and that pop up whilst meditating has been described in Buddhist literature. Also, it reforms the culture of teaching, sharing the experiences from experienced practitioner to naive and vice versa [1,3].

Sri Lankan Buddhist monks living in forest hermitages, or the '*Arannya*' commonly practice meditation as part of their life-style. *Arannya* refers to a dedicated zone bearing a calm atmosphere away from societal stressors, which allows monks to deeply avail themselves of a spiritual life [4]. The environment inside the forest hermitages would have greater influence on achieving a serene status of the mind and retaining this serene status and once achieved, results in more intense physiological changes.

Meditation is hypothesized to affect health via alterations in brain function that help to reduce negative emotional states such as anxiety and/or depression, with a concomitant reduction of stress-related

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https://doi.org/10.1016/j.eujim.2019.05.005
Received 9 January 2019; Received in revised form 5 May 2019; Accepted 5 May 2019
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impacts on biological processes. Stress is known to influence human metabolism via neuro-endocrine changes characterized by increased levels of catecholamines, including norepinephrine and cortisol [3,5]. Associations between psychological stress and disease have been well-established for a number of conditions, as well as with the lowering of immunity [6,7]. Both cardiovascular accidents (CVA) and strokes are related to underline metabolic disorders. Primary risk factors for CVA and stroke, regardless of age, gender, and geographical region are: having a high level of low-density lipoprotein (LDLc), a very low level of high-density lipoprotein (HDLc), smoking, hypertension, diabetes, abdominal obesity, negative psychosocial experience, heavy consumption of alcohol and physical inactivity [8]. In addition, the increasing consumption of fast foods, fast-paced or sedentary life styles, and stress associated with unachievable demands, especially among adolescents, may in the future increase CVA and stroke prevalence at lower ages [9]. Moreover, with increasing life-expectancy among humans, the financial and societal costs of CVA and stroke are likely to grow [10,11]. Release of various mental stresses via meditation would minimize above risks of CVA and stroke [12].

Meditation practice is objectively broader than yoga or mindfulness although each practice overlaps to a certain extent [13,14]. The present study investigated the anthropometry, blood pressure, pulse rate, serum glucose and serum cholesterol status in *Samatha and Vipassana* meditators living in forest hermitages.

2. Materials and methods

Ethical clearance for this project was obtained from the Research & Ethical Committee of the Faculty of Medicine & Allied Sciences of Rajarata University of Sri Lanka. The written consent to participate in the study was obtained from each participant and those who werefound to require medical assistance were referred to the appropriate medical care.

3. Study design

This was a cross sectional study of the cardio vascular diseases and stroke to explore the protective biochemical and physiological parameters in meditating Buddhist monks, who reside in forest hermitages and have different levels of meditation experience; non-meditating monks living in forest hermitages, and a group of non-meditating laymen living in semi-urban areas.

4. Study sample and settings

One hundred and fifty-one volunteer male Buddhist monks from the forest hermitages of Labunoruwakanda and Ritigala from the North Central Province, Nauyana from the North Western Province, Salgala, Kegalle Thapowanaya and Lellupitiya from Sabaragamuwa Province and Kanduboda, Madakada, and Kalugala from the Western Province of Sri Lanka were included in the study. Monks from only one *Aranya* refused to participate. Since numbers were low in each hermitage, a consecutive sampling method was employed. To minimize confounding, participants who had congenital hypertension, diabetes mellitus, dyslipidemia, angina and stroke or who were on anti-hypertensive, hypoglycemic, anti-cholesterol, anti-angina and stock medications were excluded from the study (22 monks). Clinical status was determined by an interviewer assisted questionnaire and by assessing the clinical records.

The participants were sub grouped according to meditation experience: Group-1 (Age-50.1 ± 6.1 and meditating period- 8.3 ± 6.8 years) was comprised of 71 monks whose meditation experience exceeded 6 months. Group-2 (Age-50.3 ± 6.5 and meditating period-0.48 ± 0.1 years) was comprised of 44 monks whose meditation experience was less than 6 months while group- 3 (Age-50.7 ± 6.1 and meditating period- 0 years) was comprised 36 non-meditating monks living in forest hermitages. All monks irrespective of their subgroups had lived in their forest hermitages > 5 years. The meditating monks were practicing for meditation minimum 5 h per each day except occasional unavoidable circumstances. Age matched healthy volunteer laymen (group-4), from semi urban Anuradhapura (North Central Province) were selected for comparison with 3 groups of monks having different meditating time periods. The comparison group (group-4) was comprised of total 101 subjects, these volunteers were non-smokers, did not drink alcoholic, non-diabetic, non-dyslipidaemic, normotensive and had no past or current history of angina, stroke or on dietary restrictions (Age-50.2 ± 6.1 and meditating period- 0 years).

5. Data collection

General life style of laymen and meditating monks who participated in this study was assessed using questionnaire (validated by investigators). Meditating (Group-1 and 2) and none meditating monks (group-3) were living in the same environment and were having the same dietary habits. None meditating layman (group-4) had different living environment. Their dietary habits were almost similar including the weight and composition (Fifty percent of carbohydrate (rice and flour); 30% of fat (milk and coconut oil); 20% of protein legumes; 15 g of fiber; 5 g of salt and 400 g of fruits. These dietary percentages were well within preferred healthy range for an active adult) except the frequency (twice/day vs trice/day) (Table 1). This data was collected using 24 -h, period recall and the investigators weighing/ measuring the composition of the diets. A comparison group was included to assess any living environment related confounders.

6. Health indicators

Changes in health status related to meditation and meditation history were examined using biochemical and physiological markers commonly used in the assessment of risk for cardiovascular disease. These included: body mass index (BMI), blood pressure, pulse rate, blood lipids and blood glucose levels.

6.1. Anthropometry

Height and weight of monks in their robes and laymen in their light clothing were measured using a height measuring improvised meter scale in cm and a weight measuring standardized bathroom scale in Kg to the nearest decimal point.

6.2. Blood pressure

Systolic and diastolic blood pressure was measured to the nearest mm of mercury using Japanese MAC™ mercury type sphygmomanometer.

Table 1
Lifestyle indicators of meditating and none meditating monks and layman.

Lifestyle	Laymen (Group-4)	Meditating and non meditating monks (Group-1,2 & 3)
Environment	Semi-urban	Forest-rocky hills
Housing	Tiled and cement floors	Caves/cottages
Diet	Lacto-vegetarian	Lacto-vegetarian
Meals	Breakfast, lunch and dinner	Breakfast and lunch
Employment	Government/private	None
Work capacity	Sedentary	Sedentary
Habits	None smoking/none alcoholic	None smoking/none alcoholic

Group 1: Meditation experience > 6 months, Group 2: Meditation experience < 6 months, Group 3: Non-meditating monks living in forest hermitages and Group 4: Non-meditating laymen.

6.3. Pulse rate

Pulse rate was measured as the number of beats per minute by counting the number of beats for 60 s and taking the average of three readings.

6.4. Lipid profile and blood sugar estimation

Blood, 4–5 mL, was collected from the antecubital vein of the subjects under standard conditions following 12 h or more fasting. Blood containing Ethylenediaminetetraacetic acid (EDTA) coated centrifuge tubes were centrifuged at 1500 g for 3 min at room temperature (25^0C) in the collection site. The supernatant from each of the samples comprising of plasma was transferred to two eppendorf tubes and stored in ice until they reached the laboratory. Plasma (10 μL) of one eppendorf tube was analyzed in duplicate for blood glucose and lipid profile, separately, using Biolabo Enzyme Kits (France).

7. Statistical analysis

The statistical software package SAS 9.1 was used for analysis [15]. Analyses of variance of blood glucose, body mass index, systolic & diastolic blood pressure, and pulse rate and lipid profile indices were performed in relation to meditation experience and age significance of meditation. Above parameters were analyzed using two ways analysis of variance (ANOVA). Mean comparison using Duncan's multiple range test was conducted to extract the exact group that having significant group mean. $P < 0.05$ taken as significant.

8. Results

All consenting monks participated in the study. All monks resided in forest hermitages on a fulltime basis with a mean period of stay of 6.3 ± 0.8 years.

8.1. BMI

BMI was not significantly different ($P > 0.05$) between the test and control groups (Table 2).

8.2. Blood pressure and pulse rate

The mean systolic and diastolic blood pressure was normal (considering age specific values [8]) in all 4 groups and there was no significant difference (Table 4). The mean pulse rate was within normal limits (60- ≤100/min) in all 4 groups and there was no significant difference (Table 2).

8.3. HDL cholesterol level

The HDL cholesterol level of the longer meditating, > 6-month, test group (Group 1) was 53.8 ± 5.3 mg/dL and was significantly higher than all groups; 6 month or lesser meditating group (Group 2): 45.6 ± 5.8 mg/dL; non-meditating monks living in forest hermitages (Group 3): 42.8 ± 5.4 mg/dL and; non-meditating laymen group (group 4): 39.1 ± 7.4 mg/dL by mean comparison analysis.

8.4. Other blood lipids (total cholesterol-TOTALc, low density lipoprotein cholesterol- LDLc and triacyl glycerol-TAG)

When considering the mean total cholesterol level, there was no significant difference among groups and the values were within normal limits. The mean total cholesterol level across groups was 176 mg/dl and was within normal limits. There was no significant difference in mean LDLc among groups. Also, there was no significant difference in triacylglycerol concentration among the 4 groups and the values were within normal limits (Table 2).

8.5. TOTALc /HDLc ratio

Total cholesterol/ HDL_c, of the meditating > 6 months test group (Group 1) was 3.6 ± 0.52 and was significantly lower than that of the < 6 month meditating group (Group 2): 4.1 ± 0.53 and non-meditating monks living in forest hermitages group (Group 3): 4.6 ± 0.93 and non-meditating laymen control group (group 4): 5.5 ± 1.6. Further, all groups except group 4 had Total cholesterol/ $HDL_c < 5$ (Table 2).

8.6. Fasting blood glucose (FBG) level

No significant difference in blood glucose levels was found between the four groups ($P > 0.05$). The values were within the normal limits. The mean FBG of those meditating more than 6 months (Group 1) was at the lower end of the normal range (Table 2).

9. Discussion

Long term meditation appeared to have had a significant positive effect on HDLc, TOTALc/HDLc ratio, LDLc /HDLc ratio, whilst fasting blood glucose, total cholesterol, BMI, LDLc, TAG, blood pressure and

Table 2
Effect of meditation on blood lipids, fasting blood glucose and cardiac parameters.

Parameter	Group 1 mean ± SD (n = 71)	Group 2 mean ± SD (n = 44)	Group 3 mean ± SD (n = 36)	Group 4 mean ± SD (n = 101)	F value	P value
HDLc**	53.8 ± 5.3	45.6 ± 5.8	42.8 ± 5.4	39.1 ± 7.4	4.09	< 0.001
TOTALc	172.5 ± 23.4	173.3 ± 34.6	187.8 ± 45.2	174.6 ± 48.5	0.89	0.44
LDLc	93.26 ± 22.5	101.0 ± 32.4	114.9 ± 27.8	119.7 ± 34.9	1.54	0.13
TAG	136.5 ± 36.4	141.8 ± 42.4	126.1 ± 37.1	158.9 ± 56.7	0.96	0.41
Fasting Blood Sugar (FBS)	79.9 ± 23.3	88.4 ± 34.1	86.1 ± 22.5	84.7 ± 25.4	1.76	0.07
BMI	21.47 ± 3.1	20.87 ± 4.5	22.20 ± 4.7	21.86 ± 2.1	1.87	0.14
Systolic Blood Pressure (SBP)	116.3 ± 24.5	120.2 ± 34.6	118.7 ± 45.2	127.1 ± 43.6	1.33	0.26
Diastolic Blood Pressure (DBP)	79.5 ± 7.3	80 ± 10.2	77 ± 12.1	81.1 ± 14.2	0.58	0.83
Pulse Rate (PR)	70.2 ± 6.7	72.8 ± 7.2	73.7 ± 9.3	73.9 ± 8.9	1.57	0.19
TOTALc/HDLc**	3.57 ± 0.52	4.08 ± 0.53	4.59 ± 0.93	5.53 ± 1.6	4.72	0.0036
LDLc/HDLc**	1.97 ± 0.58	2.43 ± 0.6	2.95 ± 0.8	3.81 ± 0.94	5.83	0.009

HDLc- high density lipoprotein cholesterol, LDLc- low density lipoprotein cholesterol, TOTALc- total lipoprotein cholesterol and BMI-body mass index. (Group 1: Meditation experience > 6 months, Group 2: Meditation experience < 6 months, Group 3:Non-meditating monks living in forest hermitages and Group 4: Non-meditating laymen control); α = < 0.05. Based on mean comparison analysis group 1 vs group 2 was having significant differences (**) while between group 2, 3 and 4 were not having significant differences.

pulse rate did not show such an effect. However, when mean values of blood pressure obtained, did show a trend towards safer levels (Table 2).

It is postulated that when a person is having higher concentration of cholesterol in the blood, the LDLc provoke plaque formation causing blood vessels to narrow and increases risk for myocardial infraction and stroke. HDLc, in contrast, is thought to remove cholesterol from arteries and carry it to the liver for removal from the body [8,9]. Compared to group 2, 3 and 4, only those in group-1 (long term meditators) had significantly high HDLc while total cholesterol levels were not significantly low. To a certain extent higher HDLc with a lower Total cholesterol/HDLc ratio would minimize the occurrence of CVA and stroke [9,10]. An increase in HDLc fraction is often associated with active life linked to aerobic exercise [16,17]. Also, following various yoga techniques has been shown to significantly increase HDLc level [13,14]. How meditation, a sedentary activity, could promote such high level of HDLc is therefore contradictory. If lowering of stress, mind control, is fundamental in this process, then it could assume that meditation perhaps works on the basis of influencing neural link of mind-gut axis. It has been found that symptoms of functional gastrointestinal disorders including irritable bowel syndrome (IBS) can be reduced by meditation, which explains the influence of the meditation on the gut [18–20].

Furthermore, the LDLc did not decrease significantly though HLCc increased. That would be an effect of long-term meditation, more than 6 months while those who had meditated for less than 6 months did not show significant increase of HDLc compared to none mediating monks and layman. Judsan A Brewer and colleagues have shown that the brain function of experienced meditators is different from naïve meditators [21]. The functional influence of meditation across the brain including stress release would be more intense in longer meditating monks than the naïve mediating monks. According to the findings of Yancura and her research team which was presented at Annual Convention of American Physiological Association, the stress level does not alter LDLc, similar to our study; however, they too found a direct effect by increasing the HDLc levels [22,23]. It has been established that gut microbiota has a connection with blood lipids [24–28]. HDLc is directly related to gut microbiota whereas LDLc is having only a weak relationship. A study done by Emeran Mayer and colleagues explains how gut microbiota is altered in structural and functional brain changes [27]. According to our results, to increase the HDLc level significantly, 6 months duration was required; presumably, would be the time needed to alter the gut microbiota and brain function. However, further studies would require establishing the mechanisms of meditation induced regulation of HDLc using the brain-gut-micro biome axis.

There are limitations to this cross-sectional study as only a single blood sample was taken to test blood lipids from all participants and we were not able to collect a follow up sample. Having high level of HDLc in monks who were meditating > 6 months could be high even prior to initiating the meditation. To try to overcome confounding and trying to represent the whole population of long-term meditators, meditating monks were recruited from different centers from different parts of the country. Further, to over-come the deficiencies, we have recruited multiple related control and comparison groups and analysis was done to assess the deviation of blood cholesterol levels and other health parameters with duration of meditation. Furthermore, we have not performed any stress assessment or explored the relationship between brain-gut-microbial axis.

10. Conclusion

HDLc level and Total cholesterol/ HDLc ratio of the group of monks who are practicing *Samatha* and *Vipassana* mediation longer time than six months is significantly higher and lower than that of meditating monks lesser than 6 months, none meditating monks and layman, respectively. These monks live in forest hermitages located inside the jungles and out-of-reach of the general community which provides distinct calm environment for meditation. Applying this scenario to lay men will be challenging. But at least calming their life by meditation therapy over a certain period would lead to alleviation of suffering. Further, it may prevent development of non-communicable disease like dyslipidemia leading CVA and stroke.

Conflict of interest

None

Authors' contribution

All research done by the authors as WWK and JAASJ analyzed and interpreted the body and blood parameters related to meditation. WWK, JAASJ, PAJP and TSH involved in development of methodology, JAASJ done the data analysis and all of them were equally contributed in writing the manuscript. All authors read and approved the final manuscript.

Funding

Rajarata University of Sri Lanka (ERC/MED/2012/12).

Acknowledgements

KAK Lakmal Chandrasiri, Indika Senevirathne, Indika Aluthgedera, Nishantha Jayasekera Lakmal Jayarathne and Dr. Asanka Kamlajeewa are acknowledged for their laboratory technical support and assistance to follow medical procedures. We thank Faculty of Medicine and Allied Sciences, Rajarata University, for funding assistance.

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