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Original Article

Yoga based cardiac rehabilitation after coronary artery bypass surgery: One-year results on LVEF, lipid profile and psychological states – A randomized controlled study

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ABSTRACT

Objective: To compare the long term effects of yoga based cardiac rehabilitation program with only physiotherapy based program as an add-on to conventional rehabilitation after coronary artery bypass grafting (CABG) on risk factors.

Methods: In this single blind prospective randomized parallel two armed active control study, 1026 patients posted for CABG at Narayana Hrudayalaya Institute of Cardiac Sciences, Bengaluru (India) were screened. Of these, 250 male participants (35–65 years) who satisfied the selection criteria and consented were randomized into two groups.

Within and between group comparisons were done at three points of follow up (i.e. 6th week, 6th month, and 12th month) by using Wilcoxon's signed ranks test and Mann Whitney *U* test respectively.

Results: Yoga group had significantly ($p = 0.001$, Mann Whitney) better improvement in LVEF than control group in those with abnormal baseline EF (<53%) after 1 year. There was a better reduction in BMI in the yoga group ($p = 0.038$, between groups) in those with high baseline BMI (≥23) after 12 months. Yoga group showed significant ($p = 0.008$, Wilcoxon's) reduction in blood glucose at one year in those with high baseline FBS ≥110 mg/dl. There was significantly better improvement in yoga than the control group in HDL ($p = 0.003$), LDL ($p = 0.01$) and VLDL ($p = 0.03$) in those with abnormal baseline values. There was significantly better improvement ($p = 0.02$, between groups) in positive affect in yoga group. Within Yoga group, there was significant decrease in perceived stress ($p = 0.001$), anxiety

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($p = 0.001$), depression ($p = 0.001$), and negative affect ($p = 0.03$) while in the control group there was reduction ($p = 0.003$) only in scores on anxiety.

Conclusion: Addition of yoga based relaxation to conventional post-CABG cardiac rehabilitation helps in better management of risk factors in those with abnormal baseline values and may help in preventing recurrence.

1. Introduction

World Health Organization (WHO) has been sounding an alarm on the rapidly rising burden of cardio-vascular disorders for the past 15 years.[1] The reported prevalence of coronary artery disease (CAD) in adult surveys has risen 4-fold over the last 40 years (to a present level of around 10%) accounting for 29% of all deaths in 2005.[2] It strikes Indians early and kills many in their productive mid-life years.[3]

Coronary artery bypass grafting (CABG) is by far the most common among the surgical methods of management in CAD[4] even in India. The cardiac functional status and the level of psychosocial stress before surgery can influence the quality of life and prognosis after CABG.[5,6] LVEF as seen in 2D-echocardiogram has favorable correspondence to invasive data[7] and has been found to be of predictive value for both, the immediate post-operatives prognosis (the duration of hospital stay) and late mortality after CABG.[8,9] Depression has been found to be another independent prognostic factor for mortality, readmission, cardiac events and lack of functional benefits 6 months[10] to 5 years[11] after CABG. These observations point to the need for integrating psychosocial interventions during critical care to provide holistic and effective management after CABG.[12]

Several studies have documented the benefits of relaxation techniques in pre and post-operative period. In a two armed randomized controlled study, Engblom et al[13] showed increased hobby activities and reduction in scores on Beck's Depression Index during the first post-operative year after CABG in the group who had a comprehensive post-op rehabilitation (physical exercise, relaxation training, group discussion sessions and dietary advice) as compared to the group who had hospital based rehabilitation. Another study observed significant reductions in both state and trait anxiety after 6 weeks of progressive muscular relaxation in anxious patients after CABG.[14] Patients who listened to audiotape information containing information to improve post-operative outcomes had significantly increased physical activity with fewer symptoms of shoulder pain or back pain or anorexia, than the control group.[15]

It is noteworthy that a few similar interventional studies,[13–15] observed no changes in the quality of life after 6 weeks to one year of interventions which points to the need for carefully designed type, frequency and duration of interventions. Yoga including meditation has been incorporated in life style interventions in CAD since nineteen seventies. Yoga is emerging as a useful rehabilitation tool for various chronic lifestyle related ailments.[16] Transcendental Meditation (TM) program has been found to decrease CAD risk factors, cardiovascular morbidity,[17,18] carotid atherosclerosis,[19] and mortality.[20,21] Intensive yoga based life style modification program have been shown to retard coronary atherosclerosis.[22–24] There are no published studies reporting the effect of add-on yogic relaxation techniques in post-CABG rehabilitation. Hence the present study was planned to assess the complimentary effects of yogic relaxation with the hypothesis that this would offer additional benefits to conventional post-CABG rehabilitation.

2. Methods

2.1. *Participants*

One thousand twenty six patients with CAD (established by coronary angiogram) who were posted for elective CABG surgery at Narayana Hrudayalaya Institute of Cardiac Sciences (NHICSc), Bengaluru (India) were screened. Two hundred and fifty male participants in the age range of 35–65 years, who fulfilled the selection criteria were randomized into two groups.

Inclusion criteria were: (a) those with established double or triple vessel disease posted for elective CABG, (b) males between 35 and 65 years of age, and (c) those with their residential address within 200 km from NHICSc hospital to ensure compliance for follow up. Female patients posted for CABG were excluded as the post-CABG prognosis is different in females[25] and the number of females available for final subgroup analysis would be insufficient. Other exclusion criteria were: emergency CABG, CABG with valve surgeries, acute and chronic renal failure with or without dialysis, physical disabilities that would prevent them from doing yoga practices, neuro-psychiatric illness, and patients already exposed to yoga. Those with left ventricular ejection fraction (LVEF) <30% were also excluded as the ethical committee was not convinced about the safety of the procedure and this was the first study with no published evidence for the safety of the yoga techniques used.

The study was funded by the Department of AYUSH, Ministry of Health and Family Welfare, New Delhi, India under the 'Extra Mural Research' scheme. The research protocol including the informed consent forms in English and Kannada languages, were approved by the institutional ethics committee of both SVYASA University and NHICSc. Signed informed consent was obtained from all participants before recruitment.

2.2. Design

This was a single blind longitudinal prospective randomized parallel two armed control study, conducted by the division of yoga and life sciences of the SVYASA University, Bengaluru, India between 2003 and 2007 at NHICSc., Bengaluru.

2.3. Procedure

Participants were allocated to two groups using a computer-generated random number table (www.randomizer.org). The table was generated by the statistician at the university center, that allocated them to the yoga based life style modification program (YLSP) or physiotherapy based life style modification program (PTLSP) groups. After recruitment all baseline data were documented by the research team. The Yoga therapist personally visited the ward and taught yogic relaxation twice a day for 1–3 days after admission during the pre-operative preparation. After ensuring the correctness of practice with right understanding, the patient was asked to continue the practice using a pre-recorded audio tape. After the surgery, the nurses in the ICU ensured the practice through the audio player. Two to three days before discharge, when the patient was out of the ICU, the yoga therapist sat with the patient and revised the practice under supervision. After discharge they were asked to continue the practices twice daily. They were taught more yoga techniques (Table 1) during their 6th week and 6th month follow up visits. Home practice (one hour/day) was monitored by providing a life style diary and regular weekly phone calls by the therapist. All relevant data were taken on the day before surgery and during their follow up visits after 6 weeks, 6 months and 1 year after surgery.

2.4. Blinding

As this was an interventional study, the participants and trainers could not be blinded; the team who did the laboratory assessments and the statistician were blind to the source of the data.

2.5. Intervention

Pharmacotherapy as advised by the clinician and the conventional post-operative rehabilitation practices, were common to both groups. The medication dosages during the baseline and intervention periods were kept stable by participant and physician consent. There was no significant difference in the percentage of subjects taking medications in the two groups (Table 3). Under conventional post-CABG rehabilitation, common daily practices (30 min) were administered by a team of trained physiotherapists to both groups which included: (a) gradually increasing distance and speed of walking with intermittent relaxation covering a total of about 2 km/day, (b) breathing exercises and (c) breathing through

Table 1 – List of practices for the experimental group (yoga based life style modification program).

Module	Duration	Yoga based life style modification program
1	Pre-op day to 6 weeks	Deep Relaxation Technique (DRT) Mind sound resonance technique (MSRT) Nadisuddhi Pranayama
2	6 weeks to 6 months	Sukshma vyayamas for Wrist – Manibandha shakti vikasaka Back of hand – Karaprasta shakti vikasaka Elbows – Kaphoni shakti vikasaka Neck – Griva shakti vikasaka I & II Back – Kati shakti vikasaka I & II Eyes – Netra shakti vikasaka Legs – Padasanchala Quick relaxation technique (QRT), DRT and MSRT
3	6 months to 12 months	Yogic Breathing practices Prasarita hasta swasah (Hands in & out breathing) Utkashita hasta swasah (Hands stretch breathing) Vyaghra swasah (Tiger breathing) Ekapadauttana swasah (Straight leg raise breathing) Asanas – 20 min Standing position Ardha kati chakrasana (Lateral half wheel posture) Trikonasana (Triangle posture) Vrikshasana (Tree posture) Garudasana (Eagle posture) Prone posture Bhujangasana (Serpent posture) Sitting posture Vakrasana (Spinal twist with leg straight) Ardhamatsyendrasana (Half spinal twist) Vajrasana (Diamond posture) Supine posture, QRT, DRT and MSRT

Table 2 – List of practices for the control group (physiotherapy based life style modification program).

Module	Duration	Physiotherapy based life style modification program
1	Pre-op day to 6 weeks	Breathing practices Physiotherapy exercises for wrist, back of hand, elbows, neck, back and legs
2	6 weeks to 6 months	Breathing exercises – Inhale through the nose and exhale forcibly through the mouth Breathing through lung exerciser Additional Physiotherapy exercises for wrist, back of hand, elbows, neck, Back, legs, Shoulder rotation, slow side bending, knee cap tightening Supine rest
3	6 months to 12 months	Additional Physiotherapy exercises Standing position practices Sit-ups, Hip rotation, Knee rotation, Forward drill, Backward drill, Sideward drill, Full arm rotation, Free walking, Sitting in a chair – Chakki chalana, Ankle bending, Toe Bending, Leg spread exercises with support - sideways, front and back Supine rest

lung exerciser. Different sets of reading material were provided for the two groups.

2.6. *Yoga intervention (Table 1)*

The integrated yoga intervention included simple and safe practices at physical, mental, emotional, intellectual levels to reach a state of mastery over the modifications of the mind (*Chitta Vritti Nirodhah* – definition of yoga by sage *Patanjali*) through effortless blissful inner awareness during all practices. Three yoga modules (of 30 min each) were prepared to suit the three periods of rehabilitation. The first module (upto 6th week) included MSRT (Mind Sound Resonance Technique), breath awareness and DRT (deep relaxation technique), all done in supine posture. MSRT is a systematic training consisting of 8 steps of sound meditation (based on *Māndukya Upanishad*[26] and *Gheranda Samhitā*.[27] It involves gentle chanting of the syllables A, U, M, and OM to feel the resonance inside the body cavities i.e. abdomen, chest, skull and entire trunk respectively. This is done repeatedly while alternating between audible chanting (*Ahata Nādanusandhāna*) and mental chanting (*Anāhata Nādanusandhāna*). This phase is followed by a resolve and closing prayer. Physical postures and *pranayama* practices were added in the second (6th week to 6th month) and third (6th month to 12th month) yoga modules (Table 1). These three modules of integrated approach of yoga therapy for life style disorders were developed by experts on the basis of ancient yogic scriptures. These modules have been found to be safe and beneficial in our clinical practice at 250 bedded holistic health home, *Arogyadhama*, Bangalore, since last 20 years.[28]

Counseling for the YLSP group on yogic life style modification included the concepts of right living from Indian yoga psychology while the PTLSP group were counseled using scientific information on life style modification recommended in conventional cardiac rehabilitation programs.[29] This concept of right living according to yogic tradition was introduced gradually in these modules as the person would return to work and normal life style. These included concepts of do's (*niyamas*) and don'ts (*yamas*) from *Ashtānga* yoga of *Patanjali*,[30] *Karma* yoga from *Bhagavadgita* that helps in working without stress[31]; *Bhakti* yoga, the path of pure love that opens up avenues for healthy relationships[32]; and *Jñana* yoga that transforms the basic notions about life through introspective correction of the meaning and purpose of life.[33] All these concepts were meant to help the individual to move towards blissfully contented joyful living with the right understanding in tune with the laws of nature that govern one's existence.

2.7. *Control group intervention*

The non-yogic intervention for the control group was designed to match the duration (30 min), and the level of physical activity suitable to different stages in the post-operative period (Table 2). This module of physical activity was an add-on and different from the conventional physiotherapy based rehabilitation which was common to both groups.

The practices included mild stretches followed by breathing exercises and supine rest. Care was taken by the therapists to avoid the yoga concepts while counseling or teaching the control group intervention.

2.8. *Measurements*

All demographic details and base line data were documented on pre-op day. The routine pre-operative assessments included coronary angiogram performed one to four weeks before posting for surgery, Echocardiogram, ECG, lipid profiles, renal function tests, clinical assessments etc as per the conventional hospital protocol.

2.8.1. *Left ventricular ejection fraction (LVEF)*

2D Doppler Echo-cardiogram was recorded using Vivid-4 model, GE Company's ultrasound sound equipment, USA (P_{max} – 1.2 KVA, Frequency – 50 Hz) by a certified technician using a 3 MV (lesser resolution) transducer. This was documented in the pre-operative week, and also during each follow

Table 3 – Demographic data.

Particulars		YLSP	PTLSP
Sex (only male)		$n = 129$	$n = 121$
Age range (years)		35–65	35–65
Age (years) Mean (SD)		53.34 (6.42)	52.6 (6.85)
Education	School	25	26
	Undergraduates	37	39
	Graduates	26	40*
	Post-Graduates	32	25
Socio-economic Status	Upper class	10	08
	Middle class	65	79
	Lower class	35	42
Duration of CAD	<1 year	71	80
	1–5	42	42
	5–10	7	08
Nature of CAD	SVD	20	15
	DVD	31	39
	TVD	69	76
Associated conditions	HTN	38	31
	DM	20	15
	HTN + DM	53	63
Ejection fraction	≤35	3	4
	36–40	8	6
	41–45	11	18
	46–50	19	27
	51–55	33	36
	56–60	46	38
Medications	Antiplatelet agents	117	111
	Statins	89	86
	Beta-blockers	67	69
	ACEI/ARB's	76	65
	CCB/Nitrates	29	24
	Hypoglycemic agents	73	78
Family history of CAD		28	22
Cigarette smoking		23	22
Tobacco chewing		18	16
Alcohol consumption		25	15*

*$p < 0.05$, Independent Samples t test.
Abbreviations: YLSP: yoga life style program; PTLSP: physiotherapy life style program; SVD: single vessel disease; DVD: double vessel disease; TVD: triple vessel disease; HTN: hypertension; DM: diabetes mellitus; CAD: coronary artery disease; SD: standard deviation; ACEI: Angiotensin Converting Enzyme Inhibitors; ARB: Angiotensin Receptor Blocker; CCB: Calcium Channel Blocker.

up visit in 6th week, 6th month and 12th month after the surgery.

BMI and other clinical variables were also documented at each of the follow up visits.

2.9. *Biochemical measures*

Fasting blood glucose (intra-assay CV = 0.9%, inter-assay CV = 1.8%), Total cholesterol (intra-assay CV = 0.8%, inter-assay CV = 1.7%) and triglycerides (intra-assay CV = 1.5%, inter-assay CV = 1.8%) were measured using the enzymatic calorimetric method. HDL cholesterol (intra-assay CV = 2.9%, inter-assay CV = 3.6%) was measured using a homogenous calorimetric assay, whereas LDL cholesterol (intra-assay CV = 0.9%, inter-assay CV = 2.0%) was measured using a homogenous turbidimetric assay.

2.10. *Psychological measures*

Perceived stress scale (PSS): This is a popularly used self-rated measure of 'stress in daily life' that is perceived by the subject as uncontrollable and overwhelming. It is a validated tool[34] that has 14 items scored on a 5-point scale and with a reliability score of 0.85.[35]

Hospital anxiety and depression (HADS) is a widely used validated[36,37] self-reported instrument designed to assess anxiety and depression in non-psychiatric population. This 14-item questionnaire consists of two sub-scales of seven items for self-reported anxiety and depression. Patients are asked to answer what they experienced during the last two weeks, on a scale of 4 ranging from 0 ("not at all") to 3 ("very much"). The reliability of HADS, and the two sub-scales (HADS-anxiety and HADS-depression) are 0.85, 0.79 and 0.87 respectively.[38]

Positive and Negative Affect Scale (PANAS): PANAS has two sub-scales i.e. positive affect (PA) and negative affect (NA) consisting of 10 items each. PA reflects the extent to which a person feels enthusiastic, active, and alert. A high PA score reflects a state of high energy, full concentration and pleasurable engagement. NA is a general dimension of subjective distress subsuming a variety of aversive mood states. A high NA score indicates more distress. This descriptive scale has proven validity[39] and its reliability ranges from 0.86 to 0.90 for PA and 0.84 to 0.87 for NA.[39]

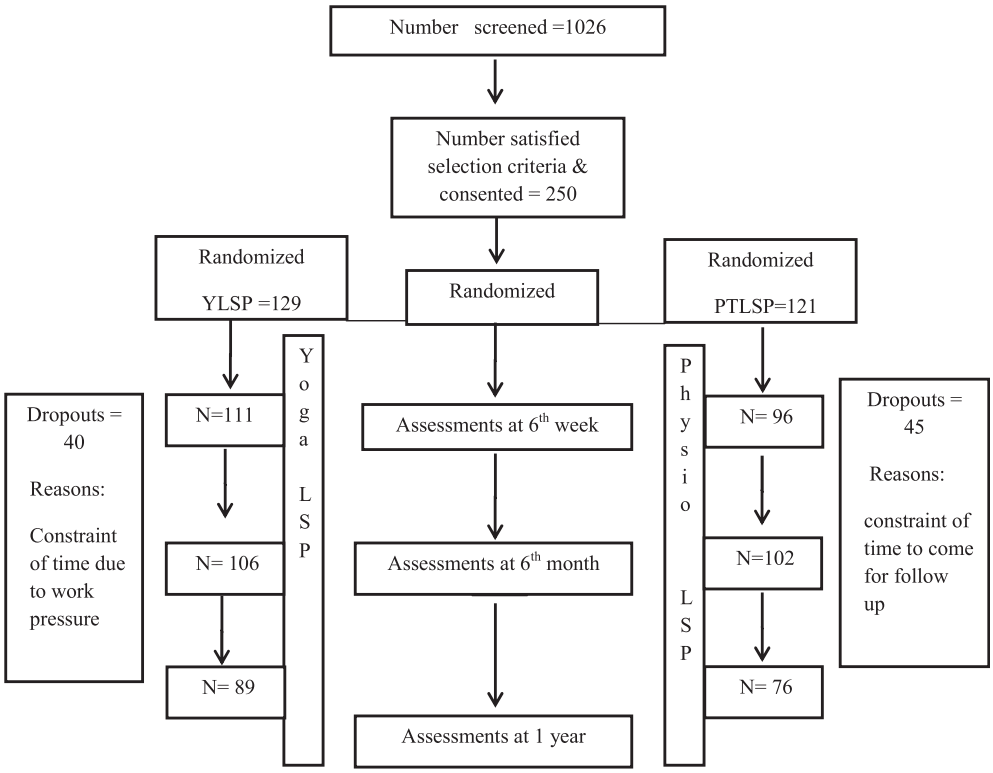
2.11. *Data extraction and analysis*

Data were analyzed using SPSS version 10.0. The baseline comparisons between the two groups were done by using independent samples *t* test. The baseline mean values of the drop out group were also compared with that of the study group by independent samples *t* test. As the data were not normally distributed, Wilcoxon's signed rank test and Mann–Whitney *U* test were used to compare the means within and between groups respectively.

3. Results

Fig. 1 shows the trial profile. Of the 1026 screened, 250 fulfilled the selection criteria and were recruited after obtaining the informed consent. Forty in yoga group and forty five in control group dropped out. The main reason for drop out was the constraint on time to come for follow up to NHICSc, as most of the patients were from different towns in Karnataka and they opted to get their routine follows up done from local medical practitioners.

The baseline characteristics are shown in Table 3. The groups were matched with no significant ($p > 0.01$, independent samples *t* test) difference between the groups at baseline except that the number of subjects consuming alcohol were higher in the yoga group. Comparison of baseline mean values of the drop out group with those who continued with the study also showed no significant difference. Three patients in yoga group and four in control group had very low (25–35%) baseline LVEF. Table 4 shows the results after the intervention.



Abbreviations: YLSP- yoga life style program, PTLSP- physiotherapy life style program

Fig. 1 – Trial profile.

3.1. *LVEF*

The recent guidelines from the American Society of Echocardiography have defined an abnormal ejection fraction (EF) of the left ventricle on echocardiographic measurement as one that is less than 55%.[40] Similarly, a few other studies defined LVEF less than 0.55 as systolic dysfunction in heart failure patients.[41,42] Based on data from a number of more recent studies, a value less than 54% has been suggested as the cut-off value that is associated with moderate adverse outcomes.[43] Another study on a large cohort (2300 subjects) of European white and Indian Asian subjects that looked at ethnicity-specific reference values of LVEF reported a cut off value of 52%.[44] Based on these studies, as our target population belonged to Indian Asian community, we set our cut off LVEF value as 53%, which was our median value between the reported cut off values. Thus, we considered values ≥53% as normal and <53% as abnormal for the analysis of our data.

There was significant improvement in LVEF in both groups with no significant difference between groups at each point of follow up. In the subgroup with abnormal baseline EF (<53, median) there was progressive increase in both yoga and control groups. Yoga group improved better than control group all along and the Mann Whitney showed significant p values ($p = 0.02$) at one year.

In the subgroup with normal baseline EF (≥53, median), the yoga group showed continuing increase in EF, while there was a decrease in EF at all points in the control group. The Mann Whitney did not show significant difference between groups at any of these points of follow up.

3.2. *Secondary outcome measures*

3.2.1. *BMI*

We used a value of 23 as the value to define overweight,[45,46] as it has been found that Indians have higher risk at lower values of BMI and the recommended cut off value is 23 (25 in Caucasians). Thus, in the subgroup with high baseline BMI (≥23), there was a significant difference between groups ($p = 0.038$) with better reduction in yoga group after one year. Also, this subgroup (BMI ≥ 23) showed that the weight and BMI decreased significantly within both groups at 6 weeks and 6 months, whereas only the yoga group showed significant reduction at the end of the year ($p < 0.001$). In those with BMI <23, there was no significant change in both the groups at any of the three time points (Table 4).

3.3. *Biochemical variables*

There were total 93 patients with baseline FBS ≥110 mg/dl (55 in yoga the group and 38 in the control). There was better glycemic control in yoga group, as seen by significant decrease within the group in those with FBS ≥110 mg/dl ($p = 0.008$) at the end of 1 year, whereas in the control group the reduction was not statistically significant ($p = 0.8$). There was no between group difference ($p = 0.41$) (Table 5). There were 11

Table 4 – Changes in ejection fraction in yoga and control groups after post-CABG rehabilitation.

	Group	Baseline		6th week			6th month			1 year		
		n	Mean ± SD	n	Mean ± SD	Wilcoxon p value	n	Mean ± SD	Wilcoxon p value	n	Mean ± SD	Wilcoxon p value
EF Total	Y	129	52.22 ± 6.69	111	54.58 ± 5.80	0.001	106	54.96 ± 5.38	0.001	89	55.91 ± 5.21	0.001
	C	121	53.39 ± 7.14	96	53.85 ± 6.33	0.001	102	53.94 ± 6.68	0.001	76	54.12 ± 6.84	0.001
Mann Whitney	p value		0.16		0.38			0.9			0.5	
EF ≤53	Y	69	47.36 ± 5.23	61	51.61 ± 6.15	0.001	55	52.42 ± 5.89	0.001	49	53.28 ± 5.69	0.001
Median	C	60	47.07 ± 5.68	50	49.0 ± 5.55	0.001	48	48.72 ± 6.29	0.001	33	48.89 ± 6.76	0.001
Mann Whitney	p Value		0.63		0.24			0.43			0.02*	
EF ≥53	Y	60	57.87 ± 2.31	50	58.03 ± 2.66	0.001	51	58.34 ± 2.55	0.001	40	58.53 ± 2.27	0.001
Median	C	61	58.72 ± 2.05	46	57.94 ± 3.37	0.001	54	57.96 ± 5.38	0.001	43	55.91 ± 5.21	0.001
Mann Whitney	p Value		0.04*		0.55			0.98			0.38	

*$p < 0.05$, **$p < 0.001$.

Legend: Yoga group showed significantly better increase in EF than control group in those with abnormal baseline EF (EF ≤ 53, median). There was significant improvement in both groups with no significant difference between groups at each point of follow up. In subgroup with abnormal baseline EF (≤53, median) there was progressive increase in EF in both yoga and control groups. Yoga group improved better than control group all along and the Mann Whitney showed significant p values ($p = 0.02$) at one year. In the subgroup with normal baseline EF (≥53, median), the yoga group showed continuing increase in EF, while there was a decrease in EF at all points in the control group. The Mann Whitney did not show significant difference between groups at any of these points of follow up.

Abbreviations: Y: yoga group (yoga life style program); C: control (physiotherapy life style program); SD: standard deviation; EF: Ejection Fraction.

patients who had baseline FBS ≥200 mg/dl (5 in yoga group and 6 in the control); analysis showed that there was a significant reduction in FBS in those with FBS ≥200 mg/dl in the yoga group at 6 months ($p = 0.003$) and at one year ($p = 0.03$), whereas in the control group there was a significant reduction after 6 months ($p = 0.008$) with non-significant change at the end of the year ($p = 0.06$) (Table 5) with no significant difference between the groups at the end of 6 months ($p = 0.213$) as well as one year ($p = 0.32$) (Table 5).

3.3.1. *Lipid profile*

There was significant decrease in triglycerides within both groups ($p = 0.001$) in those who had high baseline values (≥150 mg/dl) with no significant difference between the groups ($p = 0.37$). There was significantly better increase in HDL in yoga than control group ($p = 0.003$ between groups). Also the increase in those with low HDL values (<35 mg/dl) was better in yoga ($p = 0.001$) group than the control ($p = 0.03$) group. LDL levels also reduced significantly in both the groups, with non-significant difference between groups.

Looking at sub-group analysis, the yoga group showed significant reduction in LDL ($p = 0.01$) levels with significant difference between the groups ($p = 0.01$) in those who had values >100 mg/dl. VLDL reduced in both the groups significantly with a better reduction ($p = 0.03$) in Yoga than the control. Thus, yoga group had better changes in lipid profile than control group in those with abnormal baseline values.

3.4. *Psychological variables*

3.4.1. *PSS, HADS and PANAS (Table 5)*

Within Yoga group, there was significant decrease in PSS ($p = 0.001$), HADS-Anxiety ($p = 0.001$), HADS-Depression ($p = 0.001$), and PANAS-Negative ($p = 0.03$). In Control group, there was significant decrease only in HADS-Anxiety, ($p = 0.003$). Also, there was significant difference between Yoga and Control groups in positive component of PANAS ($p = 0.02$).

This improvement in positive affect points to better wellness and quality of life. Although no specific validated questionnaire has been included here, the clinicians who checked all patients during follow up reported that those who had practiced yoga returned to normalcy much faster and earlier than the control group.

4. Discussion

This single blind prospective randomized two armed active control study has shown that YLSP was significantly better than PTLSP in increasing LVEF ($p = 0.02$, Mann Whitney test) one year after CABG surgery in those with abnormal (<median) baseline LVEF values. YLSP was also more beneficial in normalizing many risk factors including BMI, blood glucose, triglycerides, VLDL, LDL and HDL in those with abnormal baseline values. Although anxiety and depression reduced in both cases, positive affect increased only in the yoga group pointing to the role of yoga in promoting psychological wellness in addition to the physical benefits.

Table 5 – Changes in BMI and psychological measures after one year of intervention.

Variable		Group	Base line Mean (SD)	95% CI	1 Year Mean (SD)	95% CI	p – value (within group)	% Change	p – value (between the groups)
STRESS	PSS	Y	18.76 (4.73)	9.48–28.03	15.54 (4.5)	6.72–24.36	0.001**	14.94	0.12
		C	16.28 (4.46)	7.53–25.021	16.75 (4.30)	8.32–25.178	0.49	6.71	
PANAS	Positive	Y	39.18 (8.16)	23.18–55.17	40.54 (7.97)	24.91–56.16	0.08	3.47	0.02*
		C	34.67 (8.72)	17.57–51.76	35.83 (8.72)	18.73–52.92	0.36	3.34	
	Negative	Y	28.57 (8.71)	11.49–45.64	26.82 (8.08)	10.98–42.65	0.03*	6.12	0.97
		C	27.0 (9.46)	8.45–45.54	26.3 (7.62)	11.36–41.23	0.76	2.59	
HADS	Anxiety	Y	7.42 (3.40)	0.75–14.08	5.75 (3.46)	−1.03 to 12.53	0.001**	27.03	0.42
		C	7.84 (3.05)	1.86–13.81	6.15 (2.98)	0.30–11.99	0.003*	13.02	
	Depression	Y	6.59 (3.44)	−0.15 to 13.33	4.65 (3.51)	−2.22 to 11.52	0.001**	30.77	0.07
		C	6.85 (3.56)	−0.12 to 13.82	5.61 (3.30)	−0.85 to 12.07	0.05*	14.66	
BMI (kg/m^2)	≥23	Y	26.60 (2.30)	26.16–27.03	24.47 (1.85)	20.84–28.09	0.001**	8.00	0.038*
		C	26.15 (2.10)	25.76–26.53	25.82 (2.25)	21.41–30.23	0.161	1.26	
	<23	Y	21.47 (1.32)	18.88–24.05	21.70 (1.35)	20.72–22.67	0.55	1.07	0.39
		C	21.07 (1.50)	19.13–24.01	20.94 (2.49)	18.32–23.56	0.50	0.61	
	Total	Y	26.76 (3.24)	20.40–33.11	23.93 (2.56)	18.91–28.94	0.001**	6.72	0.001**
		C	25.22 (3.15)	19.04–31.39	24.93 (3.46)	18.14–31.71	0.09	1.15	
Body weight (kgs)	≥65	Y	73.71 (7.88)	58.26–89.15	67.13 (7.59)	52.25–82.00	0.001	8.93	0.001**
		C	75.73 (7.97)	60.10–91.35	73.88 (8.08)	58.04–89.71	0.0015	2.45	
	<65	Y	63.13 (4.98)	53.36–72.89	60.42 (4.47)	51.65–69.18	0.001**	4.29	0.64
		C	61.33 (6.57)	48.45–74.20	61.10 (7.85)	45.71–76.48	0.67	0.37	
	Total	Y	69.01 (8.85)	51.66–86.35	64.12 (7.42)	49.57–78.66	0.001**	7.32	0.01*
		C	68.17 (10.34)	47.90–88.43	67.34 (10.41)	46.93–87.74	0.035	1.22	
FBS (mg%)	≥110	Y	147.22 (35.46)	77.71–216.72	135.52 (52.03)	33.54–237.49	0.008*	7.65	0.41
		C	153.77 (41.07)	73.27–234.26	142.48 (50.66)	43.18–241.77	0.08	7.34	
	≥125	Y	156.17 (21.34)	115.15–197.99	149.3 (61.9)	27.98–270.62	0.59	4.20	0.47
		C	154.41 (18.07)	119.00–189.82	139.00 (46.50)	47.86–230.14	0.17	9.97	
	≥200	Y	233.00 (29.46)	159.81–306.19	164.00 (14.17)	136.23–191.77	0.03*	29.60	0.32
		C	228.40 (27.42)	190.85–270.15	159.80 (44.63)	72.33–247.27	0.06	30.03	
	<125	Y	117.20 (36.71)	45.25–181.15	121.28 (47.06)	29.05–213.15	0.46	3.48	0.95
		C	111.35 (38.34)	36.21–186.49	120.76 (45.65)	31.29–210.13	0.21	8.45	
	Total	Y	122.3 (44.13)	35.80–208.79	119.50 (45.64)	30.04–208.95	0.04*	2.79	0.75
		C	121 (49.61)	23.76–218.23	124.02 (46.49)	32.89–215.14	0.27	2.41	

*$p < 0.05$, **$p < 0.001$.

Legend: Table 5 shows significant differences between the groups where yoga-based lifestyle modification (Y) group showed better improvement in positive affect, BMI and bodyweight as compared to physiotherapy-based lifestyle modification (C).

Abbreviations: PSS: Perceived Stress Scale; PANAS: Positive and Negative Affect Scale; HADS: Hospitals Anxiety and Depression Scale; BMI: Body Mass Index; FBS: Fasting Blood Sugar; Y: yoga group (yoga life style program); C: control (physiotherapy life style program); SD: standard deviation.

To our knowledge, this is the first randomized controlled yoga based life style study with a yearlong follow up in patients after CABG. A systematic review[47] of cardiac rehabilitation studies on 7683 patients with coronary heart disease from earlier meta-analyses concluded that both comprehensive cardiac rehabilitation and rehabilitation program based on exercise only are effective in reducing cardiac mortality. Cardiac mortality reduced by 31%, with exercise based cardiac rehabilitation and 26% with comprehensive cardiac rehabilitation program. Although such life style modification studies had established the role of intensive life style modification programs in risk-factor modification and prolonging survival among post-myocardial infarction (MI) patients before 2000, the efficacy of these programs in reducing risk factors in patients after CABG were not well-established[48] until more recent randomized prospective studies. A well designed randomized control study on behavioral and educational cardiac rehabilitation program as early as 1995 by Oldenburg et al[48] had shown few differences in risk factors between the study groups one year after CABG. Detry et al[49] studied the effects of early and short-term (2–3 months) intensive multidisciplinary ambulatory cardiac rehabilitation program after coronary artery bypass surgery (CABG) or acute myocardial infarction which showed better compliance to aspirin intake, a low rate of smoking (14% of the patients), a 15% increase in physical capacity and decrease in resting heart rate. They also observed a 4 mg/dl increase in the HDL-cholesterol while our study has shown an increase in HDL by 8 mg/dl after yoga (6.45 mg% in control group) in those who had low HDL values (Table 6).

4.1. LVEF

In patients with CAD, reduced left ventricular function is a good predictor of unfavorable long term prognosis[8] and is an important indicator for in-hospital and late mortality after CABG for CAD.[50,7,8] An intensive information, education and counseling program in CAD patients with more than 70% stenosis and left ventricular ejection fraction of more than 30%, showed significant improvement in LVEF in those with adherence to the new life style regimen by 80% or more.[51] Goodman et al[52] studied the effects of 12 weeks of

Table 6 – Changes in lipid profile after one year of intervention.

Lipids		Group	Base line Mean (SD)	95% CI	1 Year Mean (SD)	95% CI	p – value (within group)	% Change	p – value (between the groups)
Total Chol.	>200	Y	221.33 (23.86)	162.06–280.61	183.33 (65.73)	20.03–346.63	0.19	17.16	0.22
		C	219.33 (12.20)	206.52–232.15	217.67 (29.31)	186.90–248.43	0.76	14.78	
	<200	Y	146.09 (25.13)	140.05–152.13	159.59 (36.53)	150.82–168.37	0.002*	8.45	0.95
		C	146.12 (21.73)	140.35–151.89	160.51 (33.97)	151.49–169.52	0.001**	9.85	
	Total	Y	151.24 (30.35)	91.75–210.72	163.04 (38.01)	88.54–237.53	0.007*	7.80	0.61
		C	154.21 (29.92)	95.56–212.85	167.43 (38.90)	91.18–243.67	0.003*	8.57	
TGLYD	≥150	Y	228.00 (80.99)	202.10–253.90	158.45 (60.17)	139.20–177.70	0.001**	30.50	0.37
		C	237.46 (70.17)	214.06–260.86	175.30 (60.00)	155.29–195.30	0.001**	26.30	
	<150	Y	115.03 (20.73)	107.56–122.51	114.88 (47.15)	97.88–131.87	0.99	0.13	0.41
		C	116.93 (20.31)	108.89–124.96	125.48 (45.85)	107.34–143.62	0.23	8.20	
	Total	Y	180.19 (83.54)	16.45–343.92	142.57 (62.9)	19.28–265.85	0.001**	20.87	0.03*
		C	187.13 (78.74)	32.79–341.46	155.28 (57.98)	41.63–268.92	0.001**	17.02	
HDL	<35	Y	30.17 (3.15)	28.16–32.17	37.92 (6.99)	33.47–42.36	0.001**	25.68	0.57
		C	29.75 (3.91)	27.92–31.58	36.20 (11.80)	30.68–41.72	0.03*	21.68	
	≥35	Y	40.45 (4.81)	39.33–41.58	40.21 (9.55)	37.98–42.43	0.82	0.59	0.19
		C	40.77 (5.85)	39.05–42.49	37.98 (8.66)	35.43–40.52	0.01*	6.84	
	Total	Y	38.67 (6.29)	26.34–50.99	40.23 (9.30)	22.00–58.45	0.19	4.034	0.003*
		C	37.23 (7.39)	22.74–51.71	37.17 (9.68)	18.19–56.14	0.34	6.0	
LDL	≥100	Y	122.52 (22.60)	112.23–132.81	91.38 (43.04)	71.79–110.98	0.01*	25.41	0.01*
		C	114.67 (13.76)	107.05–122.29	125.20 (33.87)	106.44–143.96	0.27	9.18	
	<100	Y	66.54 (19.75)	61.72–71.36	92.19 (28.58)	85.22–99.17	0.001**	27.82	0.84
		C	69.27 (17.21)	64.62–73.93	91.15 (29.57)	83.15–99.14	0.001**	31.58	
	Total	Y	75.97 (27.65)	21.77–130.16	96.61 (29.51)	38.77–154.44	0.001**	27.16	0.75
		C	78.17 (24.15)	30.83–125.50	98.77 (33.53)	33.05–164.48	0.001**	26.35	
VLDL	≥40		55.42 (15.81)	49.62–61.22	55.16 (36.89)	41.63–68.70	0.91	0.46	0.37
			55.75 (13.67)	51.12–60.38	48.50 (24.04)	40.37–56.63	0.065	13.00	
	<40		26.52 (6.49)	24.94–28.11	27.52 (14.27)	24.04–31.00	0.57	3.77	0.70
			26.99 (7.72)	24.64–29.33	28.55 (12.60)	24.71–32.38	0.46	5.46	
	Total	Y	34.92 (16.28)	3.01–66.82	28.51 (12.59)	3.83–53.18	0.001**	18.35	0.03*
		C	36.21 (15.28)	6.26–66.15	31.58 (13.22)	5.66–57.49	0.03*	11.95	

*$p < 0.05$, **$p < 0.001$.

Legend: Table 6 shows significant differences between the groups where yoga-based lifestyle modification (Y) group showed better improvement in total triglycerides, total HDL, LDL in those with baseline more than or equal to 100 mg% and total VLDL as compared to physiotherapy-based lifestyle modification (C).

Abbreviations: Chol: Cholesterol; TLGYD: Triglycerides; LDL: Low Density Lipoproteins; HDL: High Density Lipoproteins; VLDL: Very Low Density Lipoproteins; Y: yoga group (yoga life style program); C: control (physiotherapy life style program); SD: standard deviation.

endurance exercise training on exercise performance and left ventricular ejection fraction (EF) in a group of uncomplicated CABG ($n = 31$) cases. A significant improvement in VO2max was observed after training, accompanied by an increase in the EF during submaximal exercise (60 ± 3% versus 63 ± 2% at 40% VO2max; 61 ± 3% versus 64 ± 3% at 70% VO2max). Although our patients had lower baseline EF values (53%) than Goodman's study group (60%) who were given endurance exercise training, the degree of change after the intervention was similar (around 3%) in both studies. Thus, the effects of both endurance exercise training and yoga appear to offer comparable effects on EF in post-CABG patients. In our study, we observed that LVEF reduced significantly in the control group in those with normal LVEF values (≥53, median) over a span of one year. Though, there was no significant difference between the groups for above mentioned results, this reduction within the control sub-group is surprising, as both the groups underwent successful CABG surgery. Here, one possible explanation could be the absence of relaxation sessions in the control group which were a primary focus in the yoga intervention. In a randomized controlled prospective study,[53] 90 post MI patients were randomly assigned to either exercise training plus individual relaxation group or exercise training only. Results showed that the occurrence of cardiac events, consisting of cardiac death and of readmission to hospital for unstable angina pectoris, coronary artery bypass grafting (CABG) or recurrent infarction, were significantly higher in the exercise training only group than the group with add-on relaxation in the 2–3 years follow up period after infarction.[53] Also, another study showed that for post-CABG patients with normal LVEF (≥55%), the same inpatient exercise protocol triggered a more attenuated cardiac autonomic response compared with patients with reduced LVEF (<55%).[54] This finding suggested that post-CABG patients with normal and abnormal LVEF may respond differently to the same exercise protocol in terms of their cardiac autonomic responses and those with abnormal LVEF responding more favorably than those with normal LVEF, and the volume of the inpatient exercises should be prescribed according to the left ventricular function following recovery from CABG.[54] This may possibly explain the reduction in LVEF in those with normal values (≥53, median) in the control group in our study.

4.2. *Mechanism*

We propose that yoga may have operated by reducing stress arousal.[55,56] It is known that, chronic stress has an important role in the pathogenesis of atherosclerosis[57,58]; psychological distress, depression and state anxiety are extremely frequent, often clustered, in patients after CABG[60]; and these are important determinants of health care utilization within 6 months post discharge in CABG patients.[61]

Several studies have shown that intensive cardiac rehab techniques do reduce many psychological abnormalities. A year-long prospective study on post-CABG cardiac rehabilitation program showed significant decrease in state anxiety and depression.[62] In another study,[63] there was significant reduction in anxiety and depression in the anxious and depressed groups at 12 weeks and 6 months but there was no significant reduction at 12 months after an exercise and education-based rehabilitation program after CABG in our study, the yoga group has shown sustained reduction in anxiety, depression, perceived stress and negative affect even after one year. Reduction in sympathetic activity after yoga[55,59] has been documented which explains the improvement in these variables observed in the present study. It is interesting to note that positive affect was significantly better in those who practiced yoga instead of PT exercises after CABG pointing to yoga's ability to promote positive wellbeing; this could be an important factor that contributed to the complimentary benefits.

Stress reducing effects of yoga that offer correction in the mind set by regular introspective practices at physical, mental, emotional, and intellectual levels, have been investigated in both healthy volunteers and patients with many non-communicable diseases. This may be mediated through better autonomic regulation as shown by many studies.[64–66] Yoga may produce favorable effects through modulation of neuro-endocrino-immunologic pathways. Cortisol levels are positively associated with stress and anxiety[67] and Yoga has been shown to reduce cortisol levels both in health[68] and disease[69] pointing to its effect on Hypothalamo-pituitary-adrenal (HPA) axis.

In addition, the roles of yoga on stress mediators that influence metabolic abnormalities related to lipids (adipose tissue that influences atherosclerosis) have been documented. Kiecolt-Glaser et al[70] compared adiponectin and leptin levels in well-matched novice ($n = 25$) and expert yoga practitioners ($n = 25$) on three different visits. They found that leptin, which plays a pro-inflammatory role, was 36% higher among novices compared to experts and experts' average adiponectin (anti-inflammatory in effect) levels were 28% higher than novices across all three visits. In addition, experts' average adiponectin to leptin ratio was nearly twice that of novices.[70] In our study, we observed better reduction in BMI, lipids and diabetic state in the yoga group than those who practiced physical exercise regularly. Thus, we hypothesize that yoga's effects may be mediated through both central and peripheral adaptation mechanisms i.e. stress-reduction and adipokine mechanisms.

4.3. *Limitations of the study*

(i) Recruitment took longer than expected. (ii) There were about 40% drop outs at the end of one year and hence we could not carry out intention to treat analysis. (iii) As the surgeons were not confident to allow any new intervention for their high risk cases we could not plan to include patients with very low LVEF undergoing CABG. (iv) Only male patients were included in the study as the numbers of female patients were very few. (v) 2D Doppler Echo-cardiogram findings are subjective and may vary from technician to technician. (vi) It would have been valuable to include waist circumference as an index of central obesity along with the weight and BMI which may be considered in future studies.

4.4. *Strengths of this study*

(i) This is the first randomized control study that incorporated integrated yoga program starting from the day before CABG

surgery and had regular follow up of a comprehensive battery of measurements for one year; (ii) The sample size was good and the hospital follows an internationally accepted protocol for surgery and cardiac rehabilitation; (iii) Well matched active intervention with equal attention to both groups during the entire period of follow up; (iv) Results pointing to better efficacy of YLSP than PTLSP; (v) 12.5% increase in LVEF after one year in those with high risk (low EF) and other risk factors.

5. Conclusion

Integrated yoga based cardiac rehabilitation for one year after uncomplicated CABG normalizes risk factors including LVEF, BMI, Blood glucose and Lipids which may be attributed to improvement in positive affect, decrease in stress, anxiety, depression and negative affect. Continued follow up of these cases is planned.

5.1. *Recommendations*

We recommend that these yoga modules be incorporated in all post-CABG cardiac rehabilitation programs for better in-hospital outcome and long term prognosis.

5.2. *Suggestions for future work*

(i) We recommend similar studies to be designed in other parts of India and the World to establish the generalizability of this intervention of this three tier module of YLSP. (ii) Continuous follow up of these patients for longer period. (iii) More studies using subtle instruments to measure myocardial perfusion are necessary to understand the mechanisms.

Conflicts of interest

All authors have none to declare.

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