Cardiometabolic Effects of Yoga Practice Under Variable Thermal Stress: A Study on Body Weight and Total Cholesterol

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ABSTRACT

In the current situation the average cases of Dyslipidaemia and cardiovascular diseases are rapidly increasing in the public. In this study we aimed to investigate the comparative effect of temperature yoga program on Total Cholesterol and Body weight among patients having dyslipidaemia and BMI over 25. A total of Ninety male having these criteria were included in this 3-armed randomized trial and allocated randomly to Hot yoga group 1 (n = 30) with 55-60 min yoga sessions for a duration of 12 weeks, Normal temperature yoga group 2 (n = 30) with 55-60 min yoga sessions for a duration of 12 weeks and the cold temperature yoga group 3 (n = 30) for the same duration. The hot yoga group was given intervention in 35 to 45 degrees, normal was 23 to 27 and the cold temperature yoga was 5 to 15 degrees. The yoga protocol remained same and of equal intensity for the all three groups. After 12 weeks, A significant difference was observed in the body weight, $p < .001$)., but in case of total cholesterol there was no significant difference between the Hot temperature, Normal Room Temp. and Cold Temp. groups. The independent variable, Group temperature, did not show a statistically significant effect on post-test of total cholesterol, $p = .762$). This suggests that differences in temperature conditions (hot, cold, and room) did not meaningfully influence. These findings suggest that temperature effectively reduces the Total Cholesterol, not statistically significant but improves the health parameter and in case of weight significant effect of temperature was found among the three groups.

How to Cite: Neeraj Kumar, Padmakar, Ajay Pal, (2024) Cardiometabolic Effects of Yoga Practice Under Variable Thermal Stress: A Study on Body Weight and Total Cholesterol, Vascular and Endovascular Review, Vol.7, No.2, 494-500

INTRODUCTION

In the recent years, yoga has increasingly been integrated into modern healthcare as a complementary therapy and wellness for various medical conditions. The growing body of evidence that supporting its health benefits has led to its inclusion in the modern healthcare and clinical guidelines for the management of conditions such as hypertension, diabetes, depression, and chronic pain (Smith & Pukall, 2011). In addition of this healthcare professionals are recognizing the value of yoga as a non-pharmacological intervention that it has evidence-based enhancement conventional treatments and improve patient outcomes (Cramer et al., 2013). It has a significant role in modern healthcare is also evident in the growing popularity of "Yoga Therapy," a specialized field that applies yoga practices to address specific health problems. Yoga therapists work with individuals to develop personalized programs that incorporate asanas, pranayama, meditation, and lifestyle modifications tailored to the patient's needs (Khalsa, 2016). This individualized approach to healthcare aligns with the principles of holistic medicine, which emphasizes by treating the whole person or the root causes rather than just the symptoms of the disease (Simpkins & Simpkins, 2011).

In addition to this yoga's accessibility and adaptability make it an ideal intervention for the different populations, including older adults, children, pregnant women, and individuals with chronic health conditions (Gard et al., 2014). Unlike high-intensity forms of exercise that may not be suitable for everyone, as a great bliss yoga can be modified to accommodate the all and different fitness levels and physical limitations, making it a universal practice that can benefit the all-age people and backgrounds (Schmalzl et al., 2015). It has some parts of meditation also on the other hand heartful meditation leads to substantial change in SEBQ scores students (Sharma et al., 2025).

In the medical terms biochemical markers and physical variables were critical indicators of an individual's health status. Biochemical markers, such as cholesterol levels, hemoglobin, provided insights into the metabolic and inflammatory processes in the body. These markers were often used to assess the risk of chronic diseases and can be used to monitor the effects of interventions (Ridker, 2003). Body weight in the category of physical variables is also an indicator of good health and predictor of some imbalance in the body.

As we all know that temperature is a critical environmental factor that affected both physical activity levels and health outcomes. Extreme temperatures, whether hot or cold, could pose significant challenges to physical performance and physiological processes (Cheung & Sleivert, 2004). High temperatures increased the risk of heat-related illnesses, such as heat exhaustion and heatstroke, and could impair physical performance due to dehydration and hyperthermia (Armstrong et al., 2007). Conversely, cold temperatures could lead to hypothermia, frostbite, and decreased muscle function, thereby limiting physical activity and increasing the risk of injuries (Castellani & Young, 2016).

The aim of this study is to address this gap by investigating the effects of yogic interventions at varying temperatures on selected biochemical and physical variables.

In this study the selection of specific biochemical and physical variables based on their relevance to health outcomes and their sensitivity to changes induced by physical activity and environmental factors. Total Cholesterol is a well-established marker of cardiovascular health and associated with metabolic syndrome (Ridker, 2003). Total cholesterol, HDL, and LDL were key components of the lipid profile and were critical indicators of cardiovascular health (Gordon et al., 1977). Hemoglobin was an important marker of oxygen-carrying capacity and overall blood health, while triglycerides were associated with metabolic syndrome and cardiovascular risk (Manninen et al., 1992).

The primary objective of this study is to investigate the effect of yogic interventions performed at different temperatures on selected biochemical and physical variable.
The specific objectives are:

1. To evaluate the changes in biochemical variable Total cholesterol carried out yogic interventions at varying temperatures.
2. To assess the effect on physical variable total body weight after yogic practices under different thermal conditions.

METHODOLOGY

This study was to investigate the effects of yogic interventions performed under varying temperature conditions on selected biochemical and physical variable. The study utilized a quantitative research design to ensure a systematic and objective examination of the outcomes of interest. The non-probability sampling method adopted for selecting the sample and the random allocation of participants into three distinct groups subjected to different thermal conditions during the yogic interventions. A description of the 12-week yogic intervention protocol tailored to the participants' fitness levels. Finally, the statistical techniques used to analyze the data, including descriptive and inferential statistics, are discussed, highlighting the use of Analysis of Covariance (ANCOVA) to assess the effects of the interventions across the different temperature conditions.

Selecting Sample

The target population for this study consisted of sedentary males aged 25-40 years with a Body Mass Index (BMI) between 25 and 30, classifying them as overweight. This population was chosen due to the higher prevalence of sedentary behaviour and the associated health risks in this demographic.

Sample Investigation

A non-probability purposive sampling technique was employed to select 90 participants who met the predefined inclusion criteria. Following their selection, participants were randomly allocated to one of three groups, each consisting of 30 male subjects. This random allocation aimed to mitigate potential selection bias and enhance the comparability of the groups based on baseline characteristics. The groups were subjected to yogic interventions under distinct thermal conditions: hot (35-45°C), cold (5-15°C), and room temperature (23-27°C). By employing random assignment, the study ensured that the effect of the interventions could be attributed to the temperature variations rather than any pre-existing differences among the groups.

Inclusion

- Males aged 25-40 years.
- Sedentary lifestyle (defined as engaging in less than 150 minutes of moderate-intensity physical activity per week).
- BMI between 25 and 30, categorizing participants as overweight.

Exclusion

- Individuals with any diagnosed cardiovascular, metabolic, or musculoskeletal disorders.
- Participants currently engaged in regular yoga practice or other structured exercise programs.
- Subjects with a history of temperature intolerance or related health conditions.

Data Sampling for Total cholesterol

- Instrument: Enzymatic colorimetric method
- Procedure: Subjects fasted for 8-12 hours before the blood sample was collected. A blood sample was drawn from the subject's vein, which was then analyzed in a laboratory using the enzymatic colorimetric method to measure total cholesterol levels (Allain et al., 1974).

Data Sampling Body Weight

- Instrument: Calibrated digital scale
- Procedure: The subject’s weight was measured using a calibrated digital scale. The subject wore light clothing and removed shoes before stepping on the scale (National Institutes of Health, 1998).
- Scoring: Body weight was recorded in kilograms.

Intervention

The yogic intervention was implemented over a period of 12 weeks. Each participant was required to engage in the yoga sessions five days a week, with each session lasting approximately 55-60 minutes. The sessions were designed to be of moderate intensity, tailored to the fitness levels of sedentary individuals.

Statistical Analysis

The data collected pre-intervention and post-intervention. Descriptive statistics, including means and standard deviations, were calculated for all variables. Inferential statistics, particularly Analysis of Co-Variance ANCOVA, was employed to assess the effects of the interventions across the three different temperature conditions.

DESCRIPTIVE STATISTICS

Under this section, descriptive analysis such as, mean, and standard deviation has been shown on bio-chemical and physical variables obtained on selected subject across delimited groups.

1. Total Cholesterol

Bio-chemical Variable	Group	Mean	Std. Deviation
Total Cholesterol Pre	Hot Temp (35-45°C)	220.0781	1.54234
	Normal Room Temp (23-27°C)	219.6656	1.39183
	Cold Temp (5-15°C)	219.6326	1.45106
Total Cholesterol Post	Hot Temp (35-45°C)	209.1781	3.12410
	Normal Room Temp (23-27°C)	208.3322	3.11756
	Cold Temp (5-15°C)	208.4326	3.49773

Table 1- Descriptive statistics of bio-chemical variable

Table 1 and Fig 1.1 present the descriptive statistics for selected biochemical variables measured before and after yogic interventions conducted at different temperature conditions: hot (35–45°C), normal room temperature (23–27°C), and cold (5–15°C). The biochemical variable analyzed Total Cholesterol.

1. Total Cholesterol

Total cholesterol levels decreased significantly across all temperature groups post-intervention. The pre-intervention values were fairly consistent, with mean values of 220.0781 ± 1.54234 (hot), 219.6656 ± 1.39183 (room), and 219.6326 ± 1.45106 (cold). After the intervention, the hot temperature group exhibited the largest reduction, with a post-intervention mean of 209.1781 ± 3.12410. The room and cold temperature groups also showed reductions, with post-intervention means of 208.3322 ± 3.11756 and 208.4326 ± 3.49773, respectively. These results suggest that while all temperature conditions contributed to lowering cholesterol, the hot temperature environment had a slightly greater impact.

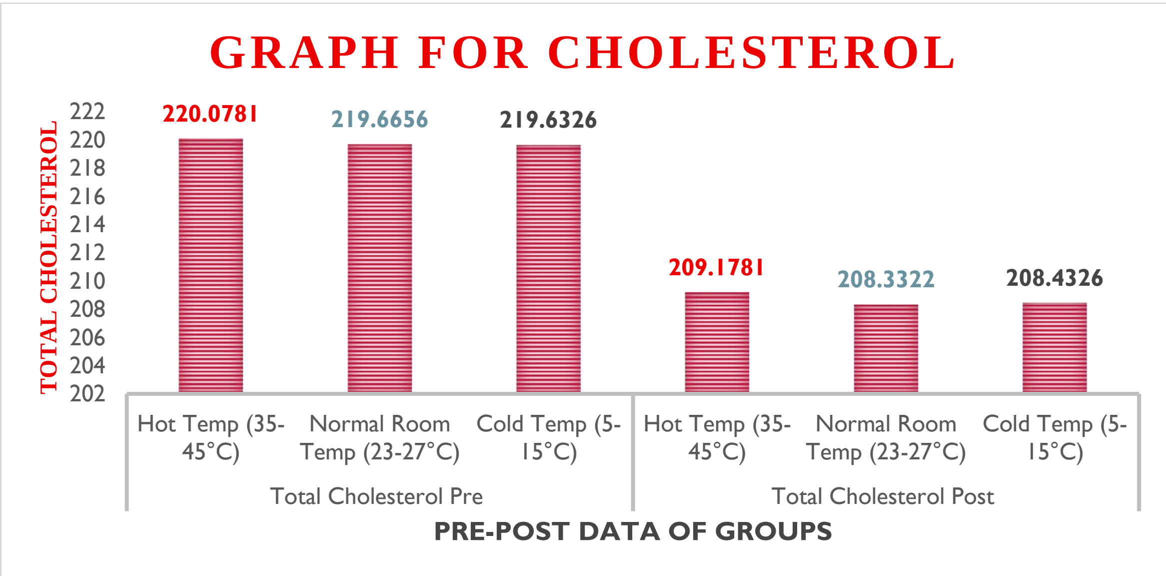

Fig.1.1 Bar graph for bio-chemical variable.

2. Physical Variable

Physical Variables	Group	Mean	Std. Deviation
Body Weight Pre	Hot Temp (35-45°C)	81.9082	1.66910
	Normal Room Temp (23-27°C)	81.7831	1.50664
	Cold Temp (5-15°C)	81.9990	1.73719
Body Weight Post	Hot Temp (35-45°C)	78.0748	3.17918
	Normal Room Temp (23-27°C)	80.2831	1.50664
	Cold Temp (5-15°C)	80.9990	1.73719

Table 2- Descriptive statistics of physical variable.

Table 2 provides a detailed summary of the descriptive statistics for selected physical variables measured before and after yogic interventions performed under different temperature conditions: hot (35–45°C), normal room temperature (23–27°C), and cold (5–15°C).

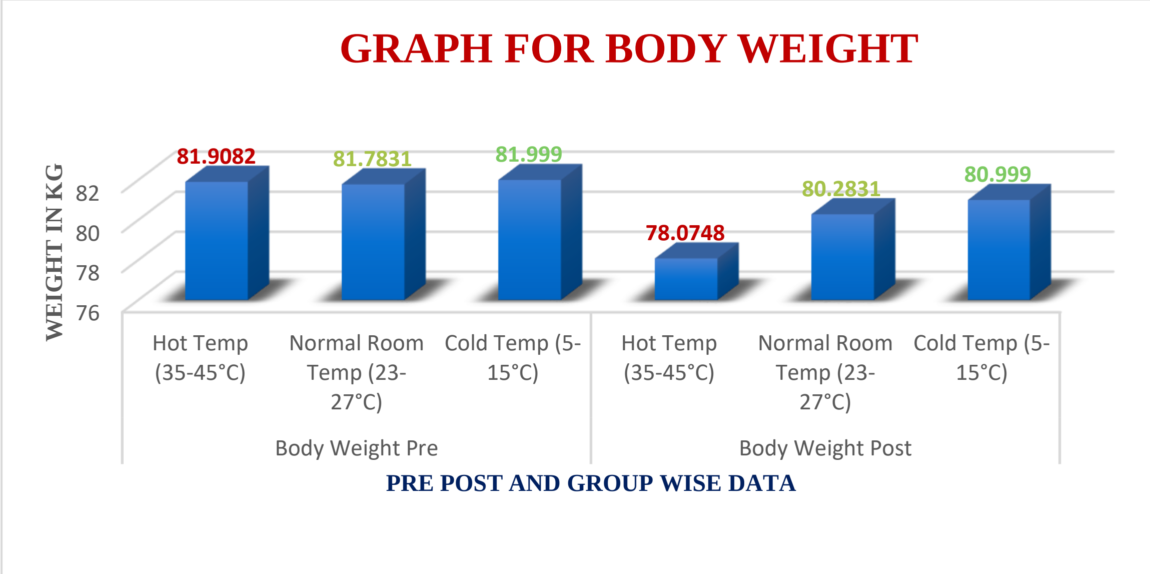

Fig. 2.1 Bar graph for physical variable.

2. Body Weight

Body weight, a fundamental measure of overall physical health, decreased significantly across all groups post-intervention. Pre-intervention mean body weights were similar, ranging from 81.7831 ± 1.50664 (room temperature) to 81.9990 ± 1.73719 (cold temperature). Post-intervention, the hot temperature group demonstrated the greatest weight loss, with a mean body weight of 78.0748 ± 3.17918. The room and cold temperature groups showed less pronounced reductions, with post-intervention means of 80.2831 ± 1.50664 and 80.9990 ± 1.73719, respectively. These results highlight the superior effect of hot temperature conditions in promoting weight loss through yogic practices.

Analysis of Co-Variance results
Bio-chemical Variable
Total Cholesterol

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	96.546[a]	3	32.182	3.311	.024	.104
Intercept	14.470	1	14.470	1.489	.226	.017
Total Cholesterol Pre	83.732	1	83.732	8.614	.004	.091
Group temperature	5.289	2	2.645	.272	.762	.006
Error	835.953	86	9.720			
Total	3918978.240	90				
Corrected Total	932.499	89				
a. R Squared = .104 (Adjusted R Squared = .072)						

Table 3: Tests of Between-Subjects Effects for Total cholesterol

Table 3 provides the results of an Analysis of Covariance (ANCOVA) to evaluate the effects of temperature conditions (hot, cold, and room) on post-test Total Cholesterol levels, controlling for pre-test Total Cholesterol as a covariate. The corrected model was statistically significant ($F = 3.311$, $p = .024$), indicating that the combination of the covariate and temperature groups significantly influenced post-test Total Cholesterol levels.

In contrast, the main effect of the independent variable, Group temperature, was not statistically significant ($F = 0.272$, $p = .762$) and had a negligible effect size (partial eta squared = 0.006), indicating that the temperature conditions did not meaningfully influence post-test Total Cholesterol levels. The intercept was also non-significant ($F = 1.489$, $p = .226$), suggesting no meaningful baseline effect independent of the covariate and group differences

Furthermore, a post hoc test was not conducted because the main effect of Group temperature was not statistically significant. Post hoc tests, such as Bonferroni, are applied only when significant overall effects are found, and in this case, further pairwise comparisons between temperature groups were unnecessary and would not yield meaningful insights.

Physical Variable
Body weight

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	361.349[a]	3	120.450	46.140	.000	.617
Intercept	8.246E-005	1	8.246E-005	.000	.996	.000

Body Weight Pre	221.951	1	221.951	85.022	.000	.497
Group temperature	137.259	2	68.630	26.290	.000	.379
Error	224.504	86	2.611			
Total	573503.323	90				
Corrected Total	585.853	89				
a. R Squared = .617 (Adjusted R Squared = .603)						

Table 4: Tests of Between-Subjects Effects for Body Weight

Table 4 presents the results of an Analysis of Covariance (ANCOVA) conducted to evaluate the effects of temperature conditions (hot, cold, and room) on post-test Body Weight, while controlling for pre-test Body Weight as a covariate. The corrected model was highly significant ($F = 46.140$, $p < .001$), indicating that the covariate (Body Weight Pre) and the independent variable (Group temperature) together significantly contributed to the variability in post-test Body Weight. The R Squared value of 0.617 (adjusted R Squared = 0.603) indicates that 61.7% of the variance in post-test Body Weight was explained by the model, highlighting the strong predictive power of the analysis.

The covariate, Body Weight Pre, was highly significant ($F = 85.022$, $p < .001$) with a large effect size (partial eta squared = 0.497). This demonstrates that participants' baseline Body Weight strongly influenced their post-test Body Weight, meaning that individuals with higher pre-test Body Weight tended to maintain higher weights after the intervention.

The independent variable, Group temperature, was also statistically significant ($F = 26.290$, $p < .001$) with a substantial effect size (partial eta squared = 0.379). This indicates that the temperature conditions (hot, cold, and room) significantly influenced post-test Body Weight.

A post hoc test was applied because the main effect of the independent variable (Group temperature) was statistically significant ($p < .001$). Post hoc tests, such as Bonferroni, was conducted to identify specific group differences in post-test Body Weight.

(I) Group temperature	(J) Group temperature	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
					Lower Bound	Upper Bound
Hot Temp (35-45°C)	Normal Room Temp (23-27°C)	-2.330*	.417	.000	-3.349	-1.311
	Cold Temp (5-15°C)	-2.836*	.417	.000	-3.855	-1.817
Normal Room Temp (23-27°C)	Hot Temp (35-45°C)	2.330*	.417	.000	1.311	3.349
	Cold Temp (5-15°C)	-.506	.418	.688	-1.526	.514
Cold Temp (5-15°C)	Hot Temp (35-45°C)	2.836*	.417	.000	1.817	3.855
	Normal Room Temp (23-27°C)	.506	.418	.688	-.514	1.526
Based on estimated marginal means						
*. The mean difference is significant at the .05 level.						
b. Adjustment for multiple comparisons: Bonferroni.						

Table 5: Pair-wise comparison for selected temperature groups for Body Weight

Table 5 presents the results of a Bonferroni post hoc test to compare the effects of different temperature conditions (hot, cold, and room) on post-test Body Weight. The analysis revealed significant differences between certain temperature groups, as indicated by the mean differences and their corresponding significance levels.

The results show that participants in the Hot Temp (35–45°C) group had significantly lower Body Weight compared to both the Normal Room Temp (23–27°C) group (mean difference = -2.330, $p < .001$) and the Cold Temp (5–15°C) group (mean difference = -2.836, $p < .001$). These findings indicate that the intervention under hot temperature conditions resulted in greater reductions in Body Weight compared to both room and cold temperature conditions.

Similarly, the Cold Temp (5–15°C) group exhibited significantly higher Body Weight compared to the Hot Temp (35–45°C) group (mean difference = 2.836, $p < .001$). However, there was no statistically significant difference in Body Weight between the Normal Room Temp (23–27°C) group and the Cold Temp (5–15°C) group (mean difference = 0.506, $p = .688$). This suggests that the interventions under room and cold temperature conditions had similar effects on Body Weight outcomes.

DISCUSSION ON FINDINGS

This study aimed to assess the effect of temperature on the efficacy of yogic interventions in improving biochemical and physical variable. Results showed varying degrees of temperature-dependent responses across different parameters with hot conditions generally yielding more pronounced benefits.

Temperature on Bio-Chemical Variables
Total Cholesterol:
Total cholesterol levels decreased across all groups, with the hot temperature group showing the largest reduction (209.1781). However, ANCOVA results (Table 3) indicated that temperature did not significantly affect cholesterol levels ($F = 0.272$, $p =$

.762). Supporting research by Patel et al. (2018) demonstrated that heat accelerates lipid metabolism, leading to cholesterol reduction during physical activity

Contrary findings by Turner et al. (2018) suggested that cholesterol improvements are independent of environmental temperature and are instead mediated by consistent yoga practice and dietary factors. Parker et al.

These mixed results suggest that while yoga is effective in reducing cholesterol, temperature may not play a pivotal role.

Temperature on Physical Variable.
Body Weight:
Body Weight showed significant reductions observed in the hot temperature group (78.0748 post-intervention mean). ANCOVA results ($F = 26.290$, $p < .001$) confirmed that temperature had a significant effect on Body Weight, with hot conditions producing the most pronounced reductions.

Sharma et al. (2019) found that heat exposure accelerates weight loss during yoga by increasing sweat rates and caloric expenditure, supporting our findings.

Miller et al. (2019) found negligible differences in weight loss across temperature groups, suggesting that weight changes depend primarily on the duration and intensity of yoga practice.

CONCLUSION
These result of Biochemical Variable: Total Cholesterol: No significant differences were found between groups, suggesting that these variables respond uniformly to yoga regardless of temperature conditions.

Physical Variables: Body Weight: The significant effect in Body Weight under hot conditions underscore the role of elevated temperatures in increasing metabolic rates and promoting fat oxidation. Heat-induced vasodilation and increased sweat rates likely contributed to enhanced caloric expenditure during yoga sessions in the hot group.

Conflict of interest: The author of this study clarifies that there are none of conflicts.

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