RESEARCH ARTICLE

Investigation of the impact of a short-term low-carbohydrate paleolithic diet on cardiovascular risk markers

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ABSTRACT

Background: Low carbohydrate diets like the Paleolithic diet have caught the attention of the public and medical professionals in their ability for weight loss, and diabetic control among others. However, an important question about their effect on lipid levels and cardiovascular risk has not been answered enough. *Aims:* Our study aimed to observe the impact of a short-term low-carbohydrate Paleolithic diet on lipids such as low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides (TAG) and cardiovascular risk markers such as apolipoprotein A1 (ApoA1) and apolipoprotein-B (ApoB). *Materials and methods:* This is a 3-month study involving 106 participants who were attending our hospital OPD for various health issues and were studied and tested before and after a diet intervention. The diet prescribed is a low carbohydrate Paleolithic diet having a protein, carbohydrate and fat ratio around 15:20:65 and are regularly followed for compliance. *Results:* After three months, it was seen that this diet has significantly decreased triglycerides ($p = 0.001$); significantly increased LDL ($p = 0.0009$), HDL ($p = 0.005$) and ApoA1 ($p = 0.01$); whereas there was no change in ApoB levels, ApoB/ApoA1 ratio and LDL/ApoB ratio. *Conclusion:* A short-term low carbohydrate paleolithic diet is not pro-atherogenic but it favorably alters lipid profile and cardiac markers thereby reducing the risk for cardiovascular disease (CVD).

Keywords: ApoB, ApoA1, LDL, HDL, Triglycerides, Cardiovascular, Low carbohydrate, Paleolithic diet.

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INTRODUCTION

Cardiovascular diseases (CVD) cause around 28% of deaths in India.[1] A few of the established risk factors for CVD are poor diet, dyslipidemia, and metabolic syndrome.[2] Dyslipidemia encompasses either elevation of LDL cholesterol, reduced HDL cholesterol, elevated triglycerides, or a combination of the above. The ICMR-INDIAB study[3] says that 21% of Indians have high LDL; 67% of Indians have high triglycerides; and 32% of Indians have lower HDL. India has one of the highest prevalence of metabolic syndrome around 30%.[4] It is known that 12 to 15% of CVDs are due to the presence of metabolic syndrome.[5]

The primary indicators of cardiovascular health are Lipid profile which includes total cholesterol, LDL, HDL, and TAG is one of the primary indicators of cardiovascular health.[6] Apolipoproteins, such as ApoA1 and ApoB, are given much importance today since they provide insights into lipid metabolism and cardiovascular risk of a person. ApoA1, the main apoprotein of HDL, is important for cholesterol efflux and reverse cholesterol transport. Conversely, ApoB, the primary protein of LDL particles, is considered a more accurate predictor of cardiovascular events than LDL cholesterol alone.[7]

The increase in the incidence of dyslipidemia and metabolic syndrome leading to cardiovascular diseases has prompted increased interest in dietary interventions that can manage these conditions. The two major types of diets are a low-fat/low-calorie diet and a low-carbohydrate diet. The last two decades have seen a considerable increase in studies using low carbohydrate diets like Paleolithic and ketogenic diets for metabolic syndrome issues like diabetes, obesity, etc., The Paleolithic diet, also known as the "Paleo" diet, is a type of low-carbohydrate diet.[8] Previous studies have demonstrated that the Paleo diet can improve body composition, glycemic control, and inflammatory markers.[9-11] Based on available evidence, the European Society of Cardiology has mentioned that low carbohydrate diets can be administered to patients under the supervision of a medical professional.[12]

The Paleo diet is characterized by a low carbohydrate intake, moderate protein consumption, and a high fat content. The reduced carbohydrate intake causes a decrease in serum insulin levels, thereby enhancing lipolysis which may lead to an improved lipid profile.[10] Additionally, a low carbohydrate diet has been shown to increase HDL cholesterol and reduce triglycerides,[9] although its effects on LDL cholesterol and ApoB levels remain controversial. An one-year study showed[13] no change in LDL but significant improvement in HDL and triglyceride after 1 year of Low carbohydrate diet. This study aims to investigate the impact

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Table 1: Model diet chart

Breakfast	50-80 pieces of almonds or 50-100 grams of roasted or boiled peanuts or 100 grams raw coconut
	30g butter mixed in 200 mL of milk/tea/coffee
Lunch	Non-Vegetarian/ovo-vegetarian-4 whole eggs +200g of vegetables + 30g cheese
	Vegetarian-300 g of vegetables + 50 grams cheese + 50g of raw coconut
Snacks	Curd 100 mL/ One raw guava 100 g/100 mL milk/50 grams pistachio
	Veg/non-veg Soups/Salted lemon juice(1 or 2 lemons)/amla (1 or 2 numbers)
	Vegetables (150 grams)/One cup of coconut (50 grams)
Dinner	Non-Vegetarian-150–300 g of meat (either chicken or mutton or fish)
	Vegetarian/ovo-vegetarian-100–200 g of paneer or mushrooms + 30 grams cheese

Must avoid: all sugars, sweets, breads, biscuits, other fruits, juices, tuberous vegetables, grains, lentils and millets.
Timing of foods: participants were advised to eat foods at their usual timings
Recipes- Various vegetarian, ovo-vegertarian and non-vegetarian recipes were provided to the participants

of a short-term low-carbohydrate Paleolithic diet on lipid profiles and apolipoproteins, which are critical biomarkers of cardiovascular risk.

MATERIALS AND METHODS

Participants for this study were recruited from Individuals who visited the Karpagam Medical College Hospital OPD, Coimbatore after obtaining Institutional human ethical clearance. Persons with a history of CVD, a history of Chronic kidney disease, alcoholics, critically ill patients, pregnant, lactating mothers, and people already on cholesterol or triglyceride medications were excluded from the study. People aged between 25 to 75 years were included in the study. Sample size calculation was done using routine statistical methods based on the prevalence of dyslipidemia in the Indian population. About 131 people were selected, the study was explained in detail and informed consent was obtained. Anthropometric measurements were done and 2 mL of venous blood was obtained, centrifuged, and the below parameters measured. Total cholesterol, LDL, HDL, and triglycerides were measured using standard enzymatic assays. ApoA1 and ApoB were measured by immunoassays. Individual dietary preferences were taken into account and participants were advised to either a vegetarian, ovo-vegetarian or a mixed diet. Individual calorie requirements were calculated based on the anthropometrics and diet was planned. A carbohydrate, protein, and fat ratio of 20:15:65 was used. A model diet chart is given in Table 1. The diet plan and recipes were advised by the dietitian.

The non-vegetarian regimen provided 64 g of carbohydrates and 1640 kcal/day, whereas the vegetarian regimen provided 1870 kcal/day and 66 g of carbohydrates/day. Based on the height and weight of the participants, calories were adjusted to deliver an isocaloric menu. An isocaloric diet is one in which per day energy needs of a person are calculated using his anthropometric measurement and providing the same calories. This is done to prevent bias on whether the effects of the diet are due to diet per se or calorie deficiency when a hypocaloric diet is used. Dietary intake was monitored through food diaries and regular consultations with a dietician to ensure compliance, i.e., participants were asked to send their food plate photos via Whatsapp daily. They were verified and specific corrections were given by the dietician. Weekly phone calls were made to ensure compliance. Participants were advised to continue their current medications for their co-morbid illnesses are advised to continue the same level of physical activity as before. Blood samples were collected at the end of the study period to measure lipid profiles and apolipoprotein levels. Statistical analyses were performed using SPSS 21 to compare values before and after the intervention and a student t-test was performed to calculate the statistical significance (*p-value*).

RESULTS

Only 106 study subjects out of 131 participants completed 3 months of dietary intervention without major deviation. Among the study population, 35 participants were diabetic; 27 were of BMI<23 and the remaining are either overweight or obese. After a 3 month dietary intervention, the average BMI and HbA1c were markedly reduced as depicted in Table 2. The various biochemical parameters checked before and after the dietary intervention are given in Table 3. It can be seen that a minor elevation of total cholesterol was seen but statistically insignificant. It may be due to elevation in LDL and HDL levels after diet. LDL levels were significantly elevated after the diet. The major change seen was the

Table 2: General characteristics of the participants

Characteristics	Before intervention	After Iintervention
Total number of participants	106 (72 males and 34 females)	
Average age of participants	43.6 Years	
Average BMI	32.3	28.9
Hba1c	7.0	5.6

Table 3: Mean values of biochemical parameters before and after diet

Parameters	*Before Dietary intervention (mean)*	*After dietary intervention (mean)*	*p-value*	*Statistical significance*
Total Cholesterol (mg/dL)	197	207	>0.05	Not-significant
LDL (mg/dL)	123.1	139.9	0.0009	Significant
HDL (mg/dL)	43.3	47.2	0.005	Significant
Triglycerides (mg/dL)	142.7	113.3	0.001	Significant
ApoB (mg/dL)	98.4	99.2	>0.05	Not-significant
ApoA1 (mg/dL)	130.6	138	0.01	Significant
ApoB/ApoA1 ratio	0.767	0.7348	>0.05	Not-significant
LDL/ApoB ratio	1.29	1.44	>0.05	Not-significant

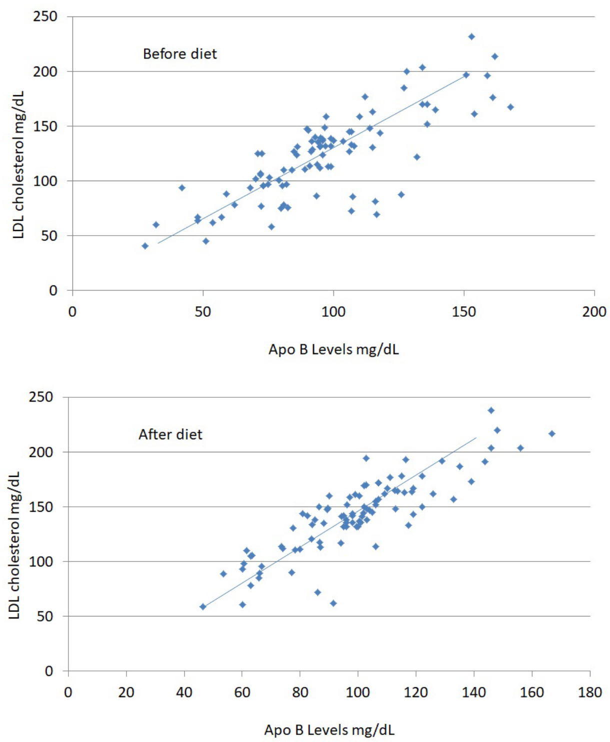

Figure 1: ApoB vs. LDL before diet, ApoB vs. LDL after diet

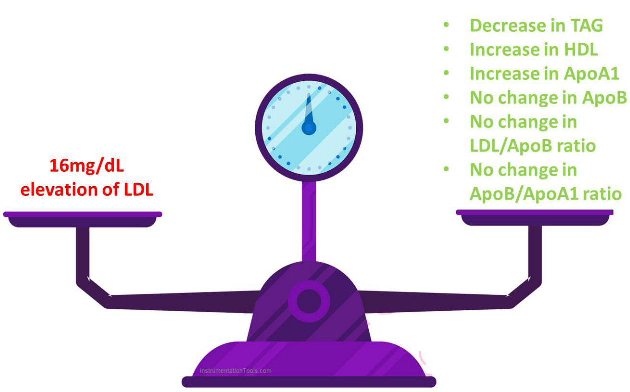

Figure 2: Overall effect of Low carbohydrate paleolithic diet on cardiovascular risk factors

huge reduction in triglycerides levels. There was a small but significant increment seen in the case of HDL levels.

The measurement of apolipoproteins provided some vital information. As expected, ApoA1 and HDL levels significantly increased but the ApoB levels were unchanged post dietary intervention. To obtain a wider picture of why LDL was elevated but ApoB stayed the same, two ratios were calculated. ApoB/ApoA1 ratio and LDL/ApoB ratio were calculated and there was no elevation seen in both of them. Even though the average LDL levels rose to 10 mg/dL after diet, there was no change in ApoB levels. This is depicted in Figure 1 scatter graphs which show almost no difference before and after dietary intervention.

DISCUSSION

Many studies have evaluated the impact of low-carbohydrate diets on dyslipidemia. Our study is one of the first to plan and assess the effect of various Paleolithic diets like vegetarian, ovo-vegetarian, and mixed diet patterns in the Indian population. Our goal was to evaluate its influence on lipid profile and to find whether these diets elevate the risk for CVD as widely believed. The levels of HDL and ApoA1 increased significantly among the study group. Previous studies[14,15] also observed these significant increments in HDL and ApoA1, when a low carbohydrate diet was given. Since HDL and ApoA1 are anti-atherogenic, their elevation can be considered beneficial.

The most important objective of this study is to research the common perception of whether eating a high-fat diet will increase LDL cholesterol levels. When there is an elevation in HDL using a dietary intervention, it is commonly thought that it will also elevate LDL levels significantly. Studies done on this area yielded mixed results. One of those showed that LDL levels elevated[14] in this diet but a recent one[16] finds no significant elevation. Our study shows that there is a small elevation in LDL cholesterol of 16 mg/dL in study subjects, and this is statistically significant.

The elevation of LDL must be considered along with other factors too. ApoB is a more important marker than LDL in the case of atherogenicity. LDL levels show only one component of atherogenic lipoprotein whereas, ApoB level is a better marker for CVD risk since it is a component of many atherogenic lipoproteins such as LDL, VLDL (Very low-density lipoprotein), IDL (Intermediate density lipoprotein), and lipoprotein (a).[17] In 2019, the European Society of Cardiology[18] issued a guideline that concludes ApoB can be considered a better predictor for CVD risk than LDL. Razavi *et al.* in 2021 found that elevation of LDL, when ApoB was normal did not accelerate atherosclerosis.[19] We observed no significant change in ApoB levels after the diet which infers that this diet may not be atherogenic. A long-term study conducted for two years[20] also showed that there was no change in ApoB levels after a low carbohydrate type diet.

LDL/ApoB ratio is widely used to detect the size of LDL particles. Small dense LDL is atherogenic whereas large sized LDL was not.[21] Our study did not find any change in this ratio after the diet. So it can be inferred that a small number of large dense LDL which is not pro-atherogenic was elevated in this diet. Another factor to support this statement comes from no significant elevation in the ApoB/ApoA1 ratio which is also a risk factor for CVD. Instead, we observed a mild decrease in this ratio which is heart-healthy. A study done in 2023 supports the fact that the ApoB/ApoA1 ratio is a better predictor for CVD risk than LDL alone.[22]

Due to the deprivation of carbohydrates in the diet, the dietary triglycerides and fat from adipose tissue are spent and utilized for energy. So a reduction of triglycerides in a low-carbohydrate diet is usually expected. This was widely shown by previous studies.[23-25] Our study shows similar results, where triglycerides were significantly reduced during a three-month, low-carbohydrate diet. Lowering triglycerides also reduces CVD risk.

Overall a low carbohydrate diet seems to decrease triglycerides, increasing HDL and ApoA1 with a mild increase in LDL whereas there is no change in atherogenic ApoB or ApoB/ApoA1 ratio. Even though there is an elevation of LDL levels, the reduction in triglycerides, elevation of HDL and ApoA1, and no change in ApoB, LDL/ApoB ratio, and ApoB/ApoA1 ratio by the dietary intervention must be taken into account (Figure 2). From our findings, it can be said that a low carbohydrate paleolithic diet could not be considered pro-atherosclerotic.

There were a few limitations in this study. Even though regularly followed up, there was not a tight control over the food consumed by the participants. Also, this is a short-term study without randomization or with a control group and done only among people of Indian ethnicity. Future larger studies must focus on this area since there is only scarce information about these diets on human health. Also, studies focussing on the effect of this diet on various lipoprotein fractions may explain the physiology of this diet on lipids.

CONCLUSION

Our study results demonstrate a favorable improvement of lipid profile and cardiac markers among participants on a low carbohydrate paleolithic diet. Understanding the effects of low-carbohydrate Paleolithic diets on lipid profiles and apolipoproteins is crucial for developing dietary recommendations aimed at reducing cardiovascular risk. Given the global rise in cardiovascular diseases, identifying dietary patterns that can favorably alter lipid metabolism holds substantial public health importance. More such studies must be conducted to study the various lipid parameters in depth to understand the effects of this diet on lipids. This study may well contribute to the broader discourse on the efficacy and safety of popular dietary interventions, providing evidence-based guidance for individuals seeking to improve their metabolic health through dietary modifications.

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PEER-REVIEWED CERTIFICATION

During the review of this manuscript, a double-blind peer-review policy has been followed. The author(s) of this manuscript received review comments from a minimum of two peer-reviewers. Author(s) submitted revised manuscript as per the comments of the assigned reviewers. On the basis of revision(s) done by the author(s) and compliance to the Reviewers' comments on the manuscript, Editor(s) has approved the revised manuscript for final publication.