Subjective experiences and blood parameter changes of individuals from Germany following a self-prescribed "carnivore diet"

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Abstract

Background & Aims: Animal-based or so-called carnivore diets more or less exclude all plant-based foods and gain increasing popularity, mainly among individuals suffering from chronic diseases. The aim of this study was to explore subjective experiences and blood parameter changes of German followers of a carnivore diet.

Methods: We conducted a statistical survey using a self-designed questionnaire and requesting blood panels. Inclusion criteria were: (i) consuming a carnivore-type diet for at least one month; (ii) completion of the self-designed study questionnaire; (iii) provision of two sets of metabolic blood parameters from the period before and after adopting a carnivore diet. The survey was complemented by qualitative interviews with four subjects on a carnivore diet.

Results: Twenty-three individuals participated in the survey. Most of them (61%) were male and the median age was 47 (range 27-62) years. The majority (65%) reported at least one clinical diagnosis and the main reason for switching to a carnivore diet was accordingly health-related. Improved health was also the major motivation to maintain the diet. Prior to the carnivore diet, participants consumed a variety of other diets, of which a ketogenic (N=6) and standard diet (N=7) were most frequently reported. There were no significant differences between on-diet and pre-diet blood parameters except for total (pre-diet median: 228mg/dl; on-diet: 305mg/dl; $p<0.0001$) and LDL-cholesterol (pre-diet: 161mg/dl; on-diet: 257mg/dl; $p=0.00049$) concentrations.

Conclusions: Individuals adopting a carnivore diet do this mainly for health-related reasons and commonly experience subjective health improvements. There was no adverse impact on blood parameters, except for significant elevations of total and LDL cholesterol. This phenomenon and its health implications should be investigated further.

Key words: carnivore diet; cholesterol; hypercholesterolemia; ketogenic diet; meat

Zusammenfassung

Einleitung: Tierbasierte bzw. carnivore Ernährung schließt mehr oder weniger alle pflanzlichen Lebensmittel aus und erfreut sich zunehmender Beliebtheit, vor allem bei chronisch kranken Personen. Ziel dieser Studie war es, die subjektiven Erfahrungen und Blutwertveränderungen bei deutschen Anhänger einer carnivoren Ernährung zu untersuchen.

Methoden: Wir führten eine statistische Erhebung mit Hilfe eines selbst entworfenen Fragebogens und der Anforderung von Blutbildern durch. Die Einschlusskriterien waren: (i) Verzehr einer carnivoren Ernährung seit mindestens einem Monat; (ii) Ausfüllen des selbst entworfenen Fragebogens; (iii) Bereitstellung von metabolischen Blutparametern aus der Zeit vor und nach der Umstellung auf carnivore Diät. Die Umfrage wurde durch qualitative Interviews mit vier Personen ergänzt, die sich carnivore ernährten.

Ergebnisse: Dreiundzwanzig Personen nahmen an der Umfrage teil. Die meisten von ihnen (61 %) waren männlich und das mediane Alter betrug 47 Jahre (Spanne 27-62 Jahre). Die Mehrheit (65 %) gab mindestens eine klinische Diagnose an, und der Hauptgrund für die Umstellung auf eine carnivore Ernährung war dementsprechend gesundheitsbezogen. Die verbesserte Gesundheit war auch die Hauptmotivation für die Beibehaltung der Diät. Vor der Umstellung auf carnivore Ernährung konsumierten die Teilnehmer eine Vielzahl anderer Diäten, von denen eine ketogene (N=6) und eine Standarddiät (N=7) am häufigsten genannt wurden. Es gab keine signifikanten Unterschiede zwischen den Blutparametern vor und während der Diät, mit Ausnahme der Konzentrationen von Gesamt- (Median vorher: 228 mg/dl; während: 305 mg/dl; $p<0,0001$) und LDL-Cholesterin (vorher: 161 mg/dl; während: 257 mg/dl; $p=0,00049$).

Schlussfolgerung: Personen, die sich carnivor ernähren, tun dies vor allem aus gesundheitlichen Gründen und erfahren in der Regel subjektive gesundheitliche Verbesserungen. Es gab keine nachteiligen Auswirkungen auf die Blutparameter, mit Ausnahme eines signifikanten Anstiegs des Gesamt- und LDL-Cholesterins, was weiter untersucht werden sollte.

Schlüsselwörter: Carnivore Ernährung; Cholesterin; Hypercholesterinämie; Ketogene Ernährung; Fleisch

Introduction

In early 1928, the Arctic explorers Vilhjámur Stefánsson and Karsten Andersen started a medically supervised, one-year long exclusive meat diet in order to proof that such a diet consisting of muscle and organ meats, fat and bone marrow is safe. The safety of this diet was indeed confirmed in several medical reports published by Tolstoi [1,2], Lieb [3,4] and McClellan et al. [5–7]. While Stefánsson justified his belief in the nutritional adequacy of this diet by his positive experience of living nine years on an exclusive meat diet while staying in the Arctic [3], Walter L. Voegtlin proposed in 1975 in his book *The Stone Age Diet* that an exclusive meat diet would best conform to the diet that humans evolved to eat during the Paleolithic era and hence to our physiology [8]. More recent data on human physiology and genetics, archaeology, paleontology, and zoology indeed provide evidence that at least since the occurrence of *Homo erectus* and lasting for many hundred thousand years, humans had occupied the highest, carnivorous position in the food chain [9–11].

An evolutionary perspective justifying the adoption of diets based exclusively or almost exclusively on animal products – including meat, organs and dairy – is also expressed in more recent popular books such as "The Carnivore Diet" by Dr. Shawn Baker [12] or "The Carnivore Code" by Dr. Paul Saladino [13]. Other popular proponents of these so-called "carnivore" or "zero-carb" diets include the Canadian psychologist Dr. Jordan Peterson (https://www.jordanbpeterson.com/ ; accessed March 20, 2024) and his daughter Mikhaila Peterson who adopted a carnivore diet in 2017 due to severe autoimmune symptoms and now runs the website "The Lion Diet" (https://liondiet.com/; accessed March 20, 2024). The growing popularity of carnivore /zero-carb diets has been explored by two surveys which aimed at identifying the motives for and benefits of adopting such diets in the longer term. Protogerou et al. obtained data from 170 international survey respondents who adhered to a zero-carb diet for at least 6 months and found that most of them were highly educated and maintained the diet due to improved health and well-being [14]. Lennerz et al. reached a sample size of 2029 survey respondents who were following a carnivore diet for a median of 14 month and confirmed that the prime motivation was health reasons, with 95% reporting improvements in overall health [15]. In addition to these two surveys, only a few case reports have been published in which a carnivore diet had been adopted either by a healthy individual [16] or by patients suffering from cancer [17,18], chronic inflammatory bowel disease [19,20] and other autoimmune conditions [21]. Hence, given the growing popularity of carnivore/zero-carb diets, there is comparatively sparse data regarding these diets' effects and safety profile.

The aim of this study was therefore to collect further data on the benefits and practical aspects of a carnivore diet as well as its effects on blood parameters of interest in a German population.

Materials and Methods

This study was composed of two parts: One statistical survey, which consisted of a self-designed questionnaire and a set of blood panels; and one qualitative part which consisted of interviews with a small set of subjects on a carnivore diet. Participants for the quantitative statistical survey were recruited in two consecutive years at the German Carnivore Convent which took place on April 21-23, 2023 in Bad Hersfeld and on April 12-14, 2024 in Bebra. The inclusion criteria for the quantitative study part were as follows:

(i) Consuming a carnivore-type diet for at least one month
(ii) Completion of the self-designed study questionnaire
(iii) Provision of two sets of blood panels, one representative for the pre-carnivore diet and one representative for the carnivore diet

The self-designed questionnaire included questions about individuals' anthropometric measures, health issues, diet characteristics and subjective changes on the carnivore diet (Supplementary File 1). The blood panels had to be come from certified medical laboratories in Germany. Parameters of interest focused on values which are frequently obtained in the context of medical checkups and included a small blood count panel, serum minerals (Na, K, Ca), serum glucose and HbA1c, serum lipids (total, LDL and HDL cholesterol, triglycerides), liver enzymes (AST, ALT, γ-GT), kidney function parameters (creatinine, uric acid), thyroid-stimulating hormone (TSH) and C-reactive protein (CRP). All quantitative date was collated into a MS Excel® file and analyzed in R version 4.4.0. Given the explorative nature of this study, we did not correct p-values for multiple testing [22], but decided to use a more conservative threshold of $p<0.005$ to claim statistical significance [23].

For the qualitative part of the study, the inclusion criteria were as follows:

(i) Consumption of a carnivore-type diet for at least one month.
(ii) Willingness to tell one´s own story towards a carnivore-type diet.

One interviewee for the qualitative part of the study also participated in the statistical survey. The other interviewees come from the author`s (JM) private environment or are former (coaching-) clients of the author.

This study was conducted in accordance with the Declaration of Helsinki. All participating individuals provided their written informed consent to participate. Because most collected data were answers to a survey and the blood parameters had been taken independently from this study, no ethical vote was requested.

Results

General characteristics of participants in the statistical survey

Twenty-three individuals volunteered to participate in the survey and to provide pre- and post-carnivore diet blood parameters. Their baseline characteristics are given in Table 1. Most participants (61%) were male and the median age was 47 (range 27-62) years. Fifteen participants reported at least one clinical diagnosis; accordingly, the main reason for switching to a carnivore diet was health-related (Figure 1). Prior to the carnivore diet, participants consumed a variety of other diets, of which a ketogenic (N=6) and standard diet (N=7) were most frequently reported.

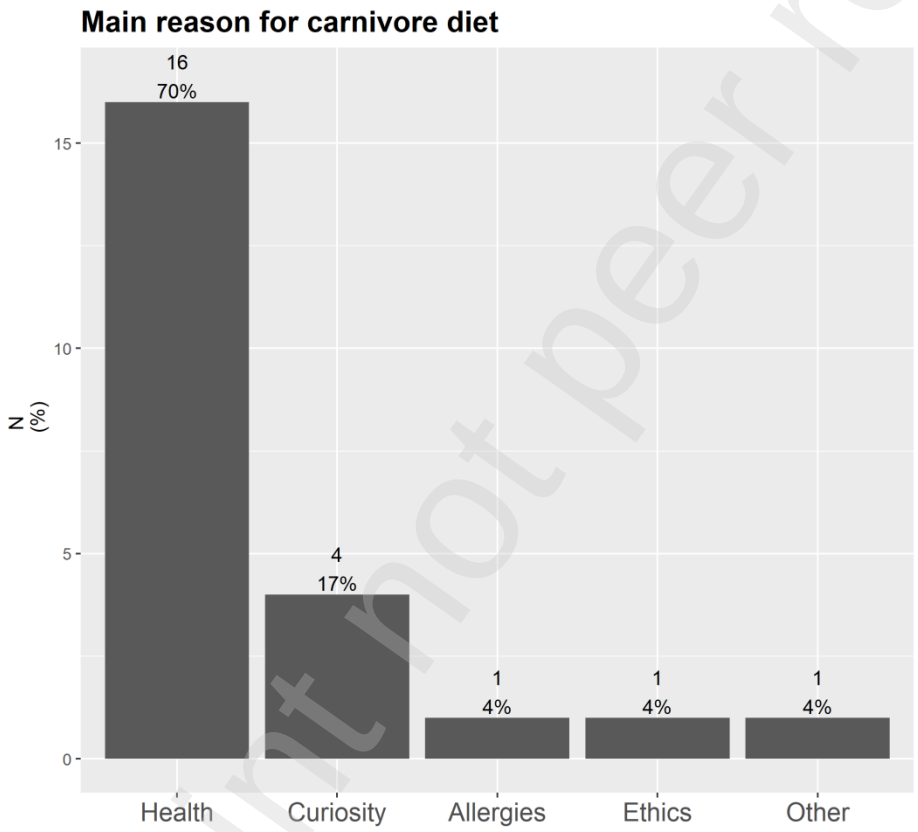

Figure 1: Distribution of the main reason for switching to a carnivore diet.

Subjective changes on the carnivore diet

The average duration on the carnivore diet was 18 months (median 12.0 months, range 1-56 months). The subjective changes experienced by individuals on the carnivore diet are displayed in

Figure 2. The majority of participants reported improvements in all health-related categories. Only one subject each reported a worsening of energy levels and endurance.

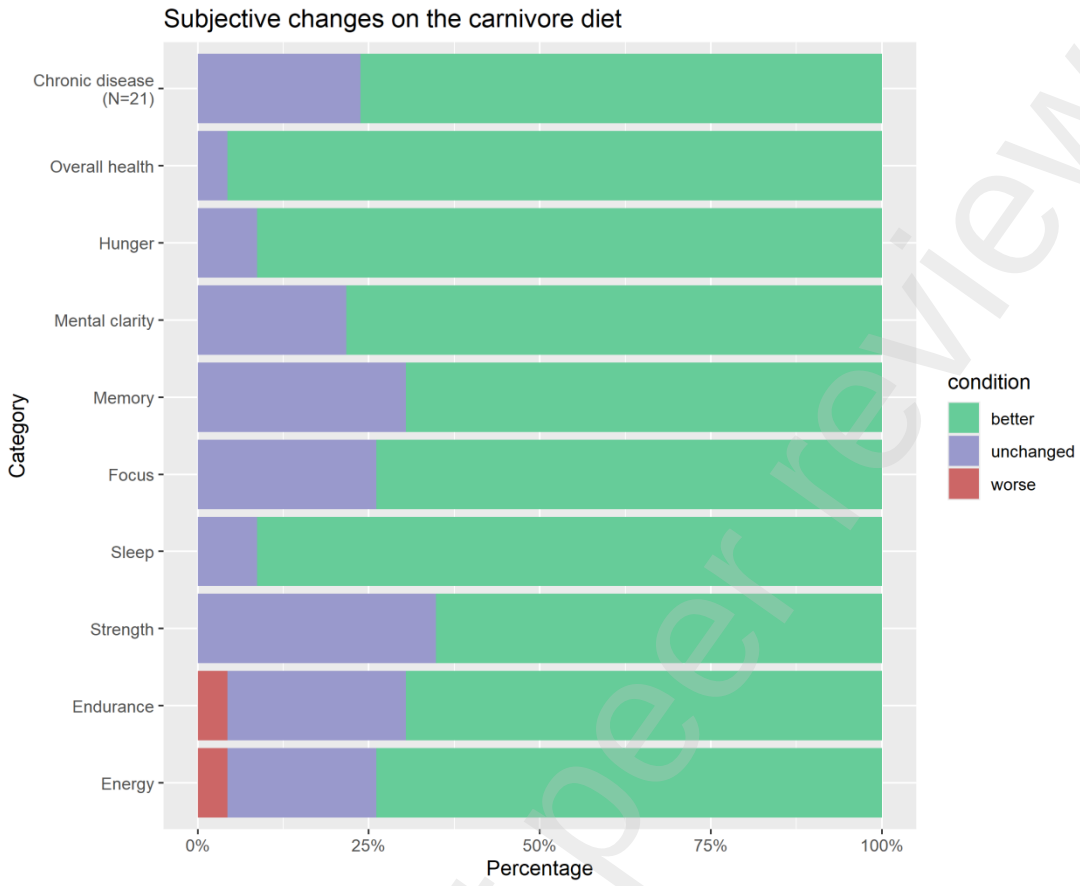

Figure 2: Subjective changes of health-related categories after switching to a carnivore diet.

Carnivore diet characteristics

According to the survey, the average daily meat intake was 588g (median 500g, range 250-1200g). Fourteen individuals (61%) characterized their diet as ketogenic and three individuals (13%) as a raw carnivore diet. In descending order, the diets were composed of the following food items: organs in 21 cases (91%), eggs in 17 cases (74%) dairy products in 14 cases (61%), fish in 12 cases (52%) and honey in 9 cases (39%). Of those consuming a ketogenic carnivore diet, 4 (29%) reported honey consumption.

The frequency of non-carnivore food consumption is plotted in Figure 3. The most frequently consumed non-animal-based food item was coffee: twelve participants reported daily and five others at least occasional coffee consumption. In contrast, the most avoided food item was grains, which were consumed only occasionally or a few times per week by five individuals, followed by

sweeteners, vegetables and cacao. Most individuals did at least occasionally include alcohol and spices into their diet.

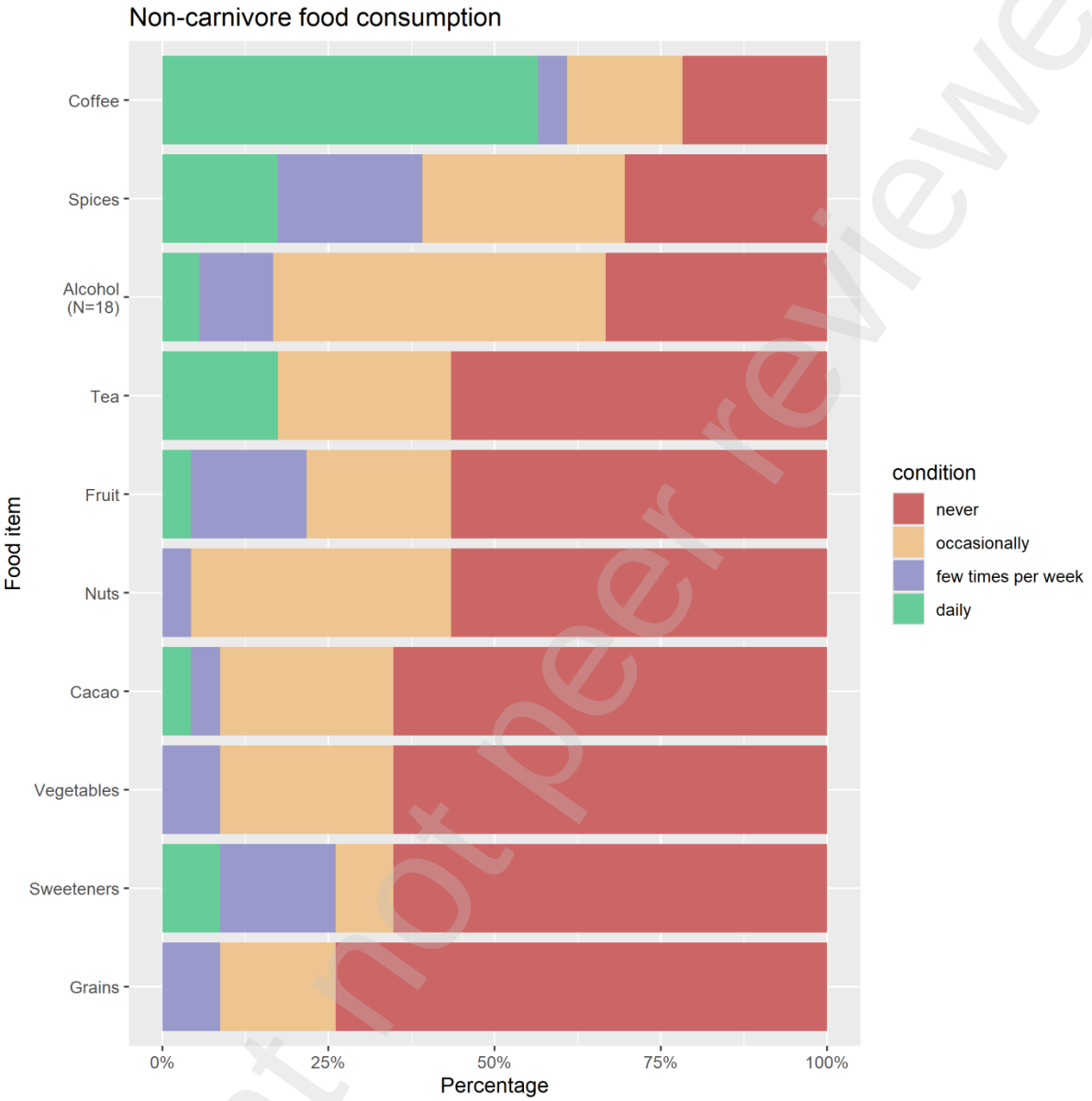

Figure 3: Frequency of consumption of non-carnivore food items.

Biochemical blood parameters

The results of the laboratory blood analyses are shown in Table 2. On-diet blood parameters were obtained after a median of 12 months on the carnivore diet (range 1-54 months) and displayed no significant differences compared to the pre-diet values except for total and LDL-cholesterol concentrations, which were raised significantly (Figure 4). There were four subjects who initially had total cholesterol concentrations greater than 300 mg/dl; their characteristics are given in Table 3.

Although cholesterol levels were already high initially, they increased further after switching to the carnivore diet. Without considering cholesterol levels, pre-diet blood parameters were out of the reference range in 60/253 cases, while this was reduced to 44/253 cases during the diet (χ^2-test: p=0.099).

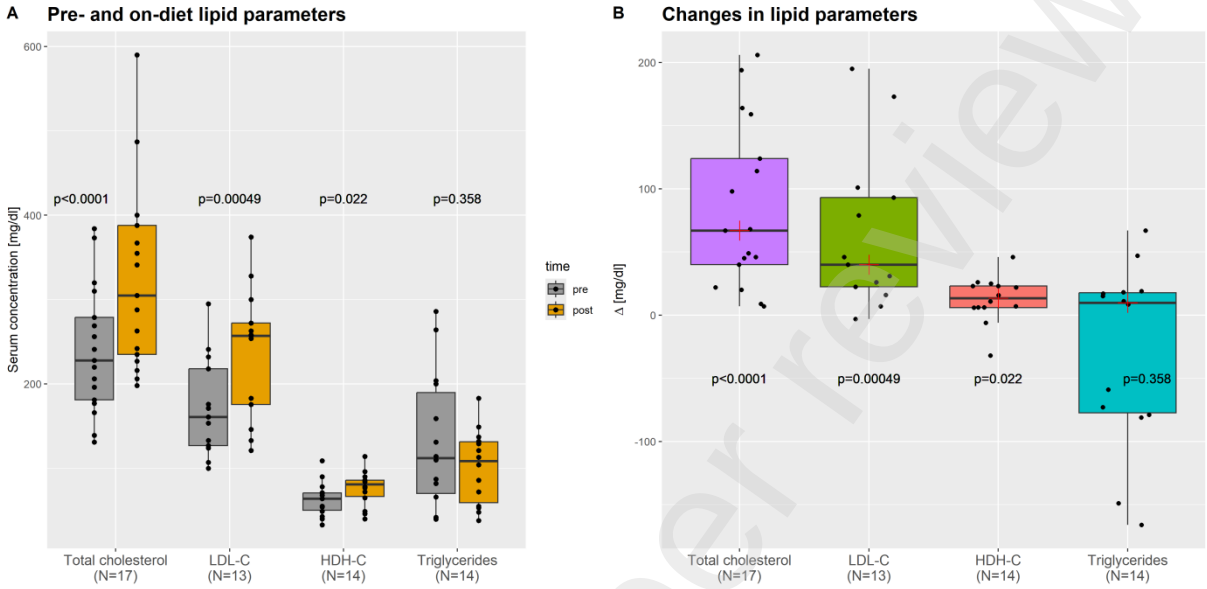

Figure 4: Changes in blood lipid parameters after switching to a carnivore diet. A: Box plots showing the pre-diet and on-diet blood lipid parameters. B: Box plots showing the median changes of blood lipid parameters. P-values correspond to a paired Wilcoxon rank sum test.

Reasons for switching to a carnivore diet

Four individuals were interviewed for this study; one of them had also taken part in the statistical survey. The mean duration of an interview was 30 minutes. Overall, the answers were very similar to the results of the statistical survey. In the qualitative interviews, health reasons were also reported as the main motivation for adopting a carnivore-type diet. Several interviewees reported that before switching to a carnivore diet, they had suffered from chronic (e.g. plantar fasciitis) or autoimmune diseases (e.g. psoriasis, rosacea) for many years and that no therapeutic treatment had really helped them until then.

Weight problems were another main motivation for most interview participants to switch to a carnivore-type diet – both underweight and overweight.

What is striking is that all interviewees reported a quick, almost radical change after adopting a carnivore diet. Accordingly, most of the interview participants quickly experienced significant health improvements (e.g. reduced inflammation and pain, more beautiful skin), including improvements

that they had not previously expected (e.g. less bloated stomach, no more feeling of fullness, better digestion, better satiety and more energy, more clarity, greatly improved sleep quality, better vision).

Another motivation mentioned by some interviewees is the desire to live in a closer connection to nature and therefore to eat more naturally again, i.e. to integrate more real food into one's own diet. Thereby, these interviewees also acknowledged that humans were mainly meat eaters during a significant period of their evolutionary history.

Table 3 provides some quotes from our interviewees as representative examples for common themes identified from the interviews.

Discussion

This study aimed to increase the knowledge about reasons why people choose to switch to a carnivore diet and what some of the physiological effects are when doing so. The study was motivated by the increasing popularity of carnivore and animal-based diets, in particular among people with chronic diseases, and a previous study from the US by Lennerz et al. [15], which produced interesting data about the motivation, characteristics and health changes of individuals eating a carnivore diet.

Despite a significantly smaller number of participants, we were able to replicate most of the main findings of Lennerz et al. [15]: Firstly, the main reason why people adopted a carnivore diet were health-related. Secondly, all health-related aspects of quality of life improved in more than 50% of participants after they had switched to a carnivore diet, with specific proportions similar to those reported by Lennerz et al. (e.g. overall health: 96% versus 95% in Lennerz et al.; chronic disease 76% vs. 69%; mental clarity: 78% vs. 85%; hunger/food cravings 91% vs. 91%; endurance: 70% vs. 76%). Thirdly, similar to the population studied by Lennerz et al., total, LDL and HDL cholesterol increased markedly on the carnivore diet compared to pre-diet values, although we could not replicate the concurrent significant drop in triglycerides, HbA1c and CRP concentrations reported by Lennerz et al. [15], possibly due to our small sample size. We also found that all other parameters besides cholesterol values tended to become more aligned to their reference ranges during the carnivore diet compared to pre-diet values ($p=0.099$).

The health improvements experienced by the majority of participants are in line with previous studies [14,15] and require an explanation. We propose three main mechanisms: One is that consumption of a carnivore diet supports a state of nutritional ketosis, i.e., an enhanced production of ketone bodies. Ketosis can exert pleiotropic health benefits mediated by the action of ketone

bodies both as an energetic substrate and as signaling molecules [24–26]. For example, β-hydroxybutyrate, the ketone body with the highest concentration in humans, is an endogenous epigenetic modifier via histone acetylation and β-hydroxybutyrylation, in this way exhibiting anti-inflammatory effects [25]. The second mechanism is that the more or less complete elimination of plant foods concurrently eliminates plant chemicals that might be problematic for sensitive individuals. In order to avoid consumption by predators, plants produce so-called anti-nutrients, which are able to damage predators or make important parts of the plant inedible. During evolution, there was an arms race between plants inventing new anti-nutrients and predators responding by the invention of new ways to detoxify those chemicals [27–29]. Contrary to the immune system whose antibodies react specifically against particular antigens, animals evolved a detoxification system that is able to detoxify a broad range of chemicals. Hence, the same enzymes that evolved to detoxify plant chemicals nowadays protect us against anthropogenic environmental toxins. However, humans possess different detoxification enzyme polymorphisms, which lead to individual differences in the ability to detoxify particular chemicals [30]. It is our hypothesis that environmental toxins might tax the detoxification capacity of sensitive individuals to such an extent that the additional consumption of plant anti-nutrients results in the emergence of symptoms. The situation might be worsened by inflammatory processes which can further inhibit the activity of detoxification enzymes [31]. In such individuals, the removal of anti-nutrients could relieve the detoxification system, leading to a subjective improvement of symptoms. Finally, a third mechanism for subjective improvements on a carnivore diet might be the high nutrient density of animal-based foods. Many micronutrients are more bioavailable or more or less exclusively available from animal-based foods; examples are choline, certain fatty acids (arachidonic, eicosapentaeic, docosahexaeic and conjugated linoleic acid), taurine, carnosine, creatine, coenzyme Q10 and the vitamins A, B_{12} and D_3. Consumption of an animal-based diet might therefore lead to rapid subjective improvements especially in individuals who formerly consumed a vegan diet, as was testified by some of our interviewees.

We found strong evidence that a carnivore diet increases total, LDL and HDL cholesterol levels. Data from randomized controlled trials indicate that carbohydrate restriction to <40% energy intake typically lowers triglyceride and elevates HDL cholesterol concentrations, while the effect on LDL cholesterol concentrations is more variable [32]. However, if the randomized trials are restricted to normal-weight adults under severe carbohydrate restriction of <10% energy intake – which is more representative of our study population – the typical result is a significant elevation of both LDL and total cholesterol levels [33]. This is consistent with the significant elevations of total and LDL cholesterol levels reported by previous case studies studies of normolipidemic and normal-weight healthy [2,34,35] as well as epileptic [36] adults after a few weeks to a few months on a ketogenic diet. Studies in athletes reported either increased [37–40] or unchanged [41–44] total and LDL

cholesterol concentrations after high-fat, partly ketogenic diets of various duration. The research group of Nicholas G. Norwitz, David Feldman and Adrian Soto-Mota conducted a meta-analysis of randomized trials and showed that the propensity for elevations in total and LDL cholesterol concentrations increases as the BMI of individuals undertaking a low carbohydrate diet decreases [45]. In other words, leaner individuals are more likely to experience an increase in their LDL and total cholesterol levels when they adopt a very low carbohydrate diet. This meta-analysis confirmed prior findings from the same group which had conducted an online survey of 548 adults consuming a low-carbohydrate diet – both lower BMI and a smaller triglyceride/HDL ratio, a maker of good metabolic health, was associated with a greater increase of LDL cholesterol levels [46]. A subset of individuals with LDL cholesterol ≥200 mg/dl, HDL cholesterol ≥80 mg/dl and trigylcerides ≤ 70 mg/dl was defined as having a "lean mass hyper-responder" phenotype, with some individuals exhibiting LDL cholesterol levels above 500 mg/dl [46]. Norwitz et al. went on to offer a theory – the lipid energy model – according to which individuals on low carbohydrate diets respond to low insulin levels and decreased liver glycogen by increased release of non-esterified fatty acids from adipose tissue which serve as a fuel for oxidative tissues such as skeletal muscle [47]. The liver also takes up non-esterified fatty acids and repackages them as triglycerides into VLDL particles. These VLDL particles are sent to peripheral tissues where they get "unpacked" through the action of lipoprotein lipase. While the triglycerides get broken down again into non-esterified fatty acids and then taken up into cells, the VLDL particles "shrink" to LDL particles, in the process losing some surface remnants such as cholesterol, phospholipids and apolipoproteins which are taken up by HDL particles. Thus, increased VLDL particle secretion would result in both an increased LDL and HDL particle mass and cholesterol content [47]. This is expected to occur to a greater extent with greater restriction of carbohydrates, lower fat mass and higher energy demands such as through exercise. A main prediction of the lipid energy model, that increased carbohydrate consumption reverses the rise of LDL cholesterol, has meanwhile been confirmed experimentally [48].

Hypercholesterolemia was also observed in Vilhjalmur Stefansson and Karsten Andersen during their one year exclusive meat diet [2]. Notably, the maximum TC level of Andersen had been measured as 800 mg/l, so he appears to have been a lean mass hyper responder, too. Consistent with the lipid energy model, TC levels in both men returned to normal after discontinuation of the diet.

The lipid energy model also explains our data. There was a significant increases in LDL and total, and to a lesser extent HDL cholesterol in this non-obese population after adopting a carnivore diet (Table 2). Two individuals also classified as lean mass hyper responders, having LDL- and HDL-cholesterol levels greater than 200 and 80 mg/dl, respectively, with concurrently low triglyceride levels below 70 mg/dl. Their BMIs were 21.5 and 19.4 kg/m^2, respectively, and they exercised for 1-2 and 7-9 hours

per week (ID 14 and 19 in Table 1). The health implications of the increased cholesterol levels in our cohort, and the two lean mass hyper responders in particular, are currently the subject of scientific debate [49]. Recently, a study compared 80 lean mass hyper-responders, who had followed a low carbohydrate diet for 4.7±2.8 years and displayed total and LDL cholesterol levels of 369±95 mg/dl and 272±91 mg/dl, respectively, with 80 matched individuals from the Miami Heart study who had total and LDL cholesterol levels of 205±40 mg/dl and 123±38 mg/dl, respectively. The median coronary artery calcium scores were 0 in the low-carbohydrate and 1 in the Miama Heart study group, which was not significantly different (p=0.520); in addition, no significant association between LDL cholesterol and coronary artery calcium scores was found. While this study implies that – at least in the short term – atherosclerotic risk may not necessarily be elevated when lean mass hyper-responders consume a low carbohydrate diet, further research is necessary to clarify the potential risks associated with this phenotype in this context.

Our study has several limitations that might bias our results or decrease their external validity. Firstly, we only had a small sample size, which could have hampered our ability to detect less pronounced blood parameter changes. However, despite the small sample size, we were able to qualitatively reproduce many results obtained in the much larger study by Lennerz et al. [15] and to detect significant blood parameter changes in cholesterol levels. Secondly, the duration of the diets and time point at which participants reported their data varied widely, which might bias the pre-diet versus on-diet comparisons and decrease the external validity of our results. Thirdly, most data were self-reported and therefore unverified by an external examiner such as a physician. However, we could at least confirm many of the self-reported subjective changes by direct interviews with four individuals. Furthermore, contrary to the study by Lennerz et al. [15], the blood parameters of our participants were not self-reported, but taken from scanned documents coming from certified medical laboratories. Fourthly, as also pointed out by Kirwan et al. [50], our study subjects might belong to a very specific group of people that is differentiated from the general population by a multitude of health behaviors of which only a small subset was included in our survey. This also makes generalized inferences from this study more difficult.

Despite these limitations, our data are useful as they provide the very first broad characterizations of the health status, motivation and behavior of German individuals following a carnivore diet. Given the growing popularity of carnivore or animal-based diets, future studies, including interventional trials, should be undertaken to further investigate the metabolic and subjective changes that occur when individuals adopt such diets. Lastly, the health implications of the carnivore diet especially for individuals who follow this diet for longer periods or who possess a lean mass hyper-responder phenotype remain to be evaluated.

Funding

No funding was received for performing this study.

Conflicts of Interest

RJK follows an animal-based and occasionally ketogenic diet. RJK cooperates with and has received refunds from www.carnivoro.eu, a supplier of nutritional supplements for consumers of a carnivore diet. JSM reports no financial or other conflicts of interest related to this work.

References

[1] Tolstoi E. The effect of an exclusive meat diet lasting one year on the carbohydrate tolerance of two normal men. J Biol Chem 1929;83:747–52.

[2] Tolstoi E. The effect of an exclusive meat diet on the chemical constituents of the blood. J Biol Chem 1929;83:753–8.

[3] Lieb CW. The effects of an exclsive, long-continued meat diet. J Am Med Assoc 1926;87:25. doi:10.1001/jama.1926.02680010025006.

[4] Lieb CW. The effects on human beings of a twelve months exclusive meat diet. J Am Med Assoc 1929;93:20–2. doi:10.1001/jama.1929.02710010026005.

[5] McClellan WS, Du Bois EF. Clinical calorimetry XLV. Prolonged meat diets with a study on kidney function and ketosis. J Biol Chem 1930;87:651–68. doi:10.1016/S0021-9258(18)76842-7.

[6] McClellan WS, Rupp VR, Toscani V. Clinical calorimetry XLVI. Prolonged meat diets with a study of the metabolism of nitrogen, calcium, and phosphorus. J Biol Chem 1930;87:669–80. doi:10.1016/S0021-9258(18)76843-9.

[7] McClellan WS, Spencer HJ, Falk EA. Clinical Calorimetry: XLVII. Prolonged meat diets with a study of the respiratory metabolism. J Biol Chem 1931;93:419–34. doi:10.1016/s0021-9258(18)76451-x.

[8] Voegtlin WL. The Stone Age Diet. 1st ed. Vantage Press; 1975.

[9] Domínguez-Rodrigo M, Pickering TR. The meat of the matter: an evolutionary perspective on human carnivory. Azania 2017;52:4–32. doi:10.1080/0067270X.2016.1252066.

[10] Ben-Dor M, Barkai R. The importance of large prey animals during the Pleistocene and the implications of their extinction on the use of dietary ethnographic analogies. J Anthropol Archaeol 2020;59:101192. doi:10.1016/j.jaa.2020.101192.

[11] Ben-Dor M, Sirtoli R, Barkai R. The evolution of the human trophic level during the Pleistocene. Yearb Phys Anthropol 2021;175:27–56. doi:10.1002/ajpa.24247.

[12] Baker S. The Carnivore Diet. 1st ed. Las Vegas: Victory Belt Publishing Inc; 2020.

[13] Saladino P. The Carnivore Code. 1st ed. New York: Fundamental Press LLC; 2020.

[14] Protogerou C, Leroy F, Hagger MS. Beliefs and experiences of individuals following a zero-carb diet. Behav Sci (Basel) 2021;11:161. doi:10.3390/bs11120161.

[15] Lennerz BS, Mey JT, Henn OH, Ludwig DS. Behavioral characteristics and self-reported health status among 2029 adults consuming a “carnivore diet.” Curr Dev Nutr 2021;5:nzab133. doi:10.1093/cdn/nzab133.

[16] Klement RJ. Was there a need for high carbohydrate content in Neanderthal diets? Am J Biol Anthropol 2022;179:668–77. doi:10.1002/ajpa.24643.

[17] Tóth C, Clemens Z. Halted Progression of Soft Palate Cancer in a Patient Treated with the Paleolithic Ketogenic Diet Alone. Am J Med Case Reports 2016;4:288–92. doi:10.12691/ajmcr-4-8-8.

[18] Seyfried TN, Shivane AG, Kalamian M, Maroon JC, Mukherjee P, Zuccoli G. Ketogenic metabolic therapy, without chemo or radiation, for the long-term management of IDH1 - mutant glioblastoma: an 80-month follow-up case report. Front Nutr 2021;8:682243. doi:10.3389/fnut.2021.682243.

[19] Norwitz NG, Soto-Mota A. Case report: Carnivore–ketogenic diet for the treatment of inflammatory bowel disease: a case series of 10 patients. Front Nutr 2024;11:1467475. doi:10.3389/fnut.2024.1467475.

[20] Klement RJ. Langjährige Remission von Colitis ulcerosa durch eine carnivore Ernährung: Ein Fallbericht. Natura 2024;29:18–21.

[21] Yar N, Mukona LT, Nguyen K, Nalbandyan L, Mukona L, St. Fleur G, et al. Consuming an all-meat ketogenic diet for the long-term management of candida vulvovaginitis and vaginal hidradenitis suppurativa: A 47-month follow-up case report. Cureus 2022;14:e30510. doi:10.7759/cureus.30510.

[22] Perneger T V. What's wrong with Bonferroni adjustments. BMJ 1998;316:1236–8.

[23] Benjamin DJ, Berger JO, Johannesson M, Nosek BA, Wagenmakers EJ, Berk R, et al. Redefine statistical significance. Nat Hum Behav 2018;2:6–10. doi:10.1038/s41562-017-0189-z.

[24] Hyde PN, Lustberg MB, Miller VJ, LaFountain RA, Volek JS. Pleiotropic effects of nutritional ketosis: Conceptual framework for keto-adaptation as a breast cancer therapy. Cancer Treat Res Commun 2017;12:32–9. doi:10.1016/j.ctarc.2017.06.001.

[25] Puchalska P, Crawford PA. Metabolic and Signaling Roles of Ketone Bodies in Health and Disease. Annu Rev Nutr 2021;41:49–77. doi:10.1146/annurev-nutr-111120-111518.

[26] Spigoni V, Cinquegrani G, Iannozzi NT, Frigeri G, Maggiolo G, Maggi M, et al. Activation of G protein-coupled receptors by ketone bodies: Clinical implication of the ketogenic diet in metabolic disorders. Front Endocrinol (Lausanne) 2022;13:972890. doi:10.3389/fendo.2022.972890.

[27] Gonzalez FJ, Nebert DW. Evolution of the P450 gene superfamily: animal-plant "warfare", molecular drive and human genetic differences in drug oxidation. Trends Genet 1990;6:182–6. doi:10.1016/0168-9525(90)90174-5.

[28] Bock KW. Vertebrate UDP-glucuronosyltransferases: Functional and evolutionary aspects. Biochem Pharmacol 2003;66:691–6. doi:10.1016/S0006-2952(03)00296-X.

[29] Bock KW. The UDP-glycosyltransferase (UGT) superfamily expressed in humans, insects and plants: Animal-plant arms-race and co-evolution. Biochem Pharmacol 2016;99:11–7. doi:10.1016/j.bcp.2015.10.001.

[30] Bieger WP. Detoxifikation. Zeitschrift Für Orthomolekulare Medizin 2016;4:16–22. doi:10.1055/s-0042-122117.

[31] Stipp MC, Acco A. Involvement of cytochrome P450 enzymes in inflammation and cancer: a review. Cancer Chemother Pharmacol 2021;87:295–309. doi:10.1007/s00280-020-04181-2.

[32] Dong T, Guo M, Zhang P, Sun G, Chen B. The effects of low-carbohydrate diets on cardiovascular risk factors: A meta-analysis. PLoS One 2020;15:e0225348. doi:10.1371/journal.pone.0225348.

[33] Joo M, Moon S, Lee YS, Kim MG. Effects of very low-carbohydrate ketogenic diets on lipid profiles in normal-weight (body mass index < 25 kg/m2) adults: a meta-analysis. Nutr Rev 2023;81:1393–401. doi:10.1093/nutrit/nuad017.

[34] Krehl WA, Lopez A, Good EI, Hodges RE. Some metabolic changes induced by low carbohydrate diets. Am J Clin Nutr 1967;20:139–48.

[35] Cham BE, Roeser HPP, Warrell A, Cham EB, Roeser HPP, Warrel A, et al. Effect of a high energy, low carbohydrate diet on serum levels of lipids and lipoproteins. Med J Aust 1981;1:237–40. doi:10.5694/j.1326-5377.1981.tb135511.x.

[36] Cervenka MC, Terao NN, Bosarge JL, Henry BJ, Klees AA, Morrison PF, et al. E-mail management of the modified Atkins Diet for adults with epilepsy is feasible and effective. Epilepsia 2012;53:728–32. doi:10.1111/j.1528-1167.2012.03406.x.

[37] Phinney SD, Bistrian BR, Evans WJ, Gervino E, Blackburn GL, Wolfe RR. The human metabolic response to chronic ketosis without caloric restriction: physical and biochemical adaptation. Metabolism 1983;32:769–76.

[38] Rosenkranz RR, Cook CM, Haub MD. Endurance training on low-carbohydrate and grain-based diets: a case study. Int J Sport Nutr Exerc Metab 2007;17:296–309.

[39] Klement RJ, Frobel T, Albers T, Fikenzer S, Prinzhausen J. A pilot case study on the impact of a self-prescribed ketogenic diet on biochemical parameters and running performance in healthy and physically active individuals. Nutr Med 2013;1:10.

[40] Creighton BC, Hyde PN, Maresh CM, Kraemer WJ, Phinney SD, Volek JS. Paradox of hypercholesterolaemia in highly trained, keto-adapted athletes. BMJ Open Sport Exerc Med 2018;4:e000429. doi:10.1136/bmjsem-2018-000429.

[41] Lambert E V, Goedecke JH, Zyle C, Murphy K, Hawley JA, Dennis SC, et al. High-fat diet versus habitual diet prior to carbohydrate loading: effects of exercise metabolism and cycling performance. Int J Sport Nutr Exerc Metab 2001;11:209–25.

[42] Brown RC, Cox CM. Effects of high fat versus high carbohydrate diets on plasma lipids and lipoproteins in endurance athletes. Med Sci Sport Exerc 1998;30:1677–83.

[43] Cooney MM, Haymes EM, Lucariello G. The effects of a low carbohydrate-ketogenic diet in trained females. Med Sci Sport Exerc 1983;15:129.

[44] Leddy J, Horvath P, Rowland J, Pendergast D. Effect of a high or a low fat diet on cardiovascular risk factors in male and female runners. Med Sci Sport Exerc 1997;29:17–25.

[45] Soto-Mota A, Flores-Jurado Y, Norwitz NG, Feldman D, Pereira MA, Danaei G, et al. Increased low-density lipoprotein cholesterol on a low-carbohydrate diet in adults with normal but not

high body weight: A meta-analysis. Am J Clin Nutr 2024;119:740–7. doi:10.1016/j.ajcnut.2024.01.009.

[46] Norwitz NG, Feldman D, Soto-Mota A, Kalayjian T, Ludwig DS. Elevated LDL Cholesterol with a Carbohydrate-Restricted Diet: Evidence for a “lean Mass Hyper-Responder” Phenotype. Curr Dev Nutr 2022;6:nzab144. doi:10.1093/cdn/nzab144.

[47] Norwitz NG, Soto-Mota A, Kaplan B, Ludwig DS, Budoff M, Kontush A, et al. The Lipid Energy Model: Reimagining Lipoprotein Function in the Context of Carbohydrate-Restricted Diets. Metabolites 2022;12:460. doi:10.3390/metabo12050460.

[48] Norwitz NG, Cromwell WC. Oreo cookie treatment lowers LDL cholesterol more than high-intensity statin therapy in a lean mass hyper-responder on a ketogenic diet: A curious crossover experiment. Metabolites 2024;14:73. doi:10.3390/metabo14010073.

[49] Norwitz NG, Mindrum MR, Giral P, Kontush A, Soto-Mota A, Wood TR, et al. Elevated LDL-cholesterol levels among lean mass hyper-responders on low-carbohydrate ketogenic diets deserve urgent clinical attention and further research. J Clin Lipidol 2022;16:765–8. doi:10.1016/j.jacl.2022.10.010.

[50] Kirwan R, Mallett GS, Ellis L, Flanagan A. Limitations of Self-reported Health Status and Metabolic Markers among Adults Consuming a “Carnivore Diet.” Curr Dev Nutr 2022;6:nzac037. doi:10.1093/cdn/nzac037.

[51] Wakabayashi I, Daimon T. Comparison of discrimination for cardio-metabolic risk by different cut-off values of the ratio of triglycerides to HDL cholesterol. Lipids Health Dis 2019;18:156. doi:10.1186/s12944-019-1098-0.

[52] Sun T, Chen M, Shen H, PingYin, Fan L, Chen X, et al. Predictive value of LDL/HDL ratio in coronary atherosclerotic heart disease. BMC Cardiovasc Disord 2022;22:273. doi:10.1186/s12872-022-02706-6.

Table 1: Baseline characteristics of study participants

ID	Sex	Age	BMI [kg/m^2]	Smoker	Clinical diagnosis	Time on carnivore diet [months]	Meat consumption [g/day]	Exercise [h/week]	Previous diet
1	w	39	20.9	no	Polycystic ovary syndrome, burnout, depression, hypothyroidism	23	300	10-12	Paleo
2	m	34	21.8	formerly	Acne, back pain, chronic fatigue syndrome, depression, hypotension	12	500	1-2	Standard
3	m	62	19.8	yes	Arthrosis, hypothyroidism	6	250	1-2	Ketogenic
4	w	44	24.5	no	Prediabates	5	400	0	Vegetarian
5	w	59	20.5	no	IBS	30	400	7-9	Standard
6	m	50	25.1	yes	−	36	530	7-9	Standard
7	m	60	26.3	no	−	7	600	0	Paleo
8	w	45	20.9	no	Hashimoto-thyroiditis,	45	1000	3-6	Ketogenic
9	m	36	25.1	no	Ulcerative colitis	56	1200	>12	Standard
10	m	39	22.8	no	−	25	550	3-6	Ketogenic

11	m	53	21.5	no	–	3	900	3-6	Low Carb
12	w	62	18.6	no	–	13	500	7-9	Primal
13	m	52	24.9	formerly	Small fiber neuropathy developed after COVID-19 vaccination, psoriasis, NAFLD	3	500	1-2	Low Carb
14	w	60	21.5	no	Polycystic kidney disease	16	400	1-2	Vegan
15	w	45	20.2	yes	–	54	500	1-2	Ketogenic
16	m	27	17.8	no	Hashimoto-thyroiditis, IBS	17	850	3-6	Ketogenic
17	m	47	25.4	no	NAFLD, IBS, parasites, coagulopathy	7	400	7-9	Vegetarian
18	w	50	18.9	formerly	–	2	600	0	Ketogenic
19	w	50	19.4	formerly	–	1	500	7-9	Intermittent fasting
20	m	33	20.6	no	Hemorrhoids	18	900	3-6	Standard
21	w	44	25.2	formerly	Adiposity	5	550	1-2	Standard
22	m	56	27.4	formerly	Chron’s disease	12	700	1-2	Standard
23	m	47	23.3	no	–	12	300	3-6	Intermittent

									fasting

IBs: Irritable bowel syndrome; NAFLD: Non-alcoholic fatty liver disease

Table 2: Pre-diet- on-diet comparison of blood parameters of interest

N	Parameter	Reference range	Pre-diet value	On-diet value	Change	p-value
20	Leukocytes (10^3/µl)	[4,10]	5.5 [3.07,21.9]	5.9 [3.75,9.6]	0.07 [-14.6, 3.7]	0.984
19	Erythrocytes (10^9/µl)	Males: 4.5–6.5 Females: 3.9–5.6	4.70 [4.1,5.8]	4.8 [4.21,5.8]	0.06 [-0.52,1.1]	0.408
19	Haemoglobin (g/dl)	Males: 14–18 Females: 12–16	14.3 [12.9,16.7]	14.7 [13.0,17.2]	0.3 [-1.7,2.9]	0.519
19	Haematocrit (%)	Males: 40–52 Females: 12–16	43.2 [38.4,50.8]	45.0 [39.2,51.0]	0.9 [-4.4,6.8]	0.500
20	Platelets (10^3/µl)	140–400	236 [132,400]	229 [137,365]	-10 [-112,49]	0.376
17	Total cholesterol (mg/dl)	<250	228 [131,384]	305 [198, 590]	58 [7, 206]	1.5×10^{-5}
14	HDL cholesterol (mg/dl)	>60	64 [33, 109]	81 [40, 114]	11 [-32,46]	0.022
13	LDL cholesterol (mg/dl)	<160	161 [100, 295]	257 [121, 374]	36 [-3, 195]	0.00049
14	Triglycerides (mg/dl)	<150	112 [40, 286]	109 [38, 183]	8 [-166, 67]	0.358
13	Triglyceride/HDL ratio	Males: <2.967 Females: <2.237 [a]	1.72 [0.44, 6.65]	1.47 [0.49, 2.80]	-0.29 [-3.86, 0.86]	0.057
13	LDL/HDL ratio	<2.517 [b]	2.5 [1.51, 6.61]	3.17 [1.39, 6.45]	0.31 [-0.78, 1.54]	0.168
13	AST (U/l)	Females: <35	23 [15, 52]	20 [16, 27]	0 [-33, 3]	0.288

15	ALT (U/l)	Females: <28	20 [11, 93]	22 [16, 47]	2 [-73, 19]	0.776
16	γ-GT (U/l)	Females: <40	17 [10, 60]	18 [11, 34]	0 [-36, 8]	0.756
10	Na (mmol/l)	135–145	139 [133, 142]	139 [137, 141]	0 [-2, 4]	0.797
9	Ca (mmol/l)	2–2.6	2.44 [2.16, 2.51]	2.39 [2.28, 2.55]	0.08 [-0.19, 0.12]	0.593
12	K (mmol/l)	3–10	4.3 [3.2, 5.35]	4.3 [3.9, 5.5]	-0.2 [-0.56, 1.2]	1
16	Creatinine (mg/dl)	Males: <1.3 Females: <1.0	0.92 [0.6, 1.44]	1.02 [0.54, 1.3]	0.08, [-0.36, 0.35]	0.124
11	Uric acid (mg/dl)	Males: 3.6–8.2 Females: 2.3–6.1	5.17 [1.78, 7.2]	4.70 [3.4, 6.4]	0.05 [-1.42, 2.82]	0.638
8	CRP (mg/dl)	<0.5	0.49 [0.03, 2.8]	0.1 [0.03, 2.2]	0 [-2.7, 0.23]	0.423
11	Glucose (mg/dl)	70–110	85 [69, 117]	86 [77, 101]	1 [-37, 32]	0.721
7	HbA1c (%)	4.3–5.8	5.6 [5.2, 7.3]	5.6 [5.3, 6.6]	-0.2 [-0.7, 0.2]	0.609
8	TSH (µIU/ml)	0.35–4.5	1.37 [0.01, 2.13]	1.09 [0.02, 2.20]	-0.08 [-0.89, 0.86]	0.297

a Wakabayashi et al. (2019) [51]

b Sun et al. (2022) [52]

Table 3: Common themes that emerged from the qualitative interviews with concrete examples

Common theme	Illustrative quote
More or less radical shift from a vegan to a carnivore diet (for ethical reasons)	"And that was the point where I was caught: this naturalness. ...Where it was said: if we all eat a vegan diet now, what will the landscape look like? Then it is a monoculture landscape. And then I thought to myself: that can't be right, it's not natural. ...And it quickly became plausible for me, so I started eating meat again; and then I actually noticed the first time that I felt fully saturated again. I actually suppressed that a lot during the years when I went vegan" (M.B., 39 years)
Starting a carnivore diet for health-related reasons	"I have been struggling with being very overweight for years. And when I heard from a friend that he had lost almost 20 kilos over the course of a few months using a carnivore-type diet, I thought to myself: I have to try that too" (T.H., 56 years) "The ultimate motivation to try carnivore was my autoimmune disease, because I've been trying everything possible to get rid of my psoriasis and get rid of the inflammation for over eight years; and that nothing worked at all, no matter how I ate...and it just made sense to me… And I've had immediate success with it because my hairdresser sees it, he always asks me about it: Ah, your skin is better today, so good. Your skin has never been like that... And I only ate like that for three weeks…" (M.A., 38 years)
Meat consumption as part of the natural order and the creation	"So for me it's actually through questioning: why are we here and how does the whole thing work? - So basically the topic of the order of creation and perhaps also the aspect: what is death? ...I see myself here as a human being, but also as a divine being who has a soul. And this soul also lives longer than the human being himself. That means, for me there is life even after death; and that's how I assume it is for animals and the like... and that the animals perhaps also have a certain function... And if you eat meat, of course, you have to deal with the topic of death or killing,

	which is also one of those taboo topics in our society. And through this realization that there is life after death and reincarnation, I came to a different approach, namely that it is a natural process. ...If you look at the natural world: there is always eating and being eaten. These are simply cycles, they are simply something natural that is part of the creation" (M.B., 39 years)
Motivation to maintain the carnivore diet	"Because my Hb1Ac value kept getting higher and because I kept hearing from my alternative practitioner it was heading towards adult-onset diabetes... and I wanted to avoid that at all costs… Over the years it was more and more towards 6.0 and then sometimes even over it... and then I thought to myself: I would like to get it under control and now I'm testing it for half a year, what it`s like and how it works and how it develops. And that was my first sign that, on the one hand, it had clearly visibly decreased over time. And on the other hand, I had problems with my feet... And my foot problem, plantar fasciitis, disappeared within a week when I switched to a carnivore-type diet, i.e. by cutting out carbohydrates, and has never come back since. And those were actually the two key experiences, the long-term sugar level and the feet that kept me on the diet" (L.H., 45 years)