Nutrition, Metabolism & Cardiovascular Diseases (xxxx) xxx, xxx

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

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

SYSTEMATIC REVIEWS AND META-ANALYSES

The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis

Negin Gholampoor [a], Amir Hossien Sharif [b], Duane Mellor [a,*]

[a] Aston Medical School, College of Health and Life Sciences, Aston University, Birmingham, United Kingdom
[b] Maidstone and Tunbridge Wells NHS Trust, Kent, United Kingdom

Received 21 August 2023; received in revised form 18 January 2024; accepted 10 February 2024
Handling Editor: A. Siani
Available online ■ ■ ■

KEYWORDS
Fasting;
Faith;
Cardiometabolic;
Orthodox christian;
Islamic;
Time restricted eating;
Systematic review

Abstract *Aims:* Cardiovascular diseases (CVD) are the leading cause of death worldwide. Fasting is common in many religions and is associated with health benefits. This systematic review to compares the impact of different religious fasting practices, on risk of cardiometabolic diseases.
Data synthesis: The search covered five databases following PRISMA guidelines to identify papers published in English from inception to March 2023 (updated January 2024). Inclusion criteria were healthy adults in observational studies, who engaged in religious fasting practices, studies were included where data on matched non-fasting individuals was available. Outcomes were systolic and diastolic blood pressure, body mass index (BMI), triglycerides, total cholesterol (TC), low-density lipoprotein cholesterol (LDLc), high-density lipoprotein cholesterol (HDLc), and fasting plasma glucose levels. A meta-analysis was conducted, and the review was registered (CRD42022352197). Fourteen studies were met the inclusion criteria with ten studies data being suitable for meta-analysis, reporting on 755 adults participating in fasting practices and 661 non-fasting controls. Religious fasting was associated with a reduction in BMI (-0.40 kg/m^2, 95% CI [-0.70, -0.10], $p < 0.01$). Observance of Ramadan fasting was associated with decreased systolic blood pressure (-3.83 mmHg, 95% CI [-7.44, -0.23], $p = 0.04$). The observance of Orthodox Christian fasting was associated with a reduction in TC (-0.52 mmoL/l, 95%CI [-0.64, -0.39], $p < 0.01$). No difference was found for the other outcomes.
Conclusion: This review found religious fasting practices which were associated with a reduction in some biomarkers of cardiometabolic diseases risk. Further research on other fasting practices is needed due to limited data.

* Corresponding author.
E-mail addresses: 190204884@aston.ac.uk (N. Gholampoor), a.sharif3@nhs.net (A.H. Sharif), d.mellor@aston.ac.uk (D. Mellor).

https://doi.org/10.1016/j.numecd.2024.02.002

1. Introduction

Cardiovascular disease (CVD) is the leading cause of premature death globally and is responsible for 32% of the world's total deaths. 85% of all CVD deaths result from myocardial infarctions and cerebrovascular accidents, typically resulting from pathological processes, including atherosclerosis and an increased risk of blood clotting [1].

The term cardiometabolic risks refers to a group of modifiable risk factors that contribute significantly to the development of CVD. These include high body mass index (BMI), hypertension, dysglycaemia, and dyslipidaemia [2] which can be modified by lifestyle factors including sedentary lifestyle, dietary behaviour and smoking. According to the International Diabetes Federation (IDF), the co-occurrence of these risk factors has been defined as metabolic syndrome [3]. These risk factors are often linked, their common underlying mediators, mechanisms, and pathways that can be associated with lifestyle-related behaviours, including diet, physical activity, and smoking [4].

For millennia, humans have practiced different lifestyle approaches that are embedded in human faith, culture, and religion. One common example of this type of practice is fasting, the voluntary abstention from food, which can be done for self-improvement, health improvement, or religious piety. Recent studies have shown that fasting has been associated with longevity and a lower risk of morbidity [5–7]. Fasting plays a central role in many religious customs and faiths globally. This practice is undertaken for a range of reasons, including humility, piety, penance, observance, and spiritual knowledge and guidance. While undertaking fasting for faith and religious reasons is widespread, it is plausible that it may also have beneficial effects with respect to cardiometabolic risk. The three common approaches to fasting include caloric restriction (e.g., eating less), dietary restriction (e.g., avoiding types of food such as meat, dairy, and fats), and time-restricted eating (e.g., not eating for a specified periods of time) [8]. However, despite the potential health benefits of these types of abstention, the impact of different types of religious fasting on cardiometabolic disease risk in healthy adults remains unclear.

Approximately 85% of the world's population identifies as following a religion, with Christianity being the most common with 2.4 billion followers, and Islam with 2 billion identifying as Muslims [9,10]. Ramadan fasting is an obligation for all Muslims [11]. However, with respect to Christianity, there are different fasting approaches depending on their denomination, with a restrictive eating pattern of fasting among Greek Orthodox, Eastern Orthodox, and Coptic Christians (who in this review will be referred to as Orthodox Christians) [12,13]. This type of fasting involves abstinence from animal products and oils. Other faiths also include periods of fasting, including Jains, who often do not eat after sunset during certain periods of the year, and followers of the Hindu faith. Hindus may follow a number of different types of fasts, from abstaining from one meal a day to a fast that only includes a small range of foods. However, not all faiths advocate fasting; within Sikhism, fasting is only advocated for health reasons.

The practice of time-restricted eating can be seen in Islamic Ramadan, a month of fasting in the ninth lunar month of the Islamic calendar, which changes in date year-to-year due to its lunar-based system [14]. During this month, Muslims abstain from food and drink from dawn time to sunset. However, there are no specific dietary restrictions, and they can eat during the night and early morning. Ramadan fasting is a core and compulsory pillar of the faith for all healthy adults once they reach puberty, with exceptions for pregnancy, breastfeeding, menstruation, and children before puberty and travellers [11]. Studies have shown that Ramadan fasting may improve blood pressure, lipid profile, weight changes, and overall cardiovascular risk factors [15–19].

Orthodox Christian fasting is a faith-based approach to fasting, which involves a periodic vegetarian diet. The recommended fasting period for Orthodox Christians can last up to 180–200 days each year, with three principal fasting periods per year: the Nativity fast (prior to Christmas during December), the Lent period (prior to Easter, typically during February to April), and the Assumption or Dormition fast (during August) [20]. The dietary restrictions vary during each period. Fish and olive oil are only abstained on Wednesdays and Fridays during the Nativity fast, while fish is only abstained on March 25th and Palm Sunday during Lent. Additionally, olive oil, meat, fish, milk, and dairy products are avoided every Wednesday and Friday throughout the year, except for the week following Christmas, Easter, and Pentecost, which form the three principal fasting periods in Orthodox Christian fasting. It often results in a dietary pattern that aligns with many of the principles of the Mediterranean diet, being high in fruit, vegetables, and legumes [21]. Studies have suggested that Orthodox Christian fasting may be associated with a positive impact on lipid profile [22,23].

Although clinical trials have suggested that both vegetarian-type patterns similar to Orthodox Christian fasting and time-restricted eating similar to Ramadan fasting can reduce risk factors associated with cardiometabolic disease, it is unclear in cohorts where this is practiced if those observing these fasts experience reduced cardiometabolic risks compared to matched individuals with many studies of these fasts only assessing the effect on the fasting individuals themself. A meta-analysis of individuals fasting during Ramadan has shown to be associated with improved blood pressure [24]. It is important, especially considering that the timing of religious and faith-based fasting can vary when it falls during the year, to examine the health and metabolic effects of fasting by comparison with matched non-fasting individuals in the same communities. Similarly, with Orthodox Christian fasting, limited data has been reported in a systematic review exploring its effects largely; however, it did not compare data with non-fasting individuals [25].

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002

This systematic review aims to investigate the available literature and provide insight into the potential impacts of fasting, specifically dietary-restricted and time-restricted eating, on reducing the risk of cardiometabolic diseases in healthy adults compared to non-fasting individuals. To date, there have been limited comparisons of different types of religious or faith-based fasting on markers of cardiometabolic risk. Whilst not looking to see if a religious or faith-based reason enhances the biological effect of fasting, as this cannot be determined, it might be possible to identify additional health effects of fasting, which may be useful in supporting people of faith to improve their health alongside other interventions. The need for this review was highlighted in previous studies [8,26] as it is important to understand the connection between religious fasting and its potential health benefits.

2. Methodology

2.1. Search strategy

The protocol for this systematic review and meta-analysis was registered with PROSPERO (CRD42022352197). The literature search was conducted in accordance with PRISMA guidelines [27]. Peer Review of Electronic Search Strategies (PRESS) was conducted by authors using CADTH methods and guidelines [28]. This sought to identify relevant observational studies on the effects of restricted eating and fasting practices linked to religious observance or cultural practice on cardiometabolic disease risk markers. The search aimed to include a potentially varied number of dietary patterns which are practiced as part of religious fasting. Although these might have different cardiometabolic effects, the primary focus of the research question being religious practice, meant that heterogeneity resulting from different types of fasting practice could be investigated using subgroup analysis.

The search was carried out across the following databases: PubMed, Embase (Ovid), CINAHL (EBSCO), APA PsycInfo (ProQuest) and MEDLINE (Ovid) for papers published in English from inception to March 2023 (then updated search to January 2024). In addition to the electronic database search, a hand search of the reference lists of included articles was also conducted. The following search terms (keywords and related medical subject headings (MeSH terms)) were used: (‘fasting’ OR ‘restricted eating’ OR ‘Buddhism fasting’ OR ‘Buddhist fasting’ OR ‘Ramadan fasting’ OR ‘Ramadan’ OR ‘Islamic fasting’ OR ‘Hindu fasting’ OR ‘spiritual fasting’ OR ‘Orthodox fasting’) AND (‘hypertension’ OR ‘blood pressure’ OR ‘cholesterol’ OR ‘hyperlipidaemia’ OR ‘dyslipidaemia’ OR ‘hypercholesterolaemia’ OR ‘cardiovascular disease risk OR ’diabetes’ OR ‘glycaemia’ OR ‘HbA1c’ OR ‘insulin’).

2.2. Population, exposure, comparison, outcomes

The population of interest were healthy adults in prospective or cross-sectional studies, including religious communities. The exposure was restricted eating and fasting practices linked to religious observance or cultural practice. The control group was individuals not adhering to such practices. The outcomes were cardiometabolic risk markers, systolic and diastolic blood pressure, BMI, triglycerides, total cholesterol, low-density lipoprotein cholesterol (LDLc), high-density lipoprotein cholesterol (HDLc) and fasting plasma glucose levels.

2.3. Study selection

Inclusion criteria were English papers, human observational studies, primarily prospective cohort, with no date restriction. Exclusion criteria were interventional studies, observational studies without a non-fasting comparator group, case reports, animal and *in vitro* studies, and studies on children, pregnant women, breastfeeding individuals, and medically unstable patients. Where studies reported data from individuals who fasted, partial fasted or did not fast, the data included in the analysis compared only fasting individuals and the non-fasting individuals.

Since the focus of this study is on the effect of the natural occurrence of religious fasting and its association with cardiometabolic risk factors, interventional studies are excluded. Two researchers independently assessed the studies for eligibility using the inclusion criteria, blind to each other’s selections. Abstracts that met the inclusion criteria were then listed and the full papers were screened by both researchers independently and blind to each other. Any discrepancies were discussed and resolved through discussion. Data extracted included lead author, date of publication, number of participants, duration of intervention, baseline, and post exposure measurements. Missing data was recorded as unreported.

The reason for excluding interventional studies is that religious practices are based solely on people’s personal beliefs and desires, holding significant meaning for individuals and communities. Therefore, it is believed that interventional studies on religious fasting may not only raise ethical concerns but also may not be a reliable method to assess the outcomes of this religiously driven behaviour.

2.4. Risk of bias (quality) assessment

The method of randomisation, completion rate, and approach to analysis were particularly focused on during quality assessment. The Cochrane risk of bias tool within RevMan5, was used at a study level. Both researchers independently undertook quality assessment and met to resolve any disagreements, supported by another researcher. Funnel plots were also used to assess for publication bias (Supplementary information).

2.5. Statistical analysis and data synthesis

Following data extraction, data was assessed for suitability for meta-analysis. A meta-analysis was undertaken to assess the overall effects of religious fasting practices, with subgroup (based on fasting approach) analysis was

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002

undertaken, using RevMan5.4, for studies meeting inclusion criteria, with at least four studies in each sub-group sufficient quality and homogeneity. Continuous data for markers of cardiometabolic risks were presented as mean difference. Data for change in systolic and diastolic blood pressure (mmHg), BMI (kg/m^2), total cholesterol (mmol/l), HDLc (mmol/l), LDLc (mmol/l), triglycerides (mmol/l) and glucose (mmol/l) were expressed as mean differences and 95% confidence intervals which were calculated as changes from baseline levels. When standard deviation (SD) of change was not available, it was estimated by using baseline and end of treatment SD as described in the Cochrane handbook [29]. Publication bias was assessed by visual examination of asymmetry in funnel plots. Subgroup analysis was undertaken to separate data types, such as markers of disease risk, which were continuous and the prospective data and cross-sectional data, which were analysed to estimate relative risk and odds ratio, respectively.

3. Result

The process for including studies in the review is shown in Fig. 1. Initially, a total of 3419 studies were identified through five electronic database searches, with an additional 11 studies found through other sources, making up a combined total of 3430 studies. No filters were used on databases; thus, no automated exclusions were performed. After removing duplicates, 1359 studies were screened for eligibility based on their titles and abstracts. At this stage, 1164 studies were excluded based on their title and abstract not meeting the population, exposure, comparison, and outcomes of the study criteria, leaving 195 studies for full-text review. During the full-text review, two duplicates were manually excluded, and 181 studies were excluded for not meeting the eligibility criteria. Almost half of the papers excluded at this stage were observational studies without a non-fasting control group. Among these, 2 were intervention studies 83 were studies on Ramadan fasting (time-restricted eating), and 10 were on Orthodox fasting (dietary-restricted eating). Additionally, 45 studies reported outcomes other than cardiometabolic risk factors, 8 were interventional studies, and 28 studies with ineligible populations (such as children and adolescents, unstable patients, or those with acute conditions like those undergoing dialysis) were excluded.

Fourteen studies conducted between 1998 and 2021 fulfilled the inclusion criteria and were included for qualitative analysis. These studies included 320 adults who participated in Ramadan fasting with 224 non-fasting controls, and 435 adults who participated in Orthodox fasting with 437 non-fasting controls. Of the included studies, 10 reported quantitative data, which was included in the meta-analysis. These 14 papers include nine Ramadan fasting studies that were conducted in nine countries across four continents (North America, Europe, Asia, and Oceania), summarized in Table 1, and five papers on Orthodox fasting that were all conducted in Greece, summarized in Table 2.

The papers that studied the effects of Ramadan fasting explored fasting periods of varying durations and were observed during the months or periods of Ramadan, Shaban, and Shawwal (Table 1). These studies observed changes in BMI, which decreased in the fasting group compared to the non-fasting group in four studies [30–33]. With respect to blood pressure outcomes, systolic blood pressure and diastolic blood pressure were decreased in the fasting groups compared to the non-fasting groups in two studies [31,34]. However, these were observed only as single time point clinic room, rather than ambulatory measurements of blood pressure. Seker et al. reported time-dependent changes in blood pressure during a 24-h period while fasting and observed an increase in systolic blood pressure in fasting patients during measurements at 18:00, 19:00, and 20:00 h. The non-fasting group, in contrast, had a more stable blood pressure compared to the fasting group [35]. The findings regarding other assessments of cardiometabolic risk were inconsistent. In three studies, HDLc was higher in the fasting group compared to the non-fasting group [32–34]. However, one study found a decrease in LDLc three months after fasting [36]. Additionally, total cholesterol was higher in a study conducted by Khan et al. [33]. Triglycerides, HDLc, and plasma glucose levels did not show any significant differences between the fasting and non-fasting groups in most studies, except in one study that found higher plasma fasting glucose levels in the fasting group [34].

With regards to studies on Orthodox Christian fasting (Table 2), Petridou et al. conducted a cross-sectional study involving a total of (n = 400) individuals, with (n = 200) adhering to a fasting regimen for a median of 15 years, and (n = 200) non-fasting controls. The study found no significant differences in anthropometric, cardiovascular, and metabolic outcomes, including systolic and diastolic blood pressure, BMI, triglycerides, total cholesterol, LDLc, and HDLc, between the fasting and non-fasting groups. However, fasting was associated with lower glucose levels and higher insulin levels compared to the non-fasting groups [37]. Rodopaios et al. reported in a cross-sectional study of fasting individuals (n = 100) compared to non-fasting (n = 100) individuals and found no significant differences between the fasting and non-fasting groups [38].

Sarri et al. conducted a series of three case–control studies in Greece in 2003, 2007, and 2009 to investigate the effects of fasting on health outcomes. The 2009 study observed 37 fasting participants for 40 days during Nativity and compared them to 48 non-fasting individuals. The study found no significant differences between the fasting and non-fasting groups for systolic and diastolic blood pressure, heart rate, BMI, triglycerides, HDLc, and glucose levels. However, the fasting group had lower total cholesterol and LDLc levels compared to the non-fasting group [39]. The 2007 study observed 38 individuals who fasted in three cohorts of Nativity, Lent, and Assumption, compared to 29 non-fasting individuals. The fasting group had higher systolic and diastolic blood pressure compared

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002

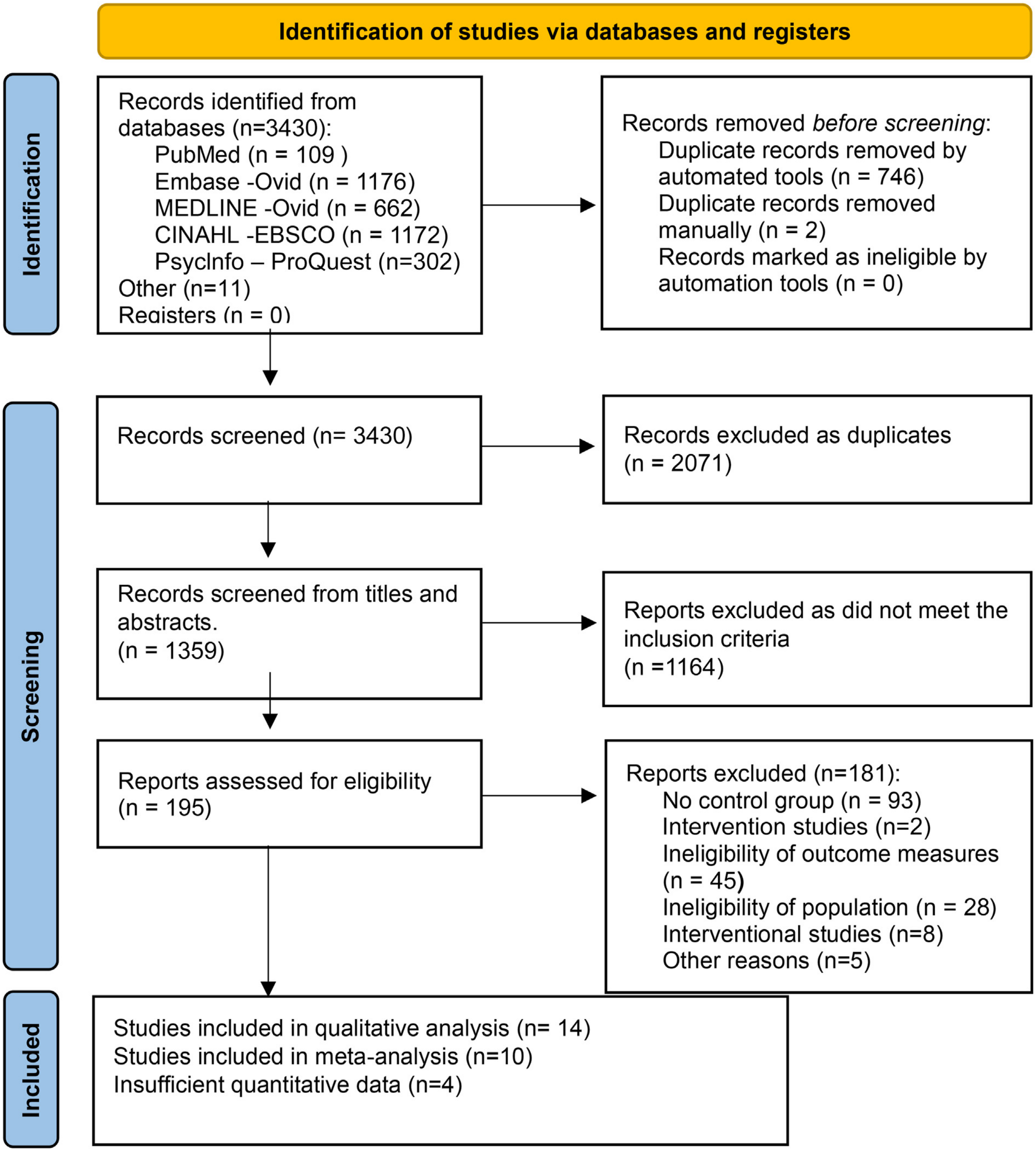

Figure 1 PRISMA Flow Diagram including searches from databases.

to the non-fasting group, but no significant differences were found [40]. The 2003 study involved 60 individuals who fasted during three observance periods of Nativity, Lent, and Assumption, compared to 60 non-fasting individuals. The fasting group had lower total cholesterol and LDLc levels compared to the non-fasting group, and a lower BMI. However, no significant differences were found for other outcomes [41].

Meta-analysis of religious fasting practices did not demonstrate any statistically significant effect on blood pressure (Fig. 2). However, the subgroup analysis revealed that Ramadan fasting was associated with significantly lower systolic blood pressure (but not diastolic blood pressure) compared to non-fasting individuals (−3.83 mmHg; 95% CI: [−7.44, −0.23]; $p = 0.04$), with no significant effect of Orthodox Christian fasting observed (1.51 mmHg; 95% CI: [−3.46, 6.47]; $p = 0.55$). Overall religious fasting was associated with, a reduction in BMI (Fig. 3) (−0.40 kg/m^2; 95% CI: [−0.70, −0.10]; $p < 0.01$), with the subgroup analysis suggested a greater effect being observed in Ramadan fasting

Table 1 Summary table of included studies on the effect of Ramadan fasting in the fasting group compared to the non-fasting group.

Author(s), year, country	Study design	Population	Fasting period and duration (hours/day)	Control	Anthropometric and blood pressure Outcomes*	Blood metabolic Outcomes	Overall risk of bias
Alsubheen et al., 2017, Canada [30]	Observational pretest-post-test control group design	9 strict Muslim males	Ramadan Duration: N/S	N = 8 Male Faith: N/S	SBP ↔ DBP ↔ HR ↔ BW↓ BMI ↓	TG ↔ TC ↔ LDLc ↔ HDLc ↔ Glucose ↔	Low-moderate
Dewanti et al., 2006, Indonesia [31]	Observational study with a non-equivalent control group.	Group a: N = 37 males Group b: 38 males Faith: N/S	Ramadan Group a: fasted fully. Group b: fasted partially. Duration: N/S	N = 25 Male Faith: N/S	SBP ↓ DBP ↓ HR — BW ↓ BMI ↓	TG — TC — LDLc — HDLc — Glucose —	Moderate
Esmaeilzadeh et al., 2016, Belgium [34]	Prospective case-controlled study	N = 14 male Faith: N/S	Ramadan, 19 h of fasting for 26 ± 0.5 consecutive days	N = 13 matched male Faith: N/S	SBP ↓ DBP ↓ HR — BW ↔ BMI ↔	TG ↔ TC ↔ LDLc ↑ HDLc ↔ Glucose ↑	Low
Gholami et al., 2019, Iran [32]	Cross-sectional study	Group a: N = 34 Muslims (67% were female) Group b: 20 (6% were female)	Ramadan Group a: 10–25 days fasting. Group b: >25-day fasting	N = 58 Muslims (37% were female)	SBP ↔ DBP ↔ HR ↔ BW ↔ BMI ↓	TG ↔ TC ↔ LDLc ↑ HDLc ↔ Glucose ↔	Moderate
Goharifar et al., 2015, Iran [36]	Pilot observational case–control study.	N = 21 (Muslim female)	2 weeks before Ramadan until 3 months after Ramadan	N = 9 (Muslim female)	SBP — DBP — HR — BW ↔ BMI ↔	TG ↔ TC ↓ LDLc ↑ ↔ HDLc ↑ ↔ Glucose ↔	Low
Khan et al., 2020, Pakistan [33]	Observational controlled study	N = 60 Muslims (75% of all participants were female)	Shaban, Ramadan, and Shawwal Duration: N/S	15 non-Muslims	SBP ↔ DBP ↔ HR ↔ BW ↔ BMI ↓	TG ↔ TC ↑ LDLc ↑ HDLc ↔ Glucose ↔	Low
Maislos et al., 1998, Israel [62]	Observational controlled study	N = 22 (14 male, 8 female)	Ramadan	16 (9 Male, 7 Female)	SBP — DBP — HR — BW — BMI —	TG ↔ TC ↔ LDLc ↔ HDLc ↑ ↔ Glucose —	Moderate
Nugraha et al., 2017, Germany [63]	Observational controlled study	N = 25 (Muslim male)	Ramadan- 19 h a day fast. Summertime.	N = 25 (male) Faith: N/S	SBP — DBP — HR — BW ↔ BMI ↔	TG — TC — LDLc — HDLc — Glucose —	Low-moderate

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002

Seker et al., 2017 [35]	Observational controlled study	N = 40 (19 Male 21 Female) Muslim	29 day fast in summer	N = 55 (25 Male 30 Female)	SBP ↑ ↔ DBP ↑ ↔ HR — BW— BMI —	TG — TC — LDLc — HDLc — Glucose —	Moderate

*Up arrow (↑): Indicates that the outcome was higher in the fasting group compared to the non-fasting group, Down arrow (↓): Indicates that the outcome was lower in the fasting group compared to the non-fasting group. Horizontal arrow (↔): Indicates that there was no significant difference in the outcome between the fasting and non-fasting groups. (↑↔): indicates that outcome was variable by time, (—): indicates a missing value or unknown information.
Note: N/S: Not specified, SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate, BM: Body Mass, BW: body weight, BMI: body mass index, TG: triglycerides, TC: total cholesterol, LDLc: low-density lipoprotein cholesterol, HDLc: high-density lipoprotein cholesterol.

−0.47 kg/m^2; 95% CI: [−0.85, −0.09]; $p < 0.01$) compared to Orthodox Christian fasting −0.26 kg/m^2; 95% CI: [−0.66, 0.15]; $p < 0.22$).

A significant reduction in total cholesterol were associated with the practice of Orthodox Christian fasting (−0.52 mmol/L; 95% CI: [−86, −39]; $p < 0.01$) but not Ramadan Fasting (−0.07 [−0.38, 0.24]; p = 0.46 (Fig. 4). This suggested that there was an overall reduction of total cholesterol associated with the practice of fasting individuals (p = 0.02). No significant associations were found between diastolic blood pressure, HDLc or triglyceride levels and any type of religious fasts investigated in this study (Appendix-figures S1-S3).

The quality of the studies was assessed, revealing varying levels of risk of bias, ranging from low to moderate. Seven studies were found to have a low risk of bias, while the other seven had a moderate risk of bias. However, the quality of the study did not influence whether fasting was associated with outcomes in either a positive or negative direction (Appendix – Tables S1 and S2). Additionally, the funnel plots suggested publication bias, which might be linked to the limited numbers of studies, the size of the studies and that many of the studies were undertaken in the same country (most being carried out in Iran for Ramadan fasting and Greece for Orthodox Christian fasting) (Appendix – Figs. S4a–g).

4. Discussion

This systematic review and meta-analysis provide evidence that religious and faith-based fasting practices are associated with improvements in cardiometabolic disease risk factors compared to similar individuals who do not fast in case–control studies. This is the first systematic review that compared the effects of two different types of religious fasting. Obesity, hypertension, and hyperlipidaemia are well-known contributors to cardiovascular complications such as myocardial infarction and cerebrovascular accidents. Ramadan observance was associated with a reduction in systolic blood pressure and BMI, while Orthodox Christian fasting observance is linked to lower total cholesterol. Therefore, these findings suggest that both Ramadan observance and Orthodox Christian fasting observance may benefit their respective communities by influencing different cardiovascular risk factors through their faith-based fasting behaviours.

The association of systolic blood pressure improvement and weight reduction, indicated by a reduction in BMI during Ramadan fasting, is consistent with a previous meta-analysis on ninety-one studies involving 4431 participants from experimental and observational studies [17]. This current analysis, which only includes data with matched non-fasting individuals, provides stronger evidence of a positive association compared to the previous analysis that included data from both fasting and non-fasting individuals in the same location, albeit with fewer studies.

A number of possible biological mechanisms have been suggested to explain the reduction in systolic blood

Table 2 Summary table of included studies on the effect of Christian Orthodox fasting in the fasting group compared to the non-fasting group.

Author(s), year, country	Study design	Population	Fasting period and duration (hours/day)	Control (number, faith, gender)	Anthropometric and blood pressure Outcomes*	Blood metabolic Outcomes	Overall risk of bias
Petridou et al., 2021, Greece [37]	Cross-sectional study	N = 200 (131 female, 69 male)	10–32 years of adherence to COF (median 15)	N = 200 (126 females, 74 males)	SBP — DBP — HR — BW ↔ BMI ↔	TG ↔ TC ↔ LDLc ↔ HDLc ↔ Glucose ↓ Insulin ↑	Moderate
Rodopaios et al., 2020, Greece [38]	Cross-sectional study	N = 100 (63 female and 37 male)	Non fasting period	100 (60 female and 40 male)	SBP ↔ DBP ↔ HR ↔ BW ↔ BMI ↔	TG — TC — LDLc — HDLc — Glucose —	Moderate
Sarri et al., 2009, Greece [39]	Case–control study	37 (19 female, 18 male)	40 d, Nativity	48 (27 female, 21 male)	SBP — DBP — HR — BW ↔ BMI ↔	TG ↔ TC↓ LDLc ↓ HDLc ↔ Glucose ↔	Moderate
Sarri et al., 2007, Greece [40]	Case–control study	38 (19 female, 19 male)	3 periods; Nativity, Lent and Assumption	29 (13 female, 16 male)	SBP ↑ DBP ↑ HR — BW ↔ BMI ↔	TG — TC — LDLc — HDLc — Glucose —	Low
Sarri et al., 2003, Greece [41]	Case–control study	60 (29 females, 31 male)	3 periods; Nativity, Lent, and Assumption	60 (36 females, 24 male)	SBP — DBP — HR — BW — BMI ↓	TG TC ↓ LDLc ↓ HDLc Glucose —	Low

*Up arrow (↑): Indicates that the outcome was higher in the fasting group compared to the non-fasting group, Down arrow (↓): Indicates that the outcome was lower in the fasting group compared to the non-fasting group. Horizontal arrow (↑ ↔): Indicates that there was no significant difference in the outcome between the fasting and non-fasting groups. (–): indicates a missing value or unknown information.

Lent falls in Spring (typically between February and April), Assumption is in August and Nativity in winter (November and December).

Note: N/S: Not specified, SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate, BM: Body Mass, BW: body weight, BMI: body mass index, TG: triglycerides, TC: total cholesterol, LDLc: low-density lipoprotein cholesterol, HDLc: high-density lipoprotein cholesterol.

Meta-analysis of religious fasting did not demonstrate any statistically significant impact on blood pressure levels overall when combining the results from fasting practices (Fig. 2). However, the subgroup analysis revealed that Ramadan fasting was associated with a significantly lower SBP in the study group compared to non-fasting individuals (−3.83 mmHg; 95% CI: [-7.44, −0.23]; $p = 0.04$), with no significant effect of Orthodox Christian fasting observed (1.51 mmHg; 95% CI: [-3.46, 6.47]; $p = 0.55$).

Overall, religious fasting was associated with a reduction in BMI (Fig. 3) (−0.40 kg/m2; 95% CI: [-0.70, −0.10]; $p < 0.01$), with the subgroup analysis suggesting a greater effect being observed in Ramadan fasting compared to Orthodox Christian fasting ($p = 0.45$).

A significant reduction in TC was associated with the practice of Orthodox Christian fasting (−0.52 mmol/L; 95% CI: [-86, −39]; $p < 0.01$) but not Ramadan fasting (−0.07 [-0.38, 0.24]; $p = 0.46$) (Fig. 4). This suggests that there was an overall reduction of TC associated with the practice of fasting individuals ($p = 0.02$). No significant associations were found between DBP, HDLc, or TG levels and any type of religious fasts investigated in this study (Appendix – S1-3).

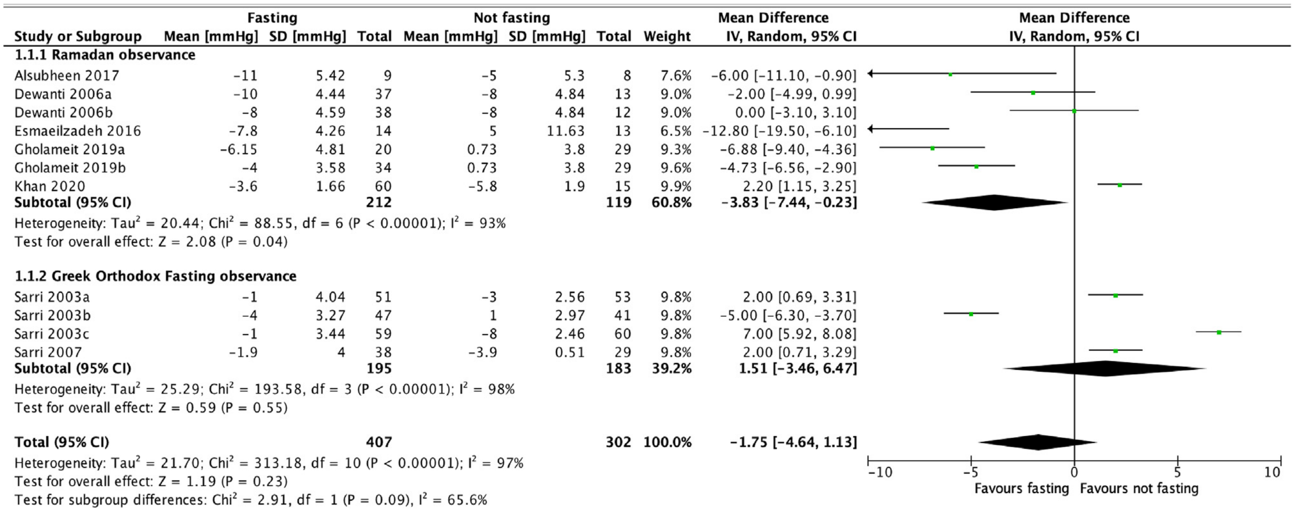

Figure 2 The forest plot with subgroup analysis comparing systolic blood pressure among fasters and non-fasters in Ramadan fasting and Orthodox Christian fasting. Dewanti et al., 2006 included two groups of individuals who fasted fully (a) and individuals who fasted partially (b) as the non-fasting group. Since the non-fasting group was the same, it was split to mitigate the risk of bias. The Sarri et al., 2003 study was analysed as three separate cohorts during three periods of Nativity (a), Lent (b), and Assumption (c).

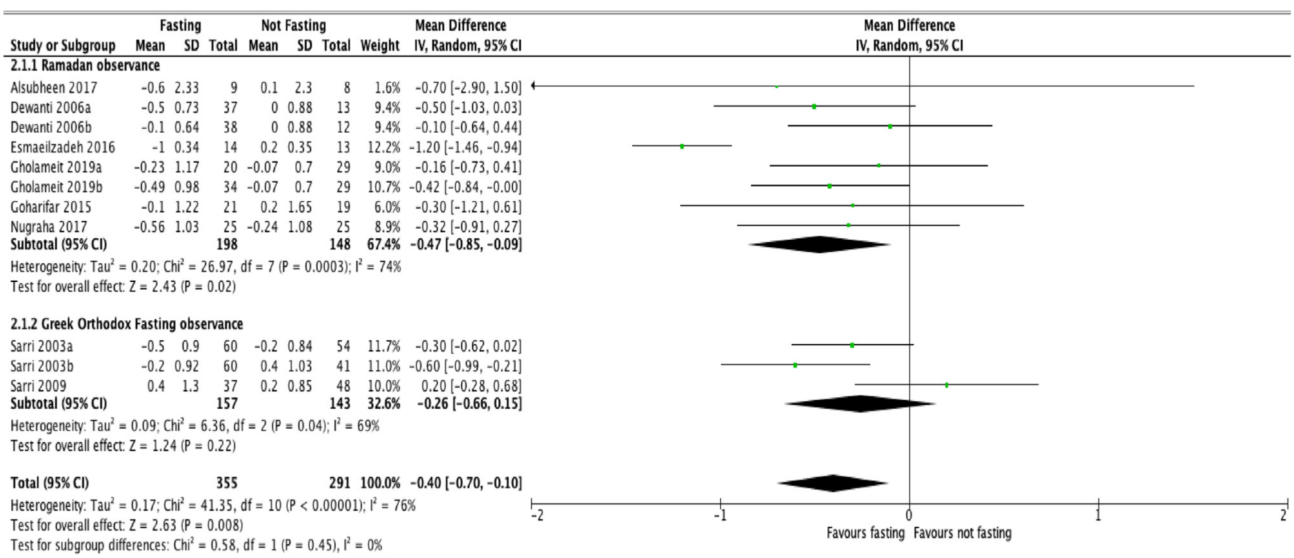

Figure 3 The forest plot and subgroup analysis comparing Body Mass Index among fasters and non-fasters in Ramadan fasting and Orthodox Christian fasting. Dewanti et al., 2006 included two groups of individuals who fasted fully(a) and individuals who fasted partially (b), as the non-fasting group were the same. This was split to mitigate the risk of bias. The Sarri et al., 2003 study was analysed as three separate cohorts during three periods of Nativity (a), Lent (b), and Assumption (c).

pressure. The simplest explanation of this effect could be via volume reduction because of reduced fluid intake. Other mechanisms could be through the effect of energy restriction, which may work by improving insulin sensitivity and increasing nitric oxide (NO) production through enhanced endothelial function. Previously studies have reported on the beneficial effects of time-restricted eating in terms of weight loss and cardiometabolic [42–44], including when associated with Ramadan fasting [45,46]. Additionally, the effect of Ramadan fasting has been shown to be possibly greater for individuals living with obesity, with more significant weight loss and BMI reduction reported compared to individuals with lower BMI [17,47] and physically active individuals [48]. This might suggest that Ramadan fasting combined with an active lifestyle has the potential to be a useful combination for effective weight management, especially for individuals with an increased risk of cardiometabolic disease [49]. According to another recent study, substantial weight loss and improvements in blood glucose and lipid profiles were shown when Ramadan fasting was paired with a High-Intensity Interval Training (HIIT) programme and strength training for four weeks [50]. Recent research also suggests that Ramadan's diurnal

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002

Study or Subgroup	Fasting Mean [mmol/l]	Fasting SD [mmol/l]	Fasting Total	Not fasting Mean [mmol/l]	Not fasting SD [mmol/l]	Not fasting Total	Weight	Mean Difference IV, Random, 95% CI
4.1.1 Ramadan observance								
Esmaeilzadeh 2016	−0.22	0.34	14	0.05	0.26	13	10.4%	−0.27 [−0.50, −0.04]
Gholameit 2019a	−0.02	0.31	20	−0.13	0.19	29	11.1%	0.11 [−0.04, 0.26]
Gholameit 2019b	0.19	0.22	34	−0.13	0.19	29	11.4%	0.32 [0.22, 0.42]
Goharifar 2015	−0.43	0.29	21	0.12	0.33	19	10.7%	−0.55 [−0.74, −0.36]
Khan 2020	−0.35	0.11	60	−0.34	0.37	15	10.8%	−0.01 [−0.20, 0.18]
Subtotal (95% CI)			**149**			**105**	**54.4%**	**−0.07 [−0.38, 0.24]**
Heterogeneity: $Tau^2 = 0.12$; $Chi^2 = 72.44$, df = 4 (P < 0.00001); $I^2 = 94\%$								
Test for overall effect: Z = 0.46 (P = 0.64)								
4.1.2 Greek Orthodox Fasting observance								
Sarri 2003a	−0.58	0.23	49	−0.17	0.21	54	11.4%	−0.41 [−0.50, −0.32]
Sarri 2003b	−0.39	0.24	47	0.32	0.25	41	11.4%	−0.71 [−0.81, −0.61]
Sarri 2003c	−0.45	0.22	59	−0.01	0.2	60	11.5%	−0.44 [−0.52, −0.36]
Sarri 2009	−0.58	0.25	37	−0.06	0.22	48	11.4%	−0.52 [−0.62, −0.42]
Subtotal (95% CI)			**192**			**203**	**45.6%**	**−0.52 [−0.64, −0.39]**
Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 22.87$, df = 3 (P < 0.0001); $I^2 = 87\%$								
Test for overall effect: Z = 8.12 (P < 0.00001)								
Total (95% CI)			**341**			**308**	**100.0%**	**−0.28 [−0.51, −0.05]**
Heterogeneity: $Tau^2 = 0.12$; $Chi^2 = 283.94$, df = 8 (P < 0.00001); $I^2 = 97\%$								
Test for overall effect: Z = 2.36 (P = 0.02)								
Test for subgroup differences: $Chi^2 = 6.80$, df = 1 (P = 0.009), $I^2 = 85.3\%$								

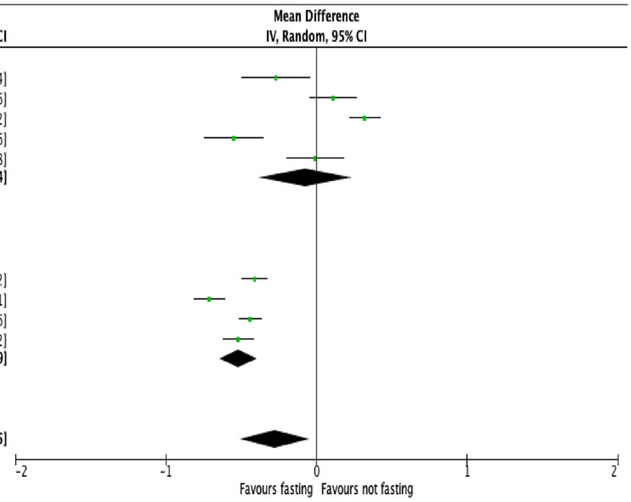

Figure 4 The forest plot displays the results of a subgroup analysis comparing total cholesterol among fasters and non-fasters in Ramadan fasting and Orthodox Christian fasting. The study by Sarri et al., 2003 was analysed as three separate cohorts during three periods of Nativity (a), Lent (b), and Assumption (c).

intermittent fasting necessitates the absorption of fat and glucose and regulates the insulin hormone, resulting in overall health benefits and the prevention of cardiovascular disease [51].

Given that this group may respond differently to different dietary interventions [52], understanding how Ramadan fasting may help in counselling overweight and obese individuals who are considering it as a potential way to manage their weight and metabolic health is crucial in the Muslim population.

In contrast to Ramadan fasting, this analysis, in common with previous reviews, found that there is no consistent evidence with respect to Orthodox Christian fasting and improvements in blood pressure [25,53] and body weight [25] (However, this reflected inconsistencies in studies, reflecting different periods of fasting observed). However, some studies have shown that the fasting practice can decrease BMI in multiple instances [23,41,54] supported by evidence from a recent meta-analysis that found a lower BMI and lower caloric intake during the fasting periods for Christian fasting individuals [53]. Further investigations are needed to confirm the effect of Orthodox Christian fasting on blood pressure, body weight and plasma glucose levels, exploring both the timing and duration of fasting periods in more detail.

The potential effects of fasting on the lipid profile remain unclear for Ramadan fasting, whereas a more consistent association suggests benefits of Orthodox Christian fasting on the lipid profile. While the effect of religious fasting on LDLc and HDLc remained unclear in this study, an association between a reduction in TC and Orthodox Christian fasting was observed compared to non-fasting individuals, supporting the findings of previous similar studies [25,55]. Moreover, Papazoagkas et al. conducted a study on both dyslipidaemia and non-dyslipidaemia fasters from both the Orthodox Christian and Muslim faiths, which reported that while a significant reduction in TC, LDLc and HDLc levels was observed in the Orthodox Christian fasters, those observing Ramadan fasting participants experienced an increase in TC, LDLc and TG levels post-fasting [22]. Similarly, Chaouachi et al. reported increased levels of TC and LDLc even among physically active individuals who practiced Ramadan fasting [56]. In contrast, Jahrami. et al. reported decreased TC and LDLc, and increased HDLc following Ramadan fasting [17]. Additionally, previous meta-analysis evaluated the ability of intermittent fasting and energy-restricted diets to enhance lipid profiles, and they found significant reductions in TC, LDLc and TG [57]. Overall, the difference between the two types of fasting practices on lipid profile could be related to biochemical response to food restriction and starvation and the fact that individuals following a time-restricted diet, such as Ramadan fasting, may have a higher tendency to consume more high-fat food after a period of long food abstention [58]. This could be useful when offering lifestyle advice to those wishing to observe a Ramadan fast and reduce their cardiovascular risk, by moderating their choices during their iftar and during non-fasting periods. On the other hand, Orthodox Christian fasters, have a high tendency to follow a similar dietary pattern to Orthodox fasting that contains reduced consumption of red and processed meats throughout the entire year which may help with lipid profile [59].

In summary, both Ramadan observance and Orthodox Christian fasting observance have been associated with improvements in several cardiometabolic risk factors. It is even possible that the effects may be strengthened when combined with an active lifestyle during religious fasting. These findings have important implications for the management and prevention of cardiometabolic diseases, particularly among individuals who are overweight or obese. The potential benefits of these fasting practices for the prevention and management of cardiometabolic diseases may have significant implications for clinical practice and public health guidelines.

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002

4.1. Limitations and implications

The search was restricted to English-language papers, which may have excluded important studies published in other languages, such as Arabic and Greek. This exclusion could be significant, as those languages are most likely used by individuals following these fasting practices, potentially resulting in missing studies. Moreover, the restriction to the English language might have also omitted studies on Vedic fasting. Additionally, all studies on Orthodox Christian fasting were conducted in Greece and only represented Greek Orthodox Christians. While this is expected given that the Greek Orthodox Church is one of the more prominent denominations of Orthodox Christianity, it limits the generalisability of the findings to other populations where Orthodox Christian communities exist, especially in south-eastern Europe and Russia. This potentially limits the generalizability of the findings to other populations in the Orthodox Christian communities. Evidence of this limitation was seen in the risk of bias highlighted by the funnel plots; it is important that future studies on faith and religious fasting are undertaken in countries where the fasting religion is not the dominant faith practiced. Whilst comparing to individuals who, aside from their religious practice are matched to those choosing to fast.

Furthermore, there was limited data on plasma glucose levels in this study, and the overall number of studies on Orthodox Christian fasting is relatively low, warranting the need for further research. Additionally, there was a lack of data from other faiths and religions that practice fasting (especially Hinduism and Jainism), despite the available literature suggesting that other religious fasting practices, such as the Daniel fast (which is practiced for both faith-based and secular reasons), can improve numerous risk factors for cardiometabolic disease [26,60,61]. Further investigations into these practices are needed to understand their potential health benefits better. This highlights the necessity for future studies on other religious fasting practices, including the Daniel fast, to explore and comprehend their effects on health outcomes. Conducting further investigations into these fasting practices can aid in identifying new approaches to improve health outcomes for those who practice these religions.

5. Conclusion

This systematic review suggests that both Ramadan and Orthodox Christian faith-based fasting practices may have cardiometabolic benefits that extend beyond their spiritual or religious purpose. Evidence supports that Ramadan observance is associated with a reduction in systolic blood pressure and body mass index, while Orthodox Christian fasting observance is linked to lower total cholesterol. Understanding how faith-based practice may improve cardiovascular risk factors could be useful in supporting people who observe faith-based fasting and could support clinicians in advising individuals, along with the formation of clinical practice and public health guidelines for the prevention and management of cardiometabolic diseases for communities where fasting is practiced. This review also highlights the need for further research on faith-based fasting practices, as currently, only limited data is available.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.numecd.2024.02.002.

References

[1] Organization WH. Cardiovascular diseases. Published 2022. Who.int; January 1, 2022. Available at: https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1.

[2] Mezhal F, Oulhaj A, Abdulle A, AlJunaibi A, Alnaeemi A, Ahmad A, et al. High prevalence of cardiometabolic risk factors amongst young adults in the United Arab Emirates: the UAE Healthy Future Study. BMC Cardiovasc Disord 2023;23(1):137. https://doi.org/10.1186/s12872-023-03165-3.

[3] Alberti KGMM, Zimmet P, Shaw J. Metabolic syndrome–a new world-wide definition. A consensus statement from the international diabetes federation. Diabet Med J Br Diabet Assoc 2006; 23(5):469–80. https://doi.org/10.1111/j.1464-5491.2006.01858.x.

[4] Huang PL. A comprehensive definition for metabolic syndrome. Dis Model Mech 2009;2(5–6):231–7. https://doi.org/10.1242/dmm.001180.

[5] Bartholomew CL, Muhlestein JB, Anderson JL, May HT, Knowlton KU, Bair TL, et al. Association of periodic fasting lifestyles with survival and incident major adverse cardiovascular events in patients undergoing cardiac catheterization. Eur J Prev Cardiol 2022;28(16):1774–81. https://doi.org/10.1093/eurjpc/zwaa050.

[6] Li K, Wang C, Wang Y, Fu L, Zhang N. Future foods, dietary factors and healthspan. J Future Foods 2023;3(2):75–98. https://doi.org/10.1016/j.jfutfo.2022.12.001.

[7] Suttajit M, Thangaleela S, Sivamaruthi BS, Charoensin S. Chapter 16 - dietary restriction, vegetarian diet, and aging intervention. In: Pandey KB, Suttajit M, editors. *Plant Bioactives as natural panacea against age-induced diseases*. Drug discovery update. Elsevier; 2023. p. 307–27. https://doi.org/10.1016/B978-0-323-90581-7.00023-2.

[8] Trepanowski JF, Bloomer RJ. The impact of religious fasting on human health. Nutr J 2010;9(1):57. https://doi.org/10.1186/1475-2891-9-57.

[9] Muslim population by country. 2023. https://worldpopulationreview.com/country-rankings/muslim-population-by-country. [Accessed 15 October 2023].

[10] Hackett C, Mcclendon D. Christians remain world's largest religious group, but they are declining in Europe. Pew Research Center. Accessed January 24, 2023. https://www.pewresearch.org/fact-tank/2017/04/05/christians-remain-worlds-largest-religious-group-but-they-are-declining-in-europe/.

[11] Ramadan. Muslim council of britain. 2022. https://mcb.org.uk/. Published March 10, 2021, https://mcb.org.uk/resources/ramadan/. [Accessed 24 January 2023]. https://mcb.org.uk/resources/ramadan/.

[12] St. Mary magdalen catholic Church. St. Mary magdalen catholic Church. Accessed January 24, 2023. https://www.stmarymagdalensa.org/daniel-fast-lent-2021/.

[13] Churches try "Daniel Fast" for spiritual renewal. USATODAY. https://www.usatoday.com/story/news/faith&reason/2013/01/25/churches-daniel-fast-spiritual-renewal/1864027/. [Accessed 24 January 2023].

[14] Lunar calendar | definition & facts | britannica. https://www.britannica.com/science/lunar-calendar. [Accessed 24 January 2023].

[15] Jahrami HA, Alsibai J, Clark CCT, Faris MAIE. A systematic review, meta-analysis, and meta-regression of the impact of diurnal intermittent fasting during Ramadan on body weight in healthy subjects aged 16 years and above. Eur J Nutr 2020;59(6): 2291–316. https://doi.org/10.1007/s00394-020-02216-1.

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002

[16] Faris "Mo'ez Al-Islam" E, Jahrami HA, Alsibai J, Obaideen AA. Impact of Ramadan diurnal intermittent fasting on the metabolic syndrome components in healthy, non-athletic Muslim people aged over 15 years: a systematic review and meta-analysis. Br J Nutr 2020;123(1):1–22. https://doi.org/10.1017/S000711451900254X.

[17] Jahrami HA, Faris ME, I Janahi A, I Janahi M, Abdelrahim DN, Madkour MI, et al. Does four-week consecutive, dawn-to-sunset intermittent fasting during Ramadan affect cardiometabolic risk factors in healthy adults? A systematic review, meta-analysis, and meta-regression. Nutr Metab Cardiovasc Dis NMCD 2021;31(8):2273–301. https://doi.org/10.1016/j.numecd.2021.05.002.

[18] Al-Rawi N, Madkour M, Jahrami H, Salahat D, Alhasan F, BaHammam A, et al. Effect of diurnal intermittent fasting during Ramadan on ghrelin, leptin, melatonin, and cortisol levels among overweight and obese subjects: a prospective observational study. PLoS One 2020;15(8):e0237922. https://doi.org/10.1371/journal.pone.0237922.

[19] Faris MAE, Madkour MI, Obaideen AK, Dalah EZ, Hasan HA, Radwan H, et al. Effect of Ramadan diurnal fasting on visceral adiposity and serum adipokines in overweight and obese individuals. Diabetes Res Clin Pract 2019 Jul;153:166–75. https://doi.org/10.1016/j.diabres.2019.05.023.

[20] Concerning Fasting on Wednesday and Friday. An excerpt from the exomologetarion. http://orthodoxinfo.com/praxis/exo_fasting.aspx. [Accessed 24 January 2023].

[21] Sarri KO, Linardakis MK, Bervanaki FN, Tzanakis NE, Kafatos AG. Greek Orthodox fasting rituals: a hidden characteristic of the Mediterranean diet of Crete. Br J Nutr 2004;92(2):277–84. https://doi.org/10.1079/BJN20041197.

[22] Papazoglou AS, Moysidis DV, Tsagkaris C, Vouloagkas I, Karagiannidis E, Kartas A, et al. Impact of religious fasting on metabolic and hematological profile in both dyslipidemic and non-dyslipidemic fasters. Eur J Clin Nutr 2022;76(6):891–8. https://doi.org/10.1038/s41430-021-01053-7.

[23] Basilakis A, Kiprouli K, Mantzouranis S, Konstantinidis T, Dionisopoulou M, Hackl JM, et al. Nutritional study in Greek-orthodox monasteries - effect of a 40-day religious fasting. Aktuelle Ernährungsmed 2002;27(4):250–5. https://doi.org/10.1055/s-2002-33359.

[24] Al-Jafar R, Zografou Themeli M, Zaman S, Akbar S, Lhoste V, Khamliche A, et al. Effect of religious fasting in ramadan on blood pressure: results from LORANS (london ramadan study) and a meta-analysis. J Am Heart Assoc 2021;10(20):e021560. https://doi.org/10.1161/JAHA.120.021560.

[25] Koufakis T, Karras SN, Antonopoulou V, Angeloudi E, Zebekakis P, Kotsa K. Effects of Orthodox religious fasting on human health: a systematic review. Eur J Nutr 2017;56(8):2439–55. https://doi.org/10.1007/s00394-017-1534-8.

[26] Bloomer RJ, Kabir MM, Canale RE, Trepanowski JF, Marshall KE, Farney TM, et al. Effect of a 21 day Daniel Fast on metabolic and cardiovascular disease risk factors in men and women. Lipids Health Dis 2010;9:94. https://doi.org/10.1186/1476-511X-9-94.

[27] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. http://www.prisma-statement.org/PRISMAStatement/FlowDiagram. [Accessed 2 April 2023].

[28] PRESS peer review of electronic search Strategies | CADTH. https://www.cadth.ca/press-peer-review-electronic-search-strategies-0. [Accessed 30 January 2023].

[29] Higgins JPT, Eldridge S, Li T. Chapter 23: including variants on randomized trials. Cochrane. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, et al., editors. Cochrane handbook for systematic reviews of interventions version 6.3 (updated february 2022); 2022. Available from: www.training.cochrane.org/handbook.

[30] Alsubheen SA, Ismail M, Baker A, Blair J, Adebayo A, Kelly L, et al. The effects of diurnal Ramadan fasting on energy expenditure and substrate oxidation in healthy men. Br J Nutr 2017;118(12):1023–30. https://doi.org/10.1017/S0007114517003221.

[31] Dewanti L, Watanabe C, Sulistiawati Ohtsuka R. Unexpected changes in blood pressure and hematological parameters among fasting and nonfasting workers during Ramadan in Indonesia. Eur J Clin Nutr 2006;60(7):877–81. https://doi.org/10.1038/sj.ejcn.1602393.

[32] Gholami S, Hazar N, Shafiei S, Hemmati M, Rahmanian M. Biochemical and anthropometric changes during Ramadan among type 2 diabetes mellitus patients. Int J Diabetes Dev Ctries 2019;39(1):160–5. https://doi.org/10.1007/s13410-018-0656-8.

[33] Khan N, Rafi S, Siddiqui S, Shakeel S, Rahman H ur, Hasan W. Effect of Ramadan on glucose levels, serum lipid profile, and blood pressure among fasting and nonfasting medical students in a public university of Karachi. Ibnosina J Med Biomed Sci 2020;12(3):177–84. https://doi.org/10.4103/ijmbs.ijmbs_84_20.

[34] Esmaeilzadeh FN, Borne P. Does intermittent fasting improve microvascular endothelial function in healthy middle-aged subjects? Biol Med 2016;8. https://doi.org/10.4172/0974-8369.1000337.

[35] Seker A, Demirci H, Ocakoglu G, Aydin U, Ucar H, Yildiz G, et al. Effect of fasting on 24-h blood pressure values of individuals with no previous history of hypertension. Blood Pres Monit 2017;22(5):247–52.

[36] Goharifar H, Faezi ST, Paragomi P, Montazeri A, Banihashemi AT, Akhlaghkhah M, et al. The effect of Ramadan fasting on quiescent systemic lupus erythematosus (SLE) patients' disease activity, health quality of life and lipid profile: a pilot study. Rheumatol Int 2015;35(8):1409–14.

[37] Petridou A, Rodopaios NE, Mougios V, Koulouri AA, Vasara E, Papadopoulou SK, et al. Effects of periodic religious fasting for decades on nutrient intakes and the blood biochemical profile. Nutrients 2021;13(11) [no pagination)].

[38] Rodopaios NE, Mougios V, Koulouri AA, Vasara E, Papadopoulou SK, Skepastianos P, et al. Bone status of young adults with periodic avoidance of dairy products since childhood. Eur J Pediatr 2020;179(4):645–51. https://doi.org/10.1007/s00431-019-03542-1.

[39] Sarri K, Bertsias G, Linardakis M, Tsibinos G, Tzanakis N, Kafatos A. The effect of periodic vegetarianism on serum retinol and alpha-tocopherol levels. Int J Vitam Nutr Res Int Z Vitam- Ernahrungsforschung J Int Vitaminol Nutr. 2009;79(5–6):271–80. https://doi.org/10.1024/0300-9831.79.56.271.

[40] Sarri K, Linardakis M, Codrington C, Kafatos A. Does the periodic vegetarianism of Greek Orthodox Christians benefit blood pressure? Prev Med 2007;44(4):341–8. https://doi.org/10.1016/j.ypmed.2006.11.009.

[41] Sarri KO, Tzanakis NE, Linardakis MK, Mamalakis GD, Kafatos AG. Effects of Greek Orthodox Christian Church fasting on serum lipids and obesity. BMC Publ Health 2003;3:16. https://doi.org/10.1186/1471-2458-3-16.

[42] Fontana L. Interventions to promote cardiometabolic health and slow cardiovascular ageing. Nat Rev Cardiol 2018;15(9):566–77. https://doi.org/10.1038/s41569-018-0026-8.

[43] Di Francesco A, Di Germanio C, Bernier M, de Cabo R. A time to fast. Science 2018;362(6416):770–5. https://doi.org/10.1126/science.aau2095.

[44] Gabel K, Cienfuegos S, Kalam F, Ezpeleta M, Varady KA. Time-restricted eating to improve cardiovascular health. Curr Atherosclerosis Rep 2021;23(5):22. https://doi.org/10.1007/s11883-021-00922-7.

[45] Tsitsou S, Zacharodimos N, Poulia KA, Karatzi K, Dimitriadis G, Papakonstantinou E. Effects of time-restricted feeding and ramadan fasting on body weight, body composition, glucose responses, and insulin resistance: a systematic review of randomized controlled trials. Nutrients 2022;14(22):4778. https://doi.org/10.3390/nu14224778.

[46] Chew HSJ, Ang WHD, Tan ZYA, Ang WW, Chan KS, Lau Y. Umbrella review of time-restricted eating on weight loss, fasting blood glucose, and lipid profile. Nutr Rev 2023;81(9):1180–99. https://doi.org/10.1093/nutrit/nuac103.

[47] Unalacak M, Kara IH, Baltaci D, Erdem O, Bucaktepe PGE. Effects of Ramadan fasting on biochemical and hematological parameters and cytokines in healthy and obese individuals. Metab Syndr Relat Disord 2011;9(2):157–61. https://doi.org/10.1089/met.2010.0084.

[48] Khaled T, Ahmed C, Zohra G, Choumous K, Zouheir S, Mounir ZK, et al. Physical activity during Ramadan fasting: effects on body composition, hematological and biochemical parameters. IOSR J Pharm IOSRPHR 2012;2(5):33–41. https://doi.org/10.9790/3013-25103341.

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002

[49] Ferrara D, Montecucco F, Dallegri F, Carbone F. Impact of different ectopic fat depots on cardiovascular and metabolic diseases. J Cell Physiol 2019;234(12):21630–41. https://doi.org/10.1002/jcp.28821.
[50] Maaloul R, Marzougui H, Ben Dhia I, Ghroubi S, Tagougui S, Kallel C, et al. Effectiveness of Ramadan diurnal intermittent fasting and concurrent training in the management of obesity: is the combination worth the weight? Nutr Metab Cardiovasc Dis NMCD 2023;33(3):659–66. https://doi.org/10.1016/j.numecd.2022.12.004.
[51] Naz H, Haider R, Rashid H, Ul Haq Z, Malik J, Zaidi SMJ, et al. Islamic fasting: cardiovascular disease perspective. Expert Rev Cardiovasc Ther 2022;20(10):795–805. https://doi.org/10.1080/14779072.2022.2138344.
[52] Hjorth MF, Zohar Y, Hill JO, Astrup A. Personalized dietary management of overweight and obesity based on measures of insulin and glucose. Annu Rev Nutr 2018;38:245–72. https://doi.org/10.1146/annurev-nutr-082117-051606.
[53] Giaginis C, Mantzorou M, Papadopoulou SK, Gialeli M, Troumbis AY, Vasios GK. Christian orthodox fasting as a traditional diet with low content of refined carbohydrates that promotes human health: a review of the current clinical evidence. Nutrients 2023;15(5):1225. https://doi.org/10.3390/nu15051225.
[54] Elshorbagy A, Jernerén F, Basta M, Basta C, Turner C, Khaled M, et al. Amino acid changes during transition to a vegan diet supplemented with fish in healthy humans. Eur J Nutr 2017;56(5):1953–62. https://doi.org/10.1007/s00394-016-1237-6.
[55] Kokkinopoulou A, Kafatos A. Impact of Christian Orthodox Church dietary recommendations on metabolic syndrome risk factors: a scoping review. Nutr Res Rev 2022;35(2):221–35. https://doi.org/10.1017/S0954422421000184.
[56] Chaouachi A, Chamari K, Roky R, Wong P, Mbazaa A, Bartagi Z, et al. Lipid profiles of judo athletes during ramadan. Int J Sports Med. Published online September 2007;18:282–8. https://doi.org/10.1055/s-2007-965338.
[57] Meng H, Zhu L, Kord-Varkaneh H, O Santos H, Tinsley GM, Fu P. Effects of intermittent fasting and energy-restricted diets on lipid profile: a systematic review and meta-analysis. Nutrition 2020;77:110801. https://doi.org/10.1016/j.nut.2020.110801.
[58] Frost G, Pirani S. Meal frequency and nutritional intake during Ramadan: a pilot study. Hum Nutr Appl Nutr 1987;41(1):47–50.
[59] Kokkinopoulou A, Pagkalos I, Hassapidou M, Kafatos A. Dietary patterns in adults following the christian orthodox fasting regime in Greece. Front Nutr 2022;9. https://www.frontiersin.org/articles/10.3389/fnut.2022.803913. [Accessed 5 April 2023].
[60] Alleman RJ, Harvey IC, Farney TM, Bloomer RJ. Both a traditional and modified Daniel Fast improve the cardio-metabolic profile in men and women. Lipids Health Dis 2013;12(1).
[61] Trepanowski JF, Kabir MM, Alleman RJ, Bloomer RJ. A 21-day Daniel fast with or without krill oil supplementation improves anthropometric parameters and the cardiometabolic profile in men and women. Nutr Metab 2012;9(1):82. https://doi.org/10.1186/1743-7075-9-82.
[62] Maislos M, Abou-Rabiah Y, Zuili I, Iordash S, Shany S. Gorging and plasma HDL-cholesterol - the Ramadan model. Eur J Clin Nutr 1998;52:127–30. https://doi.org/10.1038/sj.ejcn.1600526.
[63] Nugraha B, Ghashang SK, Hamdan I, Gutenbrunner C. Effect of Ramadan fasting on fatigue, mood, sleepiness, and health-related quality of life of healthy young men in summer time in Germany: a prospective controlled study. Appetite 2017;111:38–45.

Please cite this article as: Gholampoor N et al., The effect of observing religious or faith-based fasting on cardiovascular disease risk factors: A systematic review and meta-analysis, Nutrition, Metabolism & Cardiovascular Diseases, https://doi.org/10.1016/j.numecd.2024.02.002