

As a library, NLM provides access to scientific literature. Inclusion in an NLM database does not imply endorsement of, or agreement with, the contents by NLM or the National Institutes of Health.

Learn more: [PMC Disclaimer](#) | [PMC Copyright Notice](#)



[Can Fam Physician](#). 2020 Feb;66(2):117–125.

Show available content in: English | [French](#)

## Intermittent fasting and weight loss

Systematic review

[Stephanie Welton](#)<sup>1</sup>, [Robert Minty](#)<sup>2</sup>, [Teresa O'Driscoll](#)<sup>3</sup>, [Hannah Willms](#)<sup>4</sup>, [Denise Poirier](#)<sup>5</sup>, [Sharen Madden](#)<sup>6</sup>, [Len Kelly](#)<sup>7,✉</sup>

[Author information](#) [Copyright and License information](#)

PMCID: PMC7021351 PMID: [32060194](#)

## Abstract

---

### Objective

To examine the evidence for intermittent fasting (IF), an alternative to calorie-restricted diets, in treating obesity, an important health concern in Canada with few effective office-based treatment strategies.

### Data Sources

A MEDLINE and EMBASE search from January 1, 2000, to July 1, 2019, yielded 1200 results using the key words *fasting*, *time restricted feeding*, *meal skipping*, *alternate day fasting*, *intermittent fasting*, and *reduced meal frequency*.

### Study selection

Forty-one articles describing 27 trials addressed weight loss in overweight and obese patients: 18 small randomized controlled trials (level I evidence) and 9 trials comparing weight after IF to baseline weight with no control group (level II evidence). Studies were often of short duration (2 to 26 weeks) with low enrolment (10 to 244 participants); 2 were of 1-year duration. Protocols varied, with only 5 studies including patients with type 2 diabetes.

# Synthesis

All 27 IF trials found weight loss of 0.8% to 13.0% of baseline weight with no serious adverse events. Twelve studies comparing IF to calorie restriction found equivalent results. The 5 studies that included patients with type 2 diabetes documented improved glycemic control.

## Conclusion

Intermittent fasting shows promise for the treatment of obesity. To date, the studies have been small and of short duration. Longer-term research is needed to understand the sustainable role IF can play in weight loss.

---

In 2018, 63.1% of Canadian adults were overweight or obese.<sup>1</sup> Obesity is a risk factor for cardiovascular disease and type 2 diabetes.<sup>2,3</sup> As obesity rates climb, there is increasing focus on dietary interventions, the most common being calorie-restricted diets, which achieve initial but often unsustained weight loss.<sup>4</sup> There is recent interest in the use of fasting for the treatment of obesity<sup>5-7</sup> and diabetes.<sup>8,9</sup> *Intermittent fasting* (IF) refers to regular periods with no or very limited caloric intake. It commonly consists of a daily fast for 16 hours, a 24-hour fast on alternate days, or a fast 2 days per week on non-consecutive days.<sup>8</sup> During fasting, caloric consumption often ranges from zero to 25% of caloric needs. Consumption on nonfasting days might be *ad libitum*, restricted to a certain diet composition, or aimed to reach a specific caloric intake of up to 125% of regular caloric needs.<sup>9</sup> Various terms are used to describe regular intermittent calorie abstention, including *intermittent fasting*, *alternate-day fasting*, *reduced meal frequency*, and *time-restricted feeding*. Intermittent fasting can be used with unrestricted consumption when not fasting or in conjunction with other dietary interventions. This review provides the most recent evidence on IF's effects on weight loss and the potential role it plays in primary care treatment of obesity.

## DATA SOURCES

---

An EMBASE and MEDLINE search of articles from January 1, 2000, to July 1, 2019, returned 1200 unique results using the key words *alternate day fasting*, *intermittent fasting*, *fasting*, *time restricted feeding*, *meal skipping*, and *reduced meal frequency*. We included English-language studies that focused on weight loss for overweight and obese participants (body mass index [BMI] of  $\geq 25$  kg/m<sup>2</sup>) and excluded studies of very short duration (< 2 weeks), studies of those requiring inpatient treatment, or studies focused on stroke, seizures, or other specific medical conditions. Following these exclusions 41 articles remained, describing 27 unique experiments: 18 small randomized controlled trials (level I evidence) and 9 trials comparing weight after IF to baseline weight with no control group (level II evidence) ([Table 1](#)).<sup>10-50</sup> Levels of evidence are classified according to the Canadian Task Force on Preventive Health Care.

Table 1.

Summary of IF studies: *Total IF participants = 944.*

| STUDY, Y                               | N  | POPULATION*          | LEVEL OF EVIDENCE | DURATION                        | WEIGHT LOSS, % OF BASELINE WEIGHT | INTERVENTION                                                                                                     |
|----------------------------------------|----|----------------------|-------------------|---------------------------------|-----------------------------------|------------------------------------------------------------------------------------------------------------------|
| Anton et al, <a href="#">10</a> 2019   | 10 | Obese, > 65 y        | II                | 4 wk                            | 2.2                               | 16-h daily fast; self-reported                                                                                   |
| Antoni et al, <a href="#">11</a> 2018  | 41 | Overweight and obese | I                 | Until 5% weight loss is reached | 5.3                               | 2-d fast (25% of caloric needs) a 5-d ad libitum calorie intake vs CR; self-reported                             |
| Arnason et al, <a href="#">12</a> 2017 | 10 | Obese, T2D           | II                | 2 wk                            | 1.4                               | 18- to 20-h daily fast as a goal, but average fast was 16.8 h; 2-wk follow-up; self-reported                     |
| Bhutani et al, <a href="#">13</a> 2013 | 64 | Obese                | I                 | 12 wk                           | 3.2                               | Alternated 25% caloric needs with ad libitum calorie intake vs usual diet with or without exercise self-reported |
| Bhutani et al, <a href="#">14</a> 2013 |    |                      |                   |                                 |                                   |                                                                                                                  |

| STUDY, Y                                                                       | N   | POPULATION*          | LEVEL OF EVIDENCE | DURATION | WEIGHT LOSS, % OF BASELINE |                                                                                               |
|--------------------------------------------------------------------------------|-----|----------------------|-------------------|----------|----------------------------|-----------------------------------------------------------------------------------------------|
|                                                                                |     |                      |                   |          | WEIGHT                     | INTERVENTION                                                                                  |
| Bowen et al, <a href="#">15</a> 2018                                           | 136 | Overweight and obese | I                 | 16 wk    | 10.6                       | 3-d fast, 3-d CR and 1-d ad libitum intake vs CR; 8-wk maintenance self-reported              |
| Carter et al, <a href="#">16</a> 2016                                          | 51  | Obese, T2D           | I                 | 12 wk    | 5.9                        | 2-d fast (1670 to 2500 kJ/d) and 1-d usual diet vs CR; self-reported                          |
| Carter et al, <a href="#">17</a> 2018<br>Carter et al, <a href="#">18</a> 2019 | 137 | Obese, T2D           | I                 | 52 wk    | 6.8                        | 2-d fast (25% of usual calorie intake) and 5-d usual diet vs CR; 1-y follow-up; self-reported |
| Catenacci et al, <a href="#">19</a> 2016                                       | 26  | Obese                | I                 | 8 wk     | 8.7                        | Alternated 0% usual calorie intake with ad libitum intake vs CR; 24-wk follow-up; monitored   |

| STUDY, Y                                                                     | N  | POPULATION*          | LEVEL OF EVIDENCE | DURATION | WEIGHT LOSS, % OF BASELINE WEIGHT | INTERVENTION                                                                                                      |
|------------------------------------------------------------------------------|----|----------------------|-------------------|----------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------|
|                                                                              |    |                      |                   |          |                                   |                                                                                                                   |
| Cho et al, <a href="#">20</a> 2019                                           | 31 | Overweight and obese | I                 | 8 wk     | 5.0                               | Alternated 25% usual calorie intake with ad libitum intake v usual diet with o without exercise self-reported     |
| Corley et al, <a href="#">21</a> 2018                                        | 41 | Obese, T2D           | II                | 12 wk    | 0.8                               | 2-d fast (2 small snacks, 1 light meal) and 5-d a libitum intake; self-reported                                   |
| Coutinho et al, <a href="#">22</a> 2018                                      | 35 | Obese                | I                 | 12 wk    | 13.0                              | 3-d fast (25% of caloric needs) a 4-d full caloric needs vs CR; sel reported                                      |
| Eshghinia and Gapparov, <a href="#">23</a> 2011                              | 26 | Obese women          | II                | 4 wk     | 4.9                               | 3-d fast (25% to 40% of usual caloric intake) and 4-d CR (10% decrease in usual caloric intake) f wk; self-report |
| Eshghinia and Mohammadzadeh, <a href="#">24</a> 2013                         | 15 | Obese women          | II                | 6 wk     | 7.1                               | 3-d fast (25% to 30% of caloric needs), 3-d usu diet, and 1-d ad libitum intake; self-reported                    |
| Gabel et al, <a href="#">25</a> 2018<br>Gabel et al, <a href="#">26</a> 2019 | 46 | Obese                | I                 | 12 wk    | 3.2                               | 16-h fast daily v usual-diet historical contro self-reported                                                      |

| STUDY, Y                                                                                                                                                     | N   | POPULATION*                | LEVEL OF EVIDENCE | DURATION | WEIGHT LOSS, % OF BASELINE WEIGHT | INTERVENTION                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|----------------------------|-------------------|----------|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Harvie et al, <a href="#">27</a> 2011                                                                                                                        | 107 | Obese women                | I                 | 24 wk    | 7.9                               | 2-d fast (very low calorie intake) and 5-d usual diet vs CR; self-reported                                                      |
| Headland et al, <a href="#">28</a> 2019                                                                                                                      | 244 | Obese                      | I                 | 52 wk    | 5.6                               | 2-d fast (25% of usual calorie intake) and 5-d usual diet vs CR self-reported                                                   |
| Hoddy et al, <a href="#">29</a> 2014<br>Hoddy et al, <a href="#">30</a> 2015<br>Hoddy et al, <a href="#">31</a> 2016<br>Hoddy et al, <a href="#">32</a> 2016 | 59  | Obese                      | I                 | 8 wk     | 4.2                               | Alternated daily 25% of baseline caloric needs with ad libitum calorie intake; self-reported                                    |
| Hutchison et al, <a href="#">33</a> 2019                                                                                                                     | 88  | Overweight and obese women | I                 | 8 wk     | 4.6                               | 3-d fast (32%–37% of energy requirements) and 4 d at 100% or 145% of energy requirements vs CR and control group; self-reported |
| Kahleova et al, <a href="#">34</a> 2014                                                                                                                      | 54  | Obese, T2D                 | I                 | 12 wk    | 3.9                               | 16-h daily fast vs CR; self-reported                                                                                            |

| STUDY, Y                               | N   | POPULATION* | LEVEL OF EVIDENCE | DURATION | WEIGHT LOSS, % OF BASELINE WEIGHT | INTERVENTION                                                                                                                       |
|----------------------------------------|-----|-------------|-------------------|----------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| Klempel et al, <a href="#">35</a> 2012 | 54  | Obese women | II                | 8 wk     | 3.4                               | 1-d fast (very low-calorie intake) and 6-d CR; self-reported                                                                       |
| Kroeger et al, <a href="#">36</a> 2012 |     |             |                   |          |                                   |                                                                                                                                    |
| Klempel et al, <a href="#">37</a> 2013 | 32  | Obese women | II                | 8 wk     | 4.5                               | Alternated 25% of usual calorie intake with 125% of usual calorie intake; high-fat low-fat diet; self-reported                     |
| Klempel et al, <a href="#">38</a> 2013 |     |             |                   |          |                                   |                                                                                                                                    |
| Klempel et al, <a href="#">39</a> 2013 |     |             |                   |          |                                   |                                                                                                                                    |
| Varady et al, <a href="#">40</a> 2015  |     |             |                   |          |                                   |                                                                                                                                    |
| Schübel et al, <a href="#">41</a> 2018 | 150 | Obese       | I                 | 12 wk    | 6.4                               | 2-d fast (25% of calorie requirements) a 5-d usual diet vs CR and control group; 12-wk maintenance; 20-wk follow-up; self-reported |
| Sundfør et al, <a href="#">42</a> 2018 | 112 | Obese       | I                 | 26 wk    | 8.4                               | 2-d fast (20% of calorie requirements) a 5-d usual diet vs CR; 26-wk maintenance; self-reported                                    |

| STUDY, Y                              | N  | POPULATION* | LEVEL OF EVIDENCE | DURATION | WEIGHT LOSS, % OF BASELINE | INTERVENTION                                                                                 |
|---------------------------------------|----|-------------|-------------------|----------|----------------------------|----------------------------------------------------------------------------------------------|
|                                       |    |             |                   |          | WEIGHT                     |                                                                                              |
| Trepanowski et al, <sup>43</sup> 2017 | 79 | Obese       | I                 | 24 wk    | 6.0                        | Alternated 25% usual calorie intake with 125                                                 |
| Trepanowski et al, <sup>44</sup> 2018 |    |             |                   |          |                            | of usual calorie intake vs CR and control group; 2                                           |
| Kroeger et al, <sup>45</sup> 2018     |    |             |                   |          |                            | wk follow-up; self-reported                                                                  |
| Kalam et al, <sup>46</sup> 2019       |    |             |                   |          |                            |                                                                                              |
| Varady et al, <sup>47</sup> 2009      | 16 | Obese       | II                | 8 wk     | 5.8                        | Alternated 25% energy needs with ad libitum calor                                            |
| Bhutani et al, <sup>48</sup> 2010     |    |             |                   |          |                            | intake; self-reported                                                                        |
| Varady et al, <sup>49</sup> 2013      | 30 | Obese       | I                 | 12 wk    | 6.5                        | Alternated 25% baseline energy needs with ad libitum caloric intake vs usual diet; monitored |
| Zuo et al, <sup>50</sup> 2016         | 40 | Obese       | II                | 12 wk    | 10.0                       | 1-d fast (430 kcal) and 6-d high-protein diet; 52 wk follow-up; monitored                    |

[Open in a new tab](#)

CR—calorie restriction, HbA<sub>1c</sub>—hemoglobin A<sub>1c</sub>, IF—intermittent fasting, T2D—type 2 diabetes.

\*Where sex is not specified, both men and women were enrolled.

†*Self-reported* indicates participants reported consumption in food diaries; *monitored* indicates investigators monitored participants' consumption.

## Study design

Study interventions incorporated IF in a variety of ways, from a 24-hour fast several days per week (eg, the “5 and 2” protocol)[11,16,17,21,27,28,35,41,42,50](#) to a daily 16-hour fast.[10,12,25,34](#) The most common study design was to alternate 24-hour periods of fasting with unrestricted consumption (alternating fast and feast days).[13,15,19,20,22–24,29,33,38,43,47,49](#) Study protocols also varied in their recommendations on caloric intake, enrolment of patients with diabetes, presence of a control group, and study duration. Some studies restricted calories while others allowed ad libitum consumption when not fasting. The rigour of fasting also varied, with several studies allowing 25% of regular caloric consumption during fasting periods. Comparator groups to IF diets followed a usual diet[13,20,25,43,49](#) or calorie-restricted diet.[11,15–17,19,22,27,28,33,41–43](#)

While patients with diabetes were commonly excluded ([Table 2](#)),[10,11,13,15,19–25,27–29,32,33,35,37,38,40–43,47,49,50](#) 5 studies enrolled only those with type 2 diabetes (n = 174 patients) ([Table 3](#)).[12,16,17,21,34](#) In both diabetic and non-diabetic populations, cardiovascular risk factors were reduced. When diet composition was controlled, most protocols were consistent with Health Canada and American Heart Association guidelines at the time: 55% carbohydrates, 20% fat, and 25% protein.[51,52](#) The most common alternative was unrestricted consumption. An enrichment of protein was considered in 5 studies at the expense of carbohydrate intake.[12,15,16,28,50](#) Two followed a Mediterranean-type diet.[27,42](#) Fat consumption was examined in 1 study, which compared dietary fat intake of 45% versus 25%, at the expense of carbohydrate intake.[37](#) Sixteen studies included dietary education, with participants choosing their own meals, while 11 supplied all or part of the diet.[1,13,19,23,29,33,34,37,43,47,49](#) Others did not require a specific dietary composition outside of the fasting period.

Table 2.

Outcomes of risk factors for cardiovascular disease and type 2 diabetes in 26 individual studies of 22 intermittent fasting trials enrolling obese adults without type 2 diabetes

| RISK FACTOR               | OUTCOME | N   | STUDIES                                                                                                                             |
|---------------------------|---------|-----|-------------------------------------------------------------------------------------------------------------------------------------|
| Blood pressure            | ↔       | 324 | Examined in 16 studies, with no change in 9 studies <a href="#">10,13,27,29,35,37,42,43,47</a>                                      |
|                           | ↓       | 226 | Examined in 16 studies, with a decrease in 7 studies <a href="#">11,15,21,24,25,49,50</a>                                           |
| Body weight               | ↓       | 764 | Decrease seen in 22 studies <a href="#">10,11,13,15,19,20,22–25,27–29,33,35,37,41–43,49,47,50</a>                                   |
| BMI                       | ↓       | 566 | Decrease seen in the 16 studies measuring BMI <a href="#">10,13,15,19,20,23–25,28,29,35,37,42,43,47,50</a>                          |
| Diabetes                  |         |     |                                                                                                                                     |
| • Glucose level           | ↔       | 409 | Examined in 17 studies, with no change in 11 studies <a href="#">10,19,24,25,27,32,35,38,40,42,43</a>                               |
|                           | ↓       | 192 | Examined in 17 studies, with a decrease in 5 studies <a href="#">13,15,20,23,41</a>                                                 |
|                           | ↑       | 24  | Examined in 17 studies, with an increase in 1 study <a href="#">11</a>                                                              |
| • HbA <sub>1c</sub> level | ↓       | 54  | Decrease seen in the 1 study measuring HbA <sub>1c</sub> level <a href="#">42</a>                                                   |
| • Insulin level           | ↓       | 407 | Decrease in 8 studies, decreasing trend in 3 of 11 studies measuring insulin level <a href="#">11,13,15,19,20,25,27,32,35,41,43</a> |

[Open in a new tab](#)

BMI—body mass index, HbA<sub>1c</sub>—hemoglobin A<sub>1c</sub>.

Table 3.

Outcomes of risk factors for cardiovascular disease and type 2 diabetes in 5 intermittent fasting studies enrolling obese adults with type 2 diabetes

| RISK FACTOR               | OUTCOME | N   | STUDIES                                                                                      |
|---------------------------|---------|-----|----------------------------------------------------------------------------------------------|
| Blood pressure            | NA      | NA  | Not studied in obese patients with type 2 diabetes                                           |
| Body weight               | ↓       | 174 | Decrease seen in all 5 studies <a href="#">12,16,17,21,34</a>                                |
| BMI                       | ↓       | 174 | Decrease seen in all 5 studies <a href="#">12,16,17,21,34</a>                                |
| Diabetes                  |         |     |                                                                                              |
| • Glucose level           | ↓       | 78  | Decrease seen in the 3 studies measuring glucose level <a href="#">12,21,34</a>              |
| • HbA <sub>1c</sub> level | ↓       | 164 | Decrease seen in the 4 studies measuring HbA <sub>1c</sub> level <a href="#">16,17,21,34</a> |
| • Insulin level           | ↓       | 27  | Decrease seen in the 1 study measuring insulin level <a href="#">34</a>                      |

[Open in a new tab](#)

BMI—body mass index, HbA<sub>1c</sub>—hemoglobin A<sub>1c</sub>, NA—not available.

Studies were of limited size and duration: 18 of 27 trials analyzed fewer than 60 participants and were 12 weeks or fewer in duration. The longest studies lasted 1 year and had 137 to 244 participants.[17,28](#) Several studies had follow-up periods after the intervention ranging from 2 weeks to 1 year.[12,15,18,19,41–43,50](#)

### Weight loss

In all 27 trials (n = 944 IF participants), IF resulted in weight loss, ranging from 0.8% to 13.0% of baseline body weight ([Table 1](#)).[10–50](#) Weight loss occurred regardless of changes in overall caloric intake.[43,53](#) In the 16 studies of 2 to 12 weeks’ duration that measured BMI, BMI decreased, on average, by 4.3% to a median of 33.2 kg/m<sup>2</sup>.[10,12,13,19–21,23–25,29,34,35,37,47,50](#) Waist circumference decreased by 3 cm to 8 cm in studies longer than 4 weeks that recorded it.[13,21,23,24,27,33–35,37,41,42,47](#)

Twelve studies used calorie-restricted diets as a comparator to IF and found equivalent weight loss in both groups.[11,15–17,19,22,27,28,33,41–43](#) Study duration was 8 weeks to 1 year, with a combined total of 1206 participants (527 undergoing IF, 572 using calorie restriction, and 107 control participants) and demonstrated weight loss of 4.6% to 13.0%.[11,15–17,19,22,27,28,33,41–43](#) Adherence appears similar for both weight loss strategies.[15,17,27,28](#) The largest study comparing IF with calorie restriction was by Headland et al in 2019 of 244

obese adults who achieved a mean 4.97-kg weight loss over 52 weeks versus a mean weight loss of 6.65 kg with calorie-restricted diets ( $P = .24$ ).<sup>28</sup> All of the 11 other comparisons of IF and calorie-restriction diets also found similar results between both groups.<sup>11,15–17,19,22,27,33,41–43</sup> In several of these studies, those in the IF group consumed the same amount of calories<sup>22,41–43</sup> or less<sup>19,27,33</sup> than those in the calorie-restriction group. Four studies combined fasting and calorie restriction on the non-fasting days and found comparable weight loss to other studies (3.4% to 10.6%).<sup>15,23,33,35</sup> In a direct comparison of 88 participants over 8 weeks, IF combined with restricting calories to 30% less than their calculated energy requirements led to greater weight loss versus IF alone ( $P \leq .05$ ).<sup>33</sup>

Most of the weight loss with IF is fat loss.<sup>13,17,19,20,22,28,29,33,35,43,47,53</sup> A 2011 study by Harvie et al calculated that 79% of weight loss was owing to loss of fat specifically (level I evidence).<sup>27</sup> Participants regained some weight during follow-up after intervention, although average body weight remained statistically significantly lower than baseline levels.<sup>15,18,19,41–43,50</sup> Weight regain did occur after 6 months. Five studies followed participants for 6 months or longer after completing IF interventions of 8 weeks to 1 year and most studies saw body weight increase by 1% to 2% of their weight nadir.<sup>18,19,41,43,50</sup> Catenacci et al found a mean 2.6-kg regain over 6 months,<sup>19</sup> and Schübel et al<sup>41</sup> and Trepanowski et al<sup>43</sup> each found a regain of 2% of baseline body weight. The year-long study by Carter et al of 137 participants was the exception, demonstrating a maintained weight loss.<sup>18</sup> Zuo et al saw a BMI increase of less than 1% during a year-long follow-up period after 12 weeks of IF.<sup>50</sup> In 6 comparisons of IF and calorie restriction, the amount of weight regained after IF and calorie restriction was similar.<sup>15,18,19,41–43</sup> The 2016 study by Catenacci et al showed differing patterns of weight regain. In the 11 IF patients who completed follow-up, this was limited to lean body mass, while the 10 calorie-restricted patients who completed follow-up regained both fat and lean body mass.<sup>19</sup>

The practical length of a fast to effect changes in weight appears to be 16 hours. In IF studies with a daily fasting intervention, a total of 120 participants were able to maintain a minimum daily fast of about 16 hours (15.8 to 16.8 hours), with an 8-hour eating window each day.<sup>10,12,25,34</sup> Arnason et al found that participants were able to fast for an average of 16.8 hours per day, rather than the 18- to 20-hour goal they had set.<sup>12</sup> Combining exercise with IF improved weight loss in a 2013 study by Bhutani et al of 64 obese patients. They found weight loss doubled (6 kg) when exercise was added to IF (level I evidence).<sup>13</sup> In 2019, Cho et al found no improvement in weight loss when exercise was added to IF ( $n = 31$ ) (level I evidence).<sup>20</sup> There were high dropout rates ( $\geq 25\%$ ) in several IF studies,<sup>11,13,20,25,28,43,50</sup> which compare poorly to the 12% to 14% dropout rates of other long-term diets: Atkins, Zone, LEARN (Lifestyle, Exercise, Attitudes, Relationships, and Nutrition), and Ornish.<sup>54</sup> In direct comparisons of IF to calorie restriction, the 2 have similar dropout rates.<sup>11,15–17,19,22,27,28,33,41–43</sup> Across the IF studies, adherence to fasting ranged from 77% to 98% ( $n = 265$ ).<sup>10,11,13,17,21,29,38</sup> In a 2009 study, Varady et al found weight loss was directly related to percentage of adherent days per week (level II evidence).<sup>47</sup>

Intermittent fasting studies generally find that hunger levels remain stable<sup>22,31</sup> or decrease during IF.<sup>38,45</sup> A study of 30 participants over 12 weeks by Varady et al found reports of hunger during IF were no higher than with unrestricted consumption (level I evidence).<sup>49</sup> Kroeger et al found that among those with the highest weight losses over 12 weeks of IF, hunger decreased and fullness increased.<sup>45</sup> In the study by Harvie et al, 15% of participants reported hunger.<sup>27</sup> Sundfør et al saw higher reported hunger in the IF group compared with those in the calorie restriction group.<sup>42</sup>

Ramadan is a culturally determined example of IF for many Muslims. Those who fast often do so for approximately 14 hours per day for 30 days, presenting a real-world opportunity for examining effects of fasting.<sup>55–62</sup> Eight Ramadan studies examined weight loss in obese adults (n = 856).<sup>55–62</sup> Weight losses ranged from 0.1 kg<sup>58</sup> to 1.8 kg<sup>61</sup> (level II evidence). Studies enrolling participants with diabetes saw a modest improvement in glycemic control.<sup>58,60,62</sup> Diabetes Canada issued detailed recommendations on management of patients with diabetes during Ramadan in February 2019.<sup>63</sup> Their expert panel recommends individualized risk stratification, glucose monitoring, and treatment with medications with low hypoglycemia risk profiles.<sup>63</sup>

## Diabetes

While IF is a moderately successful strategy for weight loss, it shows promise for improving glycemic control. Five studies exclusively enrolled individuals with type 2 diabetes (Table 3).<sup>12,16,17,21,34</sup> Kahleova et al compared a daily fast of at least 16 hours to caloric restriction (n = 54).<sup>34</sup> Both groups experienced decreases in insulin levels but IF participants had significantly lower fasting glucose levels (−0.78 mmol/L vs −0.47 mmol/L,  $P < .05$ ). Increased oral glucose insulin sensitivity, decreased C-peptide levels, and decreased glucagon levels were also statistically significantly greater in the IF group. The decrease in hemoglobin A<sub>1c</sub> level was similar between the IF and calorie-restricted groups—a 0.25% decrease over 12 weeks (level I evidence).<sup>34</sup>

In a 2016 pilot study, Carter et al implemented a fast 2 days per week with an otherwise usual diet versus caloric restriction every day in participants with diabetes (n = 51).<sup>16</sup> Medication use was reduced and hemoglobin A<sub>1c</sub> levels decreased significantly (by 0.7%) during the 12-week study ( $P < .001$ ), but the effect of IF on weight did not differ from that of caloric restriction (level I evidence).<sup>16</sup> The 2018 trial that followed (n = 137) saw the same result over 12 months of IF or calorie restriction (level I evidence).<sup>17</sup> The improvements in hemoglobin A<sub>1c</sub> level were lost during the 12 months after IF, although weight losses and medication reductions remained.<sup>18</sup> In the 2017 Saskatchewan study by Arnason et al, 10 participants with type 2 diabetes fasted an average of 16.8 hours per day for 2 weeks.<sup>12</sup> They found improved glycemic control with lower morning, postprandial, and average mean daily glucose levels (level II evidence).<sup>12</sup> These improvements regressed once participants returned to their usual diets. Corley et al enrolled 41 individuals with diabetes in a 2018 study of twice-weekly 1-day fasts for 12 weeks; fasting glucose levels decreased by 1.1 mmol/L and hemoglobin A<sub>1c</sub> levels by 0.7% (level II evidence),<sup>21</sup> a decline similar to that in the earlier study by Carter et al.<sup>16</sup> Kahleova et al found a more modest decrease in blood glucose levels (−0.78 mmol/L) with a daily 16-hour fast; no adverse events were reported.<sup>34</sup>

Use of IF in patients with diabetes poses a risk of hypoglycemia. Olansky suggests adjusting medication in patients with type 2 diabetes taking insulin or insulin secretagogues (eg, sulfonylureas).<sup>64</sup> Other hypoglycemic agents such as metformin, glucagonlike peptide 1 agonists, dipeptidyl peptidase 4 inhibitors, and α-glucosidase inhibitors are considered less likely to cause hypoglycemia (level III evidence).<sup>64</sup> Olansky indicates that adjustments might not be required to long-acting basal insulin, but that short-acting analogues should be reduced on fasting days to reflect the timing of meals and anticipated carbohydrate intake (level III evidence).<sup>64</sup> Premixed insulins (ie, intermediate-acting and short-acting insulin) are not recommended during IF, as they are not adaptable to changes in meal timing and calories.<sup>64</sup> Corley et al reduced any insulin use by up to 70% on fasting days.<sup>21</sup> Hypoglycemic events (blood glucose level  $\leq 4.0$  mmol/L) in that study (n = 41) were

experienced on average every 43 days, with no severe hypoglycemic events (ie, requiring assistance of another person).<sup>21</sup> Carter et al proposed lessening the risk of hypoglycemic events through pretrial discontinuation of all insulin and sulfonylureas when participants' baseline hemoglobin A<sub>1c</sub> levels were less than 7%; discontinuation of insulin only on fast days if hemoglobin A<sub>1c</sub> levels were between 7% and 10%; and no change in medication if hemoglobin A<sub>1c</sub> levels were greater than 10%.<sup>16,65</sup> This protocol was later modified to decrease long-acting insulin by 10 units while fasting.<sup>17</sup> Arnason et al found no hypoglycemia among 10 participants with type 2 diabetes during a 2-week period with daily fasts averaging 16.8 hours; however, their study excluded those taking insulin.<sup>12</sup>

## Adverse events

No serious adverse events were reported in the 27 IF trials. Fasting-related safety concerns include mood-related side effects and binge eating, among other symptoms. Obese participants observing a fast every second day did not develop binge-eating patterns<sup>19,26</sup> or purgative behaviour,<sup>26,30</sup> and reported improved body image and less depression.<sup>26,30</sup> During the 6-month study by Harvie et al, 32% of participants reported less depression and increased positive mood and self-confidence.<sup>27</sup> Study participants also occasionally reported dizziness,<sup>10,26,30,42</sup> general weakness,<sup>26,27,30,41</sup> bad breath,<sup>30</sup> headache,<sup>10,27,41,42</sup> feeling cold,<sup>27,41</sup> lack of concentration,<sup>27,41</sup> sleep disturbance,<sup>42,30</sup> nausea,<sup>42</sup> and constipation.<sup>27,30</sup> When compared with baseline, these symptoms were unchanged with fasting.<sup>26,30</sup>

## Conclusion

Obesity treatment will always be a challenge in primary care. We have limited effective options to recommend to overweight and obese patients, many of whom have doubtless already participated in calorie-restricted diets. The heterogeneity in the current evidence limits comparison of IF to other weight-loss strategies. Intermittent fasting shows promise as a primary care intervention for obesity, but little is known about long-term sustainability and health effects. Longer-duration studies are needed to understand how IF might contribute to effective weight-loss strategies.

## Editor's key points

- In all 27 trials examined, intermittent fasting (IF) resulted in weight loss, ranging from 0.8% to 13.0% of baseline body weight. Weight loss occurred regardless of changes in overall caloric intake. In the studies of 2 to 12 weeks' duration, body mass index decreased, on average, by 4.3% to a median of 33.2 kg/m<sup>2</sup>. Symptoms such as hunger remained stable or decreased, and no adverse events were reported.
- While IF is a moderately successful strategy for weight loss, it shows promise for improving glycemic control, although it does pose a potential risk of hypoglycemia.
- The heterogeneity in the current evidence limits comparison of IF to other weight-loss strategies. Intermittent fasting shows promise as a primary care intervention for obesity, but little is known about long-term sustainability and health effects. Longer-duration studies are needed to understand how IF might contribute to effective weight-loss strategies.

## Points de repère du rédacteur

- Dans l'ensemble des 27 études examinées, le jeûne intermittent (JI) s'est traduit par une perte pondérale allant de 0,8 à 13,0 % du poids corporel au départ. La perte pondérale s'est produite quels que soient les changements dans l'apport calorique global. Dans les études d'une durée de 2 à 12 semaines, l'indice de masse corporelle a connu une baisse, en moyenne, de 4,3 % à une réduction médiane de 33,2 kg/m<sup>2</sup>. Les symptômes, comme la faim, sont demeurés stables ou ont diminué, et aucun événement indésirable n'a été rapporté.
- Si le JI est une stratégie qui connaît un succès modéré en ce qui concerne la perte pondérale, elle se révèle prometteuse pour améliorer le contrôle glycémique, quoiqu'elle comporte un risque potentiel d'hypoglycémie.
- L'hétérogénéité des données probantes actuelles limite les possibilités de comparer le JI à d'autres stratégies de perte de poids. Le jeûne intermittent est prometteur en tant qu'intervention en soins primaires pour l'obésité, mais sa durabilité et ses effets sur la santé à long terme sont peu connus. Des études plus prolongées sont nécessaires pour comprendre comment le JI pourrait contribuer à l'efficacité des stratégies de perte pondérale.

## Footnotes

---

### Contributors

All authors contributed to the concept and design of the study; data gathering, analysis, and interpretation; and preparing the manuscript for submission.

## Competing interests

None declared

This article has been peer reviewed.

Cet article a fait l'objet d'une révision par des pairs.

## References

---

1. Statistics Canada . Overweight and obese adults, 2018. Ottawa, ON: Government of Canada; 2018. Available from: <https://www150.statcan.gc.ca/n1/pub/82-625-x/2019001/article/00005-eng.htm> [↗](#). Accessed 2019 Jul 1. [[Google Scholar](#) [↗](#)]
2. Pi-Sunyer FX. Comorbidities of overweight and obesity: current evidence and research issues. *Med Sci Sports Exerc.* 1999;31(11 Suppl):S602–8. doi: 10.1097/00005768-199911001-00019. [[DOI](#) [↗](#)] [[PubMed](#)] [[Google Scholar](#) [↗](#)]
3. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of comorbidities related to obesity and overweight: a systematic review and meta-analysis. *BMC Public Health.* 2009;9:88. doi: 10.1186/1471-2458-9-88. [[DOI](#) [↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#) [↗](#)]
4. Howard BV, Manson JE, Stefanick ML, Beresford SA, Frank G, Jones B, et al. Low-fat dietary pattern and weight change over 7 years: the Women's Health Initiative Dietary Modification Trial. *JAMA.* 2006;295(1):39–49. doi: 10.1001/jama.295.1.39. [[DOI](#) [↗](#)] [[PubMed](#)] [[Google Scholar](#) [↗](#)]
5. Collier R. Intermittent fasting: the science of going without. *CMAJ.* 2013;185(9):E363–4. doi: 10.1503/cmaj.109-4451. Epub 2013 Apr 8. [[DOI](#) [↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#) [↗](#)]
6. Collier R. Intermittent fasting: the next big weight loss fad. *CMAJ.* 2013;185(8):E321–2. doi: 10.1503/cmaj.109-4437. Epub 2013 Mar 25. [[DOI](#) [↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#) [↗](#)]
7. Pilon B. Eat, stop, eat. The shocking truth that makes weight loss simple again. 2017 Published by author. [[Google Scholar](#) [↗](#)]
8. Fung J. The obesity code. Unlocking the secrets of weight loss. Vancouver, BC: Greystone Books; 2016. [[Google Scholar](#) [↗](#)]
9. Mattson MP, Longo VD, Harvie M. Impact of intermittent fasting on health and disease processes. *Ageing Res Rev.* 2017;39:46–58. doi: 10.1016/j.arr.2016.10.005. Epub 2016 Oct 31. [[DOI](#) [↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#) [↗](#)]
10. Anton SD, Lee SA, Donahoo WT, McLaren C, Manini T, Leeuwenburgh C, et al. The effects of time restricted feeding on overweight, older adults: a pilot study. *Nutrients.* 2019;11(7):1500. doi: 10.3390/nu11071500. [[DOI](#) [↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#) [↗](#)]

11. Antoni R, Johnston KL, Collins AL, Robertson MD. Intermittent v. continuous energy restriction: differential effects on postprandial glucose and lipid metabolism following matched weight loss in overweight/obese participants. *Br J Nutr*. 2018;119(5):507–16. doi: 10.1017/S0007114517003890. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
12. Arnason TG, Bowen MW, Mansell KD. Effects of intermittent fasting on health markers in those with type 2 diabetes: a pilot study. *World J Diabetes*. 2017;8(4):154–64. doi: 10.4239/wjd.v8.i4.154. [[DOI ↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
13. Bhutani S, Klempel MC, Kroeger CM, Trepanowski JF, Varady KA. Alternate day fasting and endurance exercise combine to reduce body weight and favorably alter plasma lipids in obese humans. *Obesity (Silver Spring)* 2013;21(7):1370–9. doi: 10.1002/oby.20353. Epub 2013 May 29. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
14. Bhutani S, Klempel MC, Kroeger CM, Trepanowski JF, Phillips SA, Norkeviciute E, et al. Alternate day fasting with or without exercise: effects on endothelial function and adipokines in obese humans. *ESPEN J*. 2013;8(5):e205–9. [[Google Scholar ↗](#)]
15. Bowen J, Brindal E, James-Martin G, Noakes M. Randomized trial of a high protein, partial meal replacement program with or without alternate day fasting: similar effects on weight loss, retention status, nutritional, metabolic, and behavioral outcomes. *Nutrients*. 2018;10(9):1145. doi: 10.3390/nu10091145. [[DOI ↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
16. Carter S, Clifton PM, Keogh JB. The effects of intermittent compared to continuous energy restriction on glycaemic control in type 2 diabetes; a pragmatic pilot trial. *Diabetes Res Clin Pract*. 2016;122:106–12. doi: 10.1016/j.diabres.2016.10.010. Epub 2016 Oct 19. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
17. Carter S, Clifton PM, Keogh JB. Effect of intermittent compared with continuous energy restricted diet on glycemic control in patients with type 2 diabetes: a randomized noninferiority trial. *JAMA Netw Open*. 2018;1(3):e180756. doi: 10.1001/jamanetworkopen.2018.0756. [[DOI ↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
18. Carter S, Clifton PM, Keogh JB. The effect of intermittent compared with continuous energy restriction on glycaemic control in patients with type 2 diabetes: 24-month follow-up of a randomised noninferiority trial. *Diabetes Res Clin Pract*. 2019;151:11–9. doi: 10.1016/j.diabres.2019.03.022. Epub 2019 Mar 19. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
19. Catenacci VA, Pan Z, Ostendorf D, Brannon S, Gozansky WS, Mattson MP, et al. A randomized pilot study comparing zero-calorie alternate-day fasting to daily caloric restriction in adults with obesity. *Obesity (Silver Spring)* 2016;24(9):1874–83. doi: 10.1002/oby.21581. [[DOI ↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
20. Cho AR, Moon JY, Kim S, An KY, Oh M, Jeon JY, et al. Effects of alternate day fasting and exercise on cholesterol metabolism in overweight or obese adults: a pilot randomized controlled trial.

Metabolism. 2019;93:52–60. doi: 10.1016/j.metabol.2019.01.002. Epub 2019 Jan 4. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

21. Corley BT, Carroll RW, Hall RM, Weatherall M, Parry-Strong A, Krebs JD. Intermittent fasting in type 2 diabetes mellitus and the risk of hypoglycaemia: a randomized controlled trial. *Diabet Med*. 2018;35(5):588–94. doi: 10.1111/dme.13595. Epub 2018 Feb 27. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

22. Coutinho SR, Halset EH, Gåsbakk S, Rehfeld JF, Kulseng B, Truby H, et al. Compensatory mechanisms activated with intermittent energy restriction: a randomized control trial. *Clin Nutr*. 2018;37(3):815–23. doi: 10.1016/j.clnu.2017.04.002. Epub 2017 Apr 7. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

23. Eshghinia S, Gapparov MG. Effect of short-term modified alternate-day fasting on the lipid metabolism in obese women. *Iranian J Diabetes Obes*. 2011;3(1):1–5. [[Google Scholar](#)]

24. Eshghinia S, Mohammadzadeh F. The effects of modified alternate-day fasting diet on weight loss and CAD risk factors in overweight and obese women. *J Diabetes Metab Disord*. 2013;12(1):4. doi: 10.1186/2251-6581-12-4. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

25. Gabel K, Hoddy KK, Haggerty N, Song J, Kroeger CM, Trepanowski JF, et al. Effects of 8-hour time restricted feeding on body weight and metabolic disease risk factors in obese adults: a pilot study. *Nutr Healthy Aging*. 2018;4(4):345–53. doi: 10.3233/NHA-170036. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

26. Gabel K, Hoddy KK, Varady KA. Safety of 8-h time restricted feeding in adults with obesity. *Appl Physiol Nutr Metab*. 2019;44(1):107–9. doi: 10.1139/apnm-2018-0389. Epub 2018 Sep 14. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

27. Harvie MN, Pegington M, Mattson MP, Frystyk J, Dillon B, Evans G, et al. The effects of intermittent or continuous energy restriction on weight loss and metabolic disease risk markers: a randomized trial in young overweight women. *Int J Obes (Lond)* 2011;35(5):714–27. doi: 10.1038/ijo.2010.171. Epub 2010 Oct 5. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

28. Headland ML, Clifton PM, Keogh JB. Effect of intermittent compared to continuous energy restriction on weight loss and weight maintenance after 12 months in healthy overweight or obese adults. *Int J Obes (Lond)* 2019;43(10):2028–36. doi: 10.1038/s41366-018-0247-2. Epub 2018 Nov 23. Erratum in: *Int J Obes (Lond)* 2019;43(4):942. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

29. Hoddy KK, Kroeger CM, Trepanowski JF, Barnosky A, Bhutani S, Varady KA. Meal timing during alternate day fasting: impact on body weight and cardiovascular disease risk in obese adults. *Obesity (Silver Spring)* 2014;22(12):2524–31. doi: 10.1002/oby.20909. Epub 2014 Sep 24. Erratum in: *Obesity (Silver Spring)* 2015;23(4):914. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

30. Hoddy KK, Kroeger CM, Trepanowski JF, Barnosky AR, Bhutani S, Varady KA. Safety of alternate day fasting and effect on disordered eating behaviors. *Nutr J*. 2015;14:44. doi: 10.1186/s12937-015-

0029-9. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

31. Hoddy KK, Gibbons C, Kroeger CM, Trepanowski JF, Barnosky A, Bhutani S, et al. Changes in hunger and fullness in relation to gut peptides before and after 8 weeks of alternate day fasting. *Clin Nutr*. 2016;35(6):1380–5. doi: 10.1016/j.clnu.2016.03.011. Epub 2016 Mar 30. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

32. Hoddy KK, Bhutani S, Phillips SA, Varady KA. Effects of different degrees of insulin resistance on endothelial function in obese adults undergoing alternate day fasting. *Nutr Healthy Aging*. 2016;4(1):63–71. doi: 10.3233/NHA-1611. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

33. Hutchison AT, Liu B, Wood RE, Vincent AD, Thompson CH, O'Callaghan NJ, et al. Effects of intermittent versus continuous energy intakes on insulin sensitivity and metabolic risk in women with overweight. *Obesity (Silver Spring)* 2019;27(1):50–8. doi: 10.1002/oby.22345. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

34. Kahleova H, Belinova L, Malinska H, Oliyarnyk O, Trnovska J, Skop V, et al. Eating two larger meals a day (breakfast and lunch) is more effective than six smaller meals in a reduced-energy regimen for patients with type 2 diabetes: a randomised crossover study. *Diabetologia*. 2014;57(8):1552–60. doi: 10.1007/s00125-014-3253-5. Epub 2014 May 18. Erratum in: *Diabetologia* 2015;58(1):205. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

35. Klempel MC, Kroeger CM, Bhutani S, Trepanowski JF, Varady KA. Intermittent fasting combined with calorie restriction is effective for weight loss and cardio-protection in obese women. *Nutr J*. 2012;11(1):98. doi: 10.1186/1475-2891-11-98. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

36. Kroeger CM, Klempel MC, Bhutani S, Trepanowski JF, Tangney CC, Varady KA. Improvement in coronary heart disease risk factors during an intermittent fasting/calorie restriction regimen: relationship to adipokine modulations. *Nutr Metab (Lond)* 2012;9(1):98. doi: 10.1186/1743-7075-9-98. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

37. Klempel MC, Kroeger CM, Varady KA. Alternate day fasting (ADF) with a high-fat diet produces similar weight loss and cardio-protection as ADF with a low-fat diet. *Metabolism*. 2013;62(1):137–43. doi: 10.1016/j.metabol.2012.07.002. Epub 2012 Aug 11. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

38. Klempel MC, Kroeger CM, Norkeviciute E, Goslawski M, Phillips SA, Varady KA. Benefit of a low-fat over high-fat diet on vascular health during alternate day fasting. *Nutr Diabetes*. 2013;3:e71. doi: 10.1038/nutd.2013.14. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

39. Klempel MC, Kroeger CM, Varady KA. Alternate day fasting increases LDL particle size independently of dietary fat content in obese humans. *Eur J Clin Nutr*. 2013;67:783–5. doi: 10.1038/ejcn.2013.83. Epub 2013 Apr 24. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

40. Varady KA, Dam VT, Klempel MC, Horne M, Cruz R, Kroeger CM, et al. Effects of weight loss via high fat vs. low fat alternate day fasting diets on free fatty acid profiles. *Sci Rep*. 2015;5:7561. doi:

10.1038/srep07561. Erratum in: Sci Rep 2015;5:8806. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

41. Schübel R, Nattenmüller J, Sookthai D, Nonnenmacher T, Graf ME, Riedl L, et al. Effects of intermittent and continuous calorie restriction on body weight and metabolism over 50 wk: a randomized controlled trial. *Am J Clin Nutr*. 2018;108(5):933–45. doi: 10.1093/ajcn/nqy196. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

42. Sundfør TM, Svendsen M, Tonstad S. Effect of intermittent versus continuous energy restriction on weight loss, maintenance and cardiometabolic risk: a randomized 1-year trial. *Nutr Metab Cardiovasc Dis*. 2018;28(7):698–706. doi: 10.1016/j.numecd.2018.03.009. Epub 2018 Mar 29. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

43. Trepanowski JF, Kroeger CM, Barnosky A, Klempel MC, Bhutani S, Hoddy KK, et al. Effect of alternate-day fasting on weight loss, weight maintenance, and cardioprotection among metabolically healthy obese adults: a randomized clinical trial. *JAMA Intern Med*. 2017;177(7):930–8. doi: 10.1001/jamainternmed.2017.0936. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

44. Trepanowski JF, Kroeger CM, Barnosky A, Klempel M, Bhutani S, Hoddy KK, et al. Effects of alternate-day fasting or daily calorie restriction on body composition, fat distribution, and circulating adipokines: secondary analysis of a randomized controlled trial. *Clin Nutr*. 2018;37(6 Pt A):1871–8. doi: 10.1016/j.clnu.2017.11.018. Epub 2017 Dec 5. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

45. Kroeger CM, Trepanowski JF, Klempel MC, Barnosky A, Bhutani S, Gabel K, et al. Eating behavior traits of successful weight losers during 12 months of alternate-day fasting: an exploratory analysis of a randomized controlled trial. *Nutr Health*. 2018;24(1):5–10. doi: 10.1177/0260106017753487. Epub 2018 Jan 22. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

46. Kalam F, Kroeger CM, Trepanowski JF, Gabel K, Song JH, Cienfuegos S, et al. Beverage intake during alternate-day fasting: relationship to energy intake and body weight. *Nutr Health*. 2019;25(3):167–171. doi: 10.1177/0260106019841452. Epub 2019 Apr 14. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

47. Varady KA, Bhutani S, Church EC, Klempel MC. Short-term modified alternate-day fasting: a novel dietary strategy for weight loss and cardioprotection in obese adults. *Am J Clin Nutr*. 2009;90(5):1138–43. doi: 10.3945/ajcn.2009.28380. Epub 2009 Sep 30. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

48. Bhutani S, Klempel MC, Berger RA, Varady KA. Improvements in coronary heart disease risk indicators by alternate-day fasting involve adipose tissue modulations. *Obesity (Silver Spring)*. 2010;18(11):2152–9. doi: 10.1038/oby.2010.54. Epub 2010 Mar 18. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

49. Varady KA, Bhutani S, Klempel MC, Kroeger CM, Trepanowski JF, Haus JM, et al. Alternate day fasting for weight loss in normal weight and overweight subjects: a randomized controlled trial. *Nutr J*.

2013;12(1):146. doi: 10.1186/1475-2891-12-146. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

50. Zuo L, He F, Tinsley GM, Pannell BK, Ward E, Arciero PJ. Comparison of high-protein, intermittent fasting low-calorie diet and heart healthy diet for vascular health of the obese. *Front Physiol*. 2016;7:350. doi: 10.3389/fphys.2016.00350. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

51. Health Canada . Eating well with Canada's Food Guide. A resource for educators and communicators. Ottawa, ON: Health Canada; 2011. Available from: [http://www.hc-sc.gc.ca/fn-an/alt\\_formats/hpfb-dgpsa/pdf/pubs/res-educat-eng.pdf](http://www.hc-sc.gc.ca/fn-an/alt_formats/hpfb-dgpsa/pdf/pubs/res-educat-eng.pdf). Accessed 2018 May 1. [[Google Scholar](#)]

52. Eckel RH, Jakicic J, 3rd, Ard JD, de Jesus JM, Houston Miller N, Hubbard VS, et al. 2013 AHA/ACC guideline on lifestyle management to reduce cardiovascular risk: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;129(25 Suppl 2):S76–99. doi: 10.1161/01.cir.0000437740.48606.d1. Errata in: *Circulation* 2014;129(25 Suppl 2):S100-1, *Circulation* 2015;131(4):e326. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

53. Varady KA, Hoddy KK, Kroeger CM, Trepanowski JF, Klempel MC, Barnosky A, et al. Determinants of weight loss success with alternate day fasting. *Obes Res Clin Pract*. 2016;10(4):476–80. doi: 10.1016/j.orcp.2015.08.020. Epub 2015 Sep 15. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

54. Gardner CD, Kiazand A, Alhassan S, Kim S, Stafford RS, Balise RR, et al. Comparison of the Atkins, Zone, Ornish, and LEARN diets for change in weight and related risk factors among overweight premenopausal women: the A TO Z Weight Loss Study: a randomized trial. *JAMA*. 2007;297(9):969–77. doi: 10.1001/jama.297.9.969. Erratum in: *JAMA* 2007;298(2):178. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

55. Aksungar FB, Sarikaya M, Coskun A, Serteser M, Unsal I. Comparison of intermittent fasting versus caloric restriction in obese subjects: a two year follow-up. *J Nutr Health Aging*. 2017;21(6):681–5. doi: 10.1007/s12603-016-0786-y. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

56. Alharbi TJ, Wong J, Markovic T, Yue D, Wu T, Brooks B, et al. Ramadan as a model of intermittent fasting: effects on body composition, metabolic parameters, gut hormones and appetite in adults with and without type 2 diabetes mellitus [abstract] *Obes Med*. 2017;6:15–7. [[Google Scholar](#)]

57. Boudia W, Beltaief K, Baccouche H, Sassi M, Dridi Z, Trabelsi I, et al. Effects of Ramadan fasting on aspirin resistance in type 2 diabetic patients. *PLoS One*. 2018;13(3):e0192590. doi: 10.1371/journal.pone.0192590. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]

58. El Toony LF, Hamad DA, Omar OM. Outcome of focused pre-Ramadan education on metabolic and glycaemic parameters in patients with type 2 diabetes mellitus. *Diabetes Metab Syndr*. 2018;12(5):761–7. doi: 10.1016/j.dsx.2018.04.036. Epub 2018 Apr 25. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]

59. 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;153:166–75. doi: 10.1016/j.diabres.2019.05.023. Epub 2019 May 28. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
60. Hassanein M, Abdelgadir E, Bashier A, Rashid F, Saeed MA, Khalifa A, et al. The role of optimum diabetes care in form of Ramadan focused diabetes education, flash glucose monitoring system and pre-Ramadan dose adjustments in the safety of Ramadan fasting in high risk patients with diabetes. *Diabetes Res Clin Pract.* 2019;150:288–95. doi: 10.1016/j.diabres.2018.12.013. Epub 2019 Jan 11. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
61. López-Bueno M, González-Jiménez E, Navarro-Prado S, Montero-Alonso MA, Schmidt-RioValle J. Influence of age and religious fasting on the body composition of Muslim women living in a westernized context. *Nutr Hosp.* 2015;31(3):1067–73. doi: 10.3305/nh.2015.31.3.8278. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
62. Shao Y, Lim GJ, Chua CL, Wong YF, Yeoh ECK, Low SKM, et al. The effect of Ramadan fasting and continuing sodium-glucose co-transporter-2 (SGLT2) inhibitor use on ketonemia, blood pressure and renal function in Muslim patients with type 2 diabetes. *Diabetes Res Clin Pract.* 2018;142:85–91. doi: 10.1016/j.diabres.2018.05.022. Epub 2018 May 24. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
63. Bajaj HS, Abouhassan T, Ahsan MR, Arnaout A, Hassanein M, Houlden RL, et al. Diabetes Canada position statement for people with types 1 and 2 diabetes who fast during Ramadan. *Can J Diabetes.* 2019;43(1):3–12. doi: 10.1016/j.jcjd.2018.04.007. Epub 2018 Apr 27. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
64. Olansky L. Strategies for management of intermittent fasting in patients with diabetes. *Cleve Clin J Med.* 2016;84(5):357–8. doi: 10.3949/ccjm.84a.16118. [[DOI ↗](#)] [[PubMed](#)] [[Google Scholar ↗](#)]
65. Carter S, Clifton PM, Keogh JB. Intermittent energy restriction in type 2 diabetes: a short discussion of medication management. *World J Diabetes.* 2016;7(20):627–30. doi: 10.4239/wjd.v7.i20.627. [[DOI ↗](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar ↗](#)]