Comparison of the effect of daily consumption of probiotic compared with low-fat conventional yogurt on weight loss in healthy obese women following an energy-restricted diet: a randomized controlled trial

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ABSTRACT

Background: Despite evidence for the beneficial effects of probiotics and low-fat dairy products, to our knowledge, no study has compared the beneficial effect on weight loss of consuming a probiotic yogurt (PY) compared with a standard low-fat yogurt (LF) during a hypoenergetic program.

Objective: We compared the effect of the PY with LF yogurt consumption on body weight and cardiometabolic risk factors in women during a weight-loss program.

Design: Overweight and obese women (body mass index (in kg/m²): 27–40; age: 18–50 y) who usually consumed standard LFs were asked to consume either PY or LF every day with their main meals for 12 wk while following a weight-loss program.

Results: A total of 89 participants were randomly assigned to one of the 2 intervention groups. Baseline variables were not significantly different between groups. A statistically significant reduction in anthropometric measurements and significant improvements in cardiometabolic risk characteristics were observed over the 12 wk in both groups. However, no significant differences in weight loss and anthropometric measurements were seen between groups after the intervention. Compared with the LF group, the PY group had a greater (mean ± SD) decrease in total cholesterol (PY = −0.36 ± 0.10 mmol/L; LF = −0.31 ± 0.10 mmol/L; P = 0.024), low-density lipoprotein cholesterol (PY = −0.35 ± 0.10 mmol/L; LF = −0.31 ± 0.11 mmol/L; P = 0.018), homeostasis model assessment of insulin resistance (PY = −0.55 ± 0.32, LF = −0.42 ± 0.20; P = 0.002), 2-h postprandial glucose (PY = −0.61 ± 0.24 mmol/L, LF = −0.44 ± 0.19 mmol/L; P < 0.001), and fasting insulin concentration (PY = −1.76 ± 1.01 mU/mL, LF = −1.32 ± 0.62 mU/mL; P = 0.002), as secondary endpoints after the study.

Conclusion: Consumption of PY compared with LF with main meals showed no significant effects on weight loss. However, it may have positive effects on lipid profiles and insulin sensitivity during a weight-loss program. This trial was registered at http://www.irct.ir/ as IRCT201402177754N8.

INTRODUCTION

It has been claimed that the consumption of dairy products may facilitate body weight and fat loss (1). However, a review of cohort studies (2) failed to find any consistent beneficial effect of dairy consumption on the risk of obesity. On the other hand, a large cohort study (3) showed an inverse correlation between yogurt intake and weight gain. Several observational studies have suggested that dairy food may facilitate weight loss, particularly in obese and overweight individuals (4). In terms of randomized controlled trials (RCTs),5 many studies have evaluated the effect of dairy products on weight loss and body composition, with inconsistent results (5–8). A recent RCT meta-analysis (9) only supports the beneficial effect of increasing dairy consumption on body weight and fat loss in short-term studies (<1 y) or with energy restriction. Many current dietary guidelines furthermore promote low-fat dairy products as healthy food (10) that controls blood glucose concentrations and serum lipids.

Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host. Putative health benefits include improved resistance to gastrointestinal infections (11), reduction in blood lipid concentrations (12), and stimulation of the immune system (13). It is further reported that some Bifidobacterium or Lactobacillus species have been associated with normal weight (Bifidobacterium animalis), whereas others (Lactobacillus reuteri) were associated with obesity (14). However, an animal interventional study failed to prove any antiobesity potential of a specific Lactobacillus species (15). Others have claimed that probiotics are useful for controlling weight gain, preventing obesity, improving energy metabolism, enhancing insulin sensitivity, treating obesity, treating insulin insensitivity (16), and reducing LDL cholesterol (17).

Key words: insulin resistance, lipid, probiotic, weight loss, yogurt

Despite some evidence, although inconclusive, of the beneficial effects of probiotics on weight loss, no study, to our knowledge, has evaluated whether low-fat yogurt containing a probiotic, compared with a standard low-fat yogurt, results in a greater beneficial effect on weight loss in overweight and obese subjects when they are following an energy-restricted diet. Nor has this comparison been made with respect to lipid and glucose metabolism in this group. The purpose of this study was thus to compare the effects of a low-fat probiotic yogurt with a low-fat conventional yogurt with respect to body weight (and abdominal adiposity) as a primary outcome, as well as carbohydrate and lipid metabolism as secondary outcomes, in overweight and obese women after a comprehensive 12-wk weight-loss program.

METHODS

Subjects

In total, 109 healthy overweight and obese subjects were selected between March 2014 and June 2014 from participants who were attending the NovinDiet Clinic, Tehran, Iran, to lose weight. Inclusion criteria were as follows: women aged 18–50 y, BMI (in kg/m²) of 27–40, waist circumference >88 cm, premenopausal status, willingness to introduce a dietary change to lose weight, and habitual daily consumption of low-fat yogurt (200–400 g). The exclusion criteria were as follows: antibiotic treatment, drugs for blood glucose or lipid control, pregnancy or having given birth in the past year or planning a pregnancy within the next 6 mo, lactation, weight loss of ≥10% of body weight within the 6 mo before enrollment in the study, cancer or chemotherapy/radiotherapy, participation in a competitive sport, nonconsumption of low-fat yogurts habitually, consumption of probiotic products habitually, abnormal thyroid hormone concentration, intake of medications that could affect body weight and/or energy expenditure, allergy to probiotic or dairy products, depression, immune-compromised conditions, smoking, cardiovascular disease, active colitis, solid organ transplant, fatty liver, and any other conditions that were not suitable for the trial as evaluated by the physician.

The study was approved by the Ethical Committee of the Digestive Research Institute, Tehran University of Medical Science. All subjects provided their signed consent before study enrollment. This trial was registered at http://www.irct.ir as IRCT201402177754N8.

Study design and interventions

A randomized, single-blind, controlled trial was designed that aimed to compare the effects of low-fat probiotic yogurt consumption with low-fat conventional yogurt on weight loss, waist circumference, fasting plasma glucose, serum insulin concentrations, lipid profiles, and liver function tests in healthy overweight and obese women. Eligible participants were randomly assigned after baseline measures by using a computer-generated random-numbers method by the project coordinator with allocation concealed from the participants and dietitians until randomization was revealed to the study participants at the initial intervention clinic appointment.

Eighty-nine subjects who were eligible for the study were randomly assigned to one of the 2 groups. All had a 2-wk probiotic dairy product washout period before intervention initiation. In the low-fat yogurt (LF) group (n = 45), 400 g LF was to be consumed with the main meals (200 g twice/d), whereas in the probiotic yogurt (PY) group (n = 44), PY was to be consumed with the main meals (200 g twice/d) daily for 12 wk. They were also asked not to consume other probiotic products during the intervention. Conventional LF and PY were manufactured and sent to the clinic about every second week, and the yogurt was kept in a refrigerator at a maximum of 5°C and then given to the participant at biweekly clinic visits.

Compliance with the yogurt consumption instructions was monitored once a week by telephone interviews and double-checked by using a 3-d dietary food recall questionnaire that was completed 3 times during the study period (baseline and at the end of the first and second months of intervention).

The PY was a commercially available product prepared with the starter cultures of Streptococcus thermophiles and Lactobacillus bulgaricus, enriched with the probiotic culture of 2 strains of lactobacilli (Lactobacillus acidophilus LA5 and Bifidobacteria (Bifidobacterium lactis BB12) with a total minimum of 1 × 10^7 colony-forming units. The nonprobiotic conventional yogurt contained the starter cultures of S. thermophiles and L. bulgaricus. Both yogurts’ pH was in the range of 4.3–4.5 in addition to no difference in composition, color, taste, and texture between the 2 yogurts. One hundred grams of all products contained 226 kJ (54 kcal), 4 g protein, 6.5 g carbohydrate, and 1.4 g fat. The cholesterol content was 6 mg/100 g yogurt.

Screening visit

At the screening visits, subjects underwent a physical examination by a general practitioner, completed the Beck’s Depression Inventory (18), and completed the Physical Activity Readiness Questionnaire (19). Potential subjects were instructed in how to keep a 4-d food recall by a research nutritionist. In the 30-min lesson, emphasis was placed on the necessity of accurate food and drink recordkeeping for 4 consecutive days (comprised 3 weekdays and 1 weekend day). The food record was evaluated for completeness at the next visit, and subjects were excluded if it was not sufficiently detailed. No one was excluded on the basis of the Beck’s Depression Inventory scores, but 4 subjects were excluded because they provided a food record with insufficient detail.

Dietary and activity intervention sessions

NovinDiet Clinic is a private weight-loss clinic that uses an integrated approach (dietary, behavioral, exercise, and medical treatments). The clinic staff engage in research as well as provide the clinical services. Subjects who participated in this study did not pay clinic fees. The NovinDiet protocol is based on developing a problem-solving approach for each member individually and addresses both diet and exercise. In this study, the program was designed to enable weight loss of 7–10% of starting body weight, at a rate of 0.5–1 kg/wk over 12 wk. The individual diet programs were based on the subject food diary records and their food preferences, with gradual modification to bring their diet in line with the NovinDiet protocol. The diet program was designed to introduce a 500- to 1000-kcal energy deficit based on estimated energy requirements at the start of the study.
Physical activity was encouraged; the objective was to gradually increase activity levels to achieve 60 min of moderate activity 5 d/wk. Predominant behavior change strategies applied included stages of change, goal setting, self-monitoring with food diaries, waist measurements, and physical activity (20, 21).

At biweekly sessions, the subjects’ reported behavior problems regarding their weight-loss program were discussed. Resources were provided as home booklets for each subject to record adherence to the diet protocol. During the intervention period, subjects completed the feedback form regarding their adherence to the weight-loss diet, consumption of the yogurt, and their physical activity. Subjects also had access to a website (www.novindiet.com), weekly Internet magazines, and one-to-one telephone/online support from a consultant, if needed.

**Measurements**

Anthropometric measurements of all subjects were taken at the baseline and after 12 wk (except height, which was taken only at the screening visit) by the dietician.

Blood samples of all subjects were taken after an overnight (10–12 h) fast, between 0700 and 0900, at baseline and at 12 wk for biochemical, cellular, and hormonal measurements. Fasting blood samples were collected by venipuncture according to a standard protocol.

**Anthropometric measurements**

Body weight was taken to the nearest 0.1 kg by using a digital calibrated scale (Omron Health Care) while subjects wore light clothing and no shoes. Body height was measured to the nearest 0.1 cm by using a wall-mounted stadiometer (SECA) while participants were barefoot and in a freestanding position. Waist circumference was measured with a rigid measuring tape and recorded to the nearest 0.5 cm. Waist circumference was measured at the smallest horizontal circumference between the ribs and iliac crest (the natural waist) or, in the case of an indeterminable waist narrowing, halfway between the lower rib and the iliac crest (22). BMI was calculated from measured weight in kilograms divided by the square of height in meters.

**Blood sample measurements**

Blood samples were taken while the subjects were in a sitting position, according to the standard protocol, and were centrifuged at 2000 g at room temperature within 30–45 min. Blood samples for 2-h postprandial (2hpp) glucose were taken 2 h after ingestion of 75 g glucose according to the standard method. Fasting plasma glucose and 2hpglucose concentrations were measured by using the enzymatic colorimetric method. Insulin was measured by using an immunoradiometric assay (Bio-source) and a gamma-counter system (Gamma I; Genesys). Insulin resistance was evaluated by HOMA-IR, which was calculated by using the following formula (23):

\[
\text{HOMAIR} = \frac{[\text{fasting insulin (mU/L)} \times \text{FPG (mmol/L)}]}{22.5} + \frac{22.5}{(I)} \]

Glycated hemoglobin (HbA1c) was measured by a colorimetric method after an initial separation by ion exchange chromatography (Biosystem).

Biochemical analysis of serum total cholesterol, triglyceride, and HDL cholesterol was carried out on a Selectra E auto analyzer (Vita Laboratory) following standard procedures with Pars Azmoon diagnostic kits. LDL cholesterol was calculated by using the Friedewald formula (24):

\[
\text{LDL cholesterol} = \text{Total cholesterol} - \text{HDL cholesterol} + (\text{triglyceride} ÷ 2.2) \quad (2)
\]

**Statistical analyses**

Baseline values of cardiovascular disease risk factors, including weight, waist circumference, LDL cholesterol, HDL cholesterol, total cholesterol, fasting plasma glucose, triglyceride, fasting insulin, HOMA-IR, HbA1c, and 2hpp glucose in PY and LF groups were compared by using unpaired t test.

At baseline, distribution was normal for all variables. All participants who were randomly assigned and completed an initial assessment were included in the final results by using an intention-to-treat analysis. Multiple imputations with the use of linear regression were used to impute missing values from 12 wk and were based on the assumption that data were missing at random. We used ANCOVA to compare the mean of post-intervention outcomes between the 2 groups by adjustment on baseline values as covariate.

The primary outcome addressed in this study was the difference in body weight loss after the 12-wk weight-loss program. The power calculation was based on the results described by Chang et al. (17) [\(\alpha = 0.05\), power (\(1 - \beta\)) = 0.8] and was performed based on expected differences in weight loss between diet groups (mean \(\pm SD\): 0.88 \(\pm\) 1.4 kg) to determine the targeted final sample size (\(n = 80\)). Considering a dropout rate of 10\%, the sample size required was 88. Therefore, 89 subjects were randomly assigned in the 2 groups of the intervention.

Statistical significance was set at \(P \leq 0.05\). All data are presented as means \(\pm SDs\) unless otherwise stated. All statistical analyses were performed by using SPSS 22.0 for Windows (SPSS Inc.).

**RESULTS**

**Baseline characteristics**

From 109 individuals who were interested in participating in the study, 4 subjects were excluded because they had completed the dietary record incompletely. Baseline blood test results showed that a further 16 patients were ineligible. The remaining 89 subjects gave written consent, and 45 subjects were randomly allocated to the LF group and 44 to the PY group. Eighty-one subjects completed the 12-wk intervention (91\% of the randomly assigned population, Figure 1). After starting the intervention, a total of 8 subjects dropped out, including 7 participants who did not wish to continue the study and 1 because of illness (diagnosed with rheumatoid arthritis). The retention rates were 93.3\% for the LF group and 88.6\% for the PY group. At baseline, there were no statistically significant differences in physical characteristics or biochemical measurements between the intervention groups or between those who completed or did not complete the study once recruited (Table 1).
Body weight, BMI, and waist circumference

As shown in Table 2, there was significant weight reduction in each group after 12 wk of study (LF = −5.03 ± 0.93 kg, PY = −5.30 ± 1.20 kg, P < 0.001). As shown in Table 2, there was not a significant difference between groups after 12 wk of the intervention (P = 0.248).

BMI reduction in each group was in the expected direction with significant effects over 12 wk for both groups (P < 0.001). However, there was no significant difference between groups in BMI reduction after 12 wk (P = 0.296) (Table 2).

In both groups, waist circumference had decreased significantly after 12 wk of intervention (P < 0.001). The waist circumference decline was −5.10 ± 1.49 cm in the PY group and −4.80 ± 1.17 cm in the LF group at 12 wk. However, there was not a significant difference between groups after 12 wk of the intervention for waist circumference (P = 0.269).

Lipid profiles

Reductions in total cholesterol, LDL cholesterol, and triglyceride concentration and an increase in HDL cholesterol were seen over the 12 wk of study in each group (P < 0.001). Furthermore, there were significant improvements in total cholesterol and LDL cholesterol in the PY group compared with the LF group over 12 wk (Table 2). Total cholesterol after 12 wk had reduced by −0.36 ± 0.10 mmol/L in the PY group compared with −0.31 ± 0.10 mmol/L in the LF group (P = 0.024).

LDL cholesterol after 12 wk had decreased by −0.36 ± 0.10 mmol/L in the PY group compared with −0.30 ± 0.11 mmol/L in the LF group (P = 0.018).

HDL cholesterol concentration after 12 wk had increased by 0.07 ± 0.04 mmol/L in the PY group compared with 0.06 ± 0.03 mmol/L in the LF group (P = 0.267).

Triglyceride concentrations after the 12-wk intervention had reduced by −0.17 ± 0.04 mmol/L in the PY group and −0.17 ±
TABLE 1
Subject characteristics before the intervention

<table>
<thead>
<tr>
<th></th>
<th>LF group (n = 45)</th>
<th>PY group (n = 44)</th>
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<tbody>
<tr>
<td>Age, y</td>
<td>31.78 ± 6.81</td>
<td>32.20 ± 6.94</td>
</tr>
<tr>
<td>Body weight, kg</td>
<td>82.45 ± 11.01</td>
<td>82.69 ± 9.87</td>
</tr>
<tr>
<td>Height, cm</td>
<td>160.36 ± 5.04</td>
<td>160.30 ± 4.66</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>32.05 ± 3.94</td>
<td>32.14 ± 3.20</td>
</tr>
<tr>
<td>WC, cm</td>
<td>101 ± 10</td>
<td>101 ± 7</td>
</tr>
<tr>
<td>Married, %</td>
<td>77</td>
<td>75</td>
</tr>
<tr>
<td>TC, mmol/L</td>
<td>4.14 ± 0.62</td>
<td>4.24 ± 0.61</td>
</tr>
<tr>
<td>HDL cholesterol, mmol/L</td>
<td>1.19 ± 0.18</td>
<td>1.20 ± 0.20</td>
</tr>
<tr>
<td>LDL cholesterol, mmol/L</td>
<td>2.28 ± 0.60</td>
<td>2.36 ± 0.60</td>
</tr>
<tr>
<td>TG, mmol/L</td>
<td>1.48 ± 0.31</td>
<td>1.48 ± 0.33</td>
</tr>
<tr>
<td>FPG, mmol/L</td>
<td>5.04 ± 0.46</td>
<td>5.08 ± 0.48</td>
</tr>
<tr>
<td>2hppG, mmol/L</td>
<td>6.54 ± 0.49</td>
<td>6.50 ± 0.46</td>
</tr>
<tr>
<td>HbA1c, %</td>
<td>5.01 ± 0.57</td>
<td>5.11 ± 0.48</td>
</tr>
<tr>
<td>Insulin, mU/L</td>
<td>12.69 ± 3.63</td>
<td>12.85 ± 3.98</td>
</tr>
<tr>
<td>WC, cm</td>
<td>101.00 ± 3.63</td>
<td>101.18 ± 3.98</td>
</tr>
<tr>
<td>HOMA-IR</td>
<td>2.86 ± 0.92</td>
<td>2.93 ± 1.03</td>
</tr>
</tbody>
</table>

1Group difference, P > 0.05. FPG, fasting plasma glucose; HbA1c, glycated hemoglobin; LF, low-fat yogurt; PY, probiotic yogurt; TC, total cholesterol; TG, triglyceride; WC, waist circumference; 2hppG, 2-h postprandial glucose.
2Mean ± SD (all such values).

Regarding 2hpp glucose differences during the 12 wk of intervention, the mean reduction of 2hpp was –0.61 ± 0.24 mmol/L in the PY group compared with –0.44 ± 0.19 mmol/L in the LF group. As shown in Table 2, there was a significant difference in 2hpp glucose effects after 12 wk between the groups (P < 0.001). HbA1c decline over 12 wk in the LF group was –0.28% ± 0.12%, whereas this reduction was –0.29% ± 0.11% in the PY group at week 12 (Table 2). There was no significant difference in the change between groups after 12 wk (P = 0.763).

A 0.24 mmol/L reduction in fasting serum insulin concentration occurred in the PY group compared with –0.12% in the LF group. As shown in Table 2, there was a significant difference in the change between groups after 12 wk (P = 0.002). The reduction of insulin concentration was –1.76 ± 1.01 mU/mL in the PY group compared with –1.32 ± 0.62 mU/mL in the LF group after 12 wk.

Furthermore, there was a significant improvement in insulin resistance in the PY group compared with the LF group after 12 wk (P = 0.002). HOMA-IR decreased by –0.55 ± 0.32 in the PY group compared with –0.42 ± 0.20 in the LF group at 12 wk (Table 2).

DISCUSSION
The aim of this study was to compare the effects of LF (25) and low-fat PY consumption at main meals (lunch and dinner) on weight loss and other indexes of carbohydrate and lipid metabolism in overweight and obese women attending a weight-loss program for 12 wk. We found that consumption of PY compared with LF with lunch may result in positive changes in carbohydrate and lipid metabolism in overweight and obese women.

Previous longitudinal cohort trials (2, 3, 26–28) and RCTs assessing the effects of dairy products on weight loss indicated inconsistent results (5–8). A recent RCT meta-analysis (9) supported consistent results (5–8). A recent RCT meta-analysis (9) supported the beneficial effect of increased dairy consumption, in general, on body weight and fat loss in short-term studies (<1 y) or with

TABLE 2
Anthropometric and blood measurement characteristics in LF and PY groups before and after the 12-wk interventions

|                      | PY group (n = 44) | LF group (n = 45) | P  
<table>
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<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Week 12</td>
<td>Baseline</td>
<td>Week 12</td>
</tr>
<tr>
<td></td>
<td>Weight, kg</td>
<td>82.69 ± 9.87</td>
<td>77.39 ± 9.68</td>
<td>82.45 ± 11.01</td>
</tr>
<tr>
<td></td>
<td>BMI, kg/m²</td>
<td>32.14 ± 3.20</td>
<td>30.08 ± 3.15</td>
<td>32.05 ± 3.94</td>
</tr>
<tr>
<td></td>
<td>WC, cm</td>
<td>101.18 ± 7.19</td>
<td>96.08 ± 6.98</td>
<td>101.33 ± 10.10</td>
</tr>
<tr>
<td></td>
<td>TC, mmol/L</td>
<td>4.24 ± 0.61</td>
<td>3.88 ± 0.59</td>
<td>4.14 ± 0.62</td>
</tr>
<tr>
<td></td>
<td>HDL cholesterol, mmol/L</td>
<td>1.20 ± 0.20</td>
<td>1.27 ± 0.19</td>
<td>1.19 ± 0.18</td>
</tr>
<tr>
<td></td>
<td>LDL cholesterol, mmol/L</td>
<td>2.36 ± 0.60</td>
<td>2.00 ± 0.58</td>
<td>2.28 ± 0.60</td>
</tr>
<tr>
<td></td>
<td>TG, mmol/L</td>
<td>1.48 ± 0.33</td>
<td>1.31 ± 0.31</td>
<td>1.48 ± 0.31</td>
</tr>
<tr>
<td></td>
<td>FPG, mmol/L</td>
<td>5.08 ± 0.48</td>
<td>4.78 ± 0.44</td>
<td>5.04 ± 0.46</td>
</tr>
<tr>
<td></td>
<td>2hppG, mmol/L</td>
<td>6.50 ± 0.46</td>
<td>5.89 ± 0.43</td>
<td>6.54 ± 0.49</td>
</tr>
<tr>
<td></td>
<td>Insulin, mU/mL</td>
<td>12.85 ± 3.98</td>
<td>11.09 ± 3.31</td>
<td>12.69 ± 3.63</td>
</tr>
<tr>
<td></td>
<td>HOMA-IR</td>
<td>2.93 ± 1.03</td>
<td>2.38 ± 0.80</td>
<td>2.86 ± 0.92</td>
</tr>
</tbody>
</table>

1Values are means ± SDs. FPG, fasting plasma glucose; HbA1c, glycated hemoglobin; LF, low-fat yogurt; PY, probiotic yogurt; TC, total cholesterol; TG, triglyceride; WC, waist circumference; 2hppG, 2-h postprandial glucose.
2P values are for the PY group relative to the LF group by using an ANCOVA with baseline values as covariate.
energy restriction. Many current dietary guidelines furthermore promote low-fat dairy as a healthy food (10) and for the control of blood glucose concentrations and serum lipids, which could affect the risk of cardiovascular diseases.

Previous literature also indicated that some species of probiotics were associated with normal weight (B. animalis), whereas others (L. reuteri) were associated with obesity (14). However, interventional animal (15) and human studies on the effects of probiotics on weight control and improvement of lipid and carbohydrate metabolism are inconclusive (16).

Despite evidence for the beneficial effects of probiotics and low-fat dairy products on obesity and health, although with inconclusive results, to our knowledge, this was the first randomized controlled trial that investigated the effect of consuming either LF or PY on weight loss in overweight and obese women who were previously regular consumers of LF with their meal and who were undertaking a voluntary weight-reduction program.

The present study showed no significant difference in weight reduction between LF and PY groups in this weight-loss study with lifestyle intervention, which is similar to the conclusions drawn in a previous review on the effect of probiotic on obesity (16) but was inconsistent with the few RCTs (17, 29) undertaken. Overall, the participants in both arms lost >5% of their body weight, which was considered clinically significant in previous trials (30–32).

A parallel decline in other anthropometric measurements and cardiometabolic risk factors, including fasting plasma glucose, insulin, HOMA-IR, 2hpp, triglyceride, and cholesterol concentrations, was also observed, to a degree that would be expected with an energy-restricted diet intervention (33).

The total cholesterol and LDL cholesterol concentrations decreased to a significantly greater extent in the PY group than in LF group, which is similar to the effects seen in studies using these strains of probiotics on lipid profiles in diabetic patients (34). However, this is in contrast with other studies that found no significant differences in lipid profiles (35–37). The potential reasons for this finding could include dietary differences in terms of energy intake and/or fat intake (38) of the accompanying diet or differences depending on the strain of probiotic in terms of effects on total and LDL cholesterol concentrations (39). In vitro experiments showed that these strains have the activity of bile-salt hydrolases, which is linked to a higher cholesterol-removing capacity that may have the cholesterol-lowering effect (40). No significant effect of PY on lipid profiles in some of the previous studies might be due to different experimental designs, in terms of different strains of lactic bacteria (36), short intervention periods (35–37), too few subjects (37), and a smaller volume of yogurt consumed (37). This limits evaluation of the results. In addition, in previous studies, subjects were not following a hypoenergetic diet during the interventions, and they might have been after different diet patterns. In the present study, no significant change in the other measured lipid profiles, including HDL cholesterol and triglyceride, was seen. Nevertheless, future long-term clinical trials are required to inform evidence-based recommendation regarding the beneficial effects of probiotics on lipid profiles.

Finally, regarding the effects of PY on glucose metabolism, interestingly, despite similar changes in fasting glucose concentrations in both groups, the PY group showed statistically significant improvements in insulin sensitivity compared with the control LF group over 12 wk. These positive effects of PY on insulin sensitivity are similar to those seen in a recent clinical trial undertaken in pregnant women (41). Further comprehensive RCTs are still needed to establish the full clinical implication of probiotic consumption on carbohydrate metabolism because these statistical differences have been seen. The principal strength of this study is that it was a randomized, outpatient clinical trial conducted while subjects were following a comprehensive diet plan for weight control in a substantially longer-term intervention (i.e., 12 wk) than previous studies. Second, subjects wished to lose weight and included middle-aged overweight and obese women who were able to comply with a weight-loss plan, and hence they demonstrated that they were motivated to adhere to the weight-loss diet protocol (42). Third, providing the yogurt for the LF and PY groups was an incentive for regular biweekly visits with the dietitian when compliance could be encouraged in both groups.

On the other hand, there are some limitations. First, although the sample size provided adequate power to distinguish statistically significant effects in the key outcome variables, the sample was not representative of the general population, particularly because it did not include men. The study was of a relatively short duration (12 wk). Longer-term studies are now required to establish whether the effects seen are sustained over the longer period. This would require continued consumption of the yogurts for a longer period. Last, despite our weekly follow-up by phone call and fortnight clinic visit to measure dietary compliance of the subjects, the present study relied only on subjective report of storing and consuming the yogurts, which is not as accurate as objective methods for measuring their compliance.

Future work might build on the differences noted in carbohydrate metabolism by examining the effects of consuming LF compared with PY in diabetic and prediabetic patients.

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The authors’ responsibilities were as follows—AM, NM, and HRF: contributed to the initial study design, study protocol setup, and data collection; AM: provided data analysis and wrote the first draft of the manuscript; HRF: designed the research, conducted the research, contributed to data interpretation, revised the manuscript, and provided medical supervision; MAT and IAM: refined the study design and contributed to data interpretation and redrafting of the manuscript; AD and RM: provided advice and consultation for the study design and conducted the research; and all authors: read and approved the final manuscript. None of the authors reported any financial or personal conflicts of interest.

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