Coffee Mannooligosaccharides, Consumed As Part of a Free-Living, Weight-Maintaining Diet, Increase the Proportional Reduction in Body Volume in Overweight Men

Taylor C. Salinardi, Kristin Herron Rubin, Richard M. Black, and Marie-Pierre St-Onge

Abstract

Clinical studies have shown that the consumption of coffee mannooligosaccharides (MOS) decreases body fat, suggesting that MOS consumption may be useful for weight management. This study was undertaken to determine whether consumption of coffee MOS improves body composition when consumed as part of a weight-maintaining diet. In this double-blind, randomized, placebo-controlled study, 54 men and women, age 19–65 y and with BMI of 27–33 kg/m², consumed study beverages twice daily, for 12 wk. Beverages were identical except for the presence (MOS group) or absence (placebo group) of MOS (4 g/d). Body composition was assessed at baseline and endpoint using magnetic resonance imaging (MRI). Body weight, blood pressure, and assessments of feelings of appetite and satiety were taken weekly. Fifty men and women completed both baseline and endpoint MRI scans. There was a significant beverage x time interaction on total body volume (P = 0.026), total adipose tissue (TAT) (P = 0.046), and total subcutaneous adipose tissue (P = 0.032) in men but not women. Men consuming the MOS beverage had a greater percent change in total body volume (P = 0.043) and tended to have greater percent changes in subcutaneous (P = 0.069) and TAT (P = 0.098) compared with the placebo group. Consumption of a MOS-containing beverage, as part of a free-living weight-maintaining diet, leads to reductions in total body volume, relative to placebo, in men. More research is needed to further investigate the mechanism by which MOS may act to improve body composition and to elucidate the influence of gender. J. Nutr. 140: 1943–1948, 2010.

Introduction

Coffee beans contain indigestible mannooligosaccharides (MOS) that can be extracted from the water-insoluble β-mannan component (1). Several studies have investigated the functionality of MOS as a bioactive agent (1–11), specifically due to its prebiotic properties. In fact, an in vitro investigation of MOS digestibility and fermentation found that MOS remains undigested until it reaches the large intestine, where it is then fermented by human fecal bacteria into short chain fatty acids, consequently improving digestion (2). Thus, this group found that MOS was resistant to human α-amylase. Moreover, concentrations of acetate, propionate, and butyrate were significantly higher in the cecal contents of rats fed a MOS diet compared with those fed a control diet, suggesting that MOS also promotes the growth of beneficial bacteria (3).

Earlier studies in both animals (7) and humans (8–10) have also found MOS to be effective in lowering total body fat. Because fat excretion has been shown to be increased with MOS consumption, this has been proposed as a means by which MOS acts to reduce body fat (8,9). An alternative mechanism may be via inhibition of lipogenesis in the liver, caused by propionic acid produced by the process of intestinal fermentation (10), resulting from the incomplete digestion of MOS discussed above.

The goal of the present study was to investigate the effects of a coffee beverage enriched with MOS, relative to a placebo beverage, on body composition in healthy, overweight men and women. Based on previous knowledge of the effects of MOS on fat excretion and liver lipogenesis, we hypothesized that the...
addition of a MOS-containing beverage, as part of a free-living, weight-maintaining diet, would lead to reductions in total adipose tissue (TAT) and visceral adipose tissue (VAT) relative to a placebo beverage.

Methods

Participants and study design. Overweight men and women, ages 19–65 y, were recruited through local newspaper advertisements and posted announcements at St. Luke’s/Roosevelt Hospital Center and Columbia University (New York, NY). Potential participants were screened by phone and adults with a BMI of 27–33 kg/m² and a stable body weight for at least 3 mo were scheduled to attend an in-person screening and consenting session. Inclusion criteria included having a normal score on the Brief Symptom Inventory questionnaire, which assesses a person’s level of depression and anxiety over the previous week (12), and a maximum body width of 46 cm due to size restrictions of the magnetic resonance imaging (MRI) instrument. Potential participants were excluded if they were diabetic, hypertensive, or taking medications known to affect body weight, plasma lipids, and blood pressure. Participants were given the opportunity to discuss the study protocol prior to signing an informed consent and to taste both study beverages to ensure that each beverage was equally palatable and acceptable for their daily consumption throughout the duration of the study. The study was approved by the St. Luke’s/Roosevelt Hospital Center Institutional Review Board.

Upon enrollment, participants were randomized to 1 of 2 groups, MOS or placebo (Kraft Foods), and began the 12-wk study. Randomization was done with the use of a random digit table. Treatment and placebo beverages were assigned a 3-digit code by a third party. Study participants and investigators were unaware of the code assigned to the placebo and MOS beverages. Participants were given a 2-wk supply of beverages at baseline and a 1-wk supply every week during the study. Extra beverages were provided at study onset to ensure that participants would have enough study beverages in the event that they missed a weekly pick-up appointment.

Preparation of MOS. Roasted and ground coffee obtained by an ordinary method was extracted with a commercially used percolation system and the remaining coffee extraction residue was used. To facilitate the feeding of the coffee extraction residue into a reactor, the residue was first ground into a particle size of ~1 mm. A slurry composed of water and the ground product, having a total solids concentration of ~14% by weight, was then prepared and heat treated in a 4-m thermal plug flow reactor. The slurry was pumped together with high-pressure steam at a speed corresponding to a residence time of 8 min into a plug flow reactor and kept at ~210°C. Subsequently, the slurry was spouted at atmospheric pressure to quickly stop the reaction. The resultant slurry was filtered to separate a solution containing soluble solids from insoluble solids. This soluble solids-containing solution was decolorized using active carbon and an adsorbent resin and further desalted with an ion-exchange resin followed by concentration and drying to provide, at a yield of 14%, a composition comprising oligosaccharides in which 1–10 molecules of MOS, mainly mannose, were linked together. The MOS thus obtained were used to perform the present experiment.

Beverage consumption. Participants were instructed to consume their study beverage twice daily with meals. Beverages were distributed in powder form and required reconstitution with water. If needed, participants were provided with sucralose (Splenda, McNeil Nutritional) to sweeten their coffee beverage. The MOS beverages provided a total of 132.2 kJ/d (31.6 kcal/d), 2.04 g of protein, 5.24 g of carbohydrates (4.4 g fiber), and 0.08 g of fat whereas the placebo beverages provided a total of 100.4 kJ/d (24 kcal/d), 1.22 g of protein, 4.12 g of carbohydrates, and 0.06 g of fat. Each MOS beverage contained 2 g of MOS serving for a total of 4 g/d. This dose was considered effective for inducing body composition changes based on a previous study (1). Also, earlier clinical studies did not find any side effects with consumption of up to 6 g of MOS daily (8,9). MOS is a naturally occurring substance that is found in coffee and is recognized to be safe for human consumption.

Measurements. At screening, body weight was measured to the nearest 0.1 kg and height to the nearest 0.1 cm using a calibrated scale (Tanita BWB-800A Class III scale, Tanita) and a stadiometer (Detecto Industrial Scales of New York), respectively. Blood pressure measurements were obtained weekly with the participant in a seated position after a 2- to 3- min resting period. Two separate blood pressure measurements were taken and averaged. Both body weight and blood pressure measurements were taken at each weekly visit to the Weight Control Unit. Waist and hip circumferences were obtained at baseline, wk 6, and wk 12 of each study period. Waist circumference was measured at the level of the umbilicus (13) and hip circumference was measured at the point of maximum girth over the buttocks while participants stood with their heels placed together.

Diaries and questionnaires. Participants were asked to fill out daily diaries to record product consumption, medication use, and physical activity. They were also asked to maintain their baseline level of physical activity throughout both phases of the trial. Satiety was assessed on a weekly basis using visual analogue scale questionnaires (14). The questions asked included: over the last week, 1) how hungry did you feel; 2) how satisfied did you feel; 3) how full did you feel; 4) how much did you think you could eat; 5) how energetic did you feel; and 6) how sluggish did you feel? Participants rated their feelings on a 100-mm scale, with 0 being “not at all” and 100 being “very much so.”

Dietary counseling. During the study and at baseline, wk 4, and wk 8, all participants met with a dietician on an individual basis at the Weight Control Unit to discuss general nutrition-related topics. Adherence to study protocol and beverage consumption was reinforced during each counseling session.

MRI. Whole-body MRI scans were performed as previously reported by Gallagher et al. (15). MRI measurements were used to assess total adiposity and regional fat distribution at baseline and endpoint of the study period. T1-weighted MRI scans were prepared using a 1.5-Tesla scanner (General Electric, 6x Horizon). Participants laid in a supine position with their arms extended above their heads while transverse images with 10-mm slice thickness were obtained every 40 mm from hand to foot, resulting in ~40–45 axial images per participant. Participants were required to hold their breath for ~25 s during the abdominal portion of slice imaging. MRI scans were segmented and analyzed by trained techni-
cicians using image analysis software (Tomovision). Scans from each participant were analyzed by the same technician at the New York Obesity Nutrition Research Center Image Reading Center. The CV for TAT, subcutaneous adipose tissue (SAT), VAT, intermuscular adipose tissue (IMAT), and skeletal muscle at our center are 2.0, 2.0, 6.8, 10.4, and 2.1%, respectively. The inter-class correlation coefficients are 0.99 for VAT and SAT, 0.97 for VAT and muscle, and 0.76 for IMAT. The image analysis method involves a semiautomated identification of adipose tissue based on image contrast intensity with manually set boundaries for each tissue. IMAT is manually identified within muscle tissue using contrast intensity thresholds.

Statistical analyses. A final sample size of ~24 men and women/group was estimated to provide 80% power to detect a difference between groups in the change in total abdominal adiposity. This was determined by assuming a difference of 0.5 kg in change in total abdominal fat mass from baseline between groups based on previous evidence using computed tomography data transformed to absolute total abdominal fat content assessed by MRI and using SD as observed by Ross et al. (16).

The data analysis included body composition data (anthropometric measurements and MRI data), diastolic and systolic blood pressure, and food records from the weight maintenance period. Our analyses of anthropometric and blood pressure measurements included data collected at wk 0, 6, and 12. For participants missing measurements for wk 6, wk 5 and 7 were averaged and used as the midpoint values. Similarly, wk 11 was used as an endpoint measurement for participants missing wk 12 values. All data were analyzed on a completers basis. Completers of the study were defined as those who completed all assessments and physical measurements through wk 11 of the study. MRI data were analyzed for 2
time points: baseline and endpoint. Mixed-measures ANOVA was used to analyze the data. Using ANOVA, we tested the effects of time, beverage, and beverage x time interactions on body composition, diastolic and systolic blood pressure, and appetite ratings. Age, gender, and race were also entered in the model to control for any demographic effects. Three-way interactions with race, beverage, and time and gender, beverage, and time were also tested. Three-way interactions of race, beverage, and time were not significant and were not included in the models. Similarly, if age, gender, or race was not significant, the variable was removed from our main model. Time, beverage, and the time x beverage interaction always remained in the model, because these were our main variables of interest. When gender x beverage x time interactions were found, models were assessed separately by gender. Data are presented with the unadjusted P-value, because we had few preplanned post hoc comparisons. Percent change was calculated using wk 12 and baseline data and analyzed using unpaired t test. Statistical analyses were performed using SAS for Windows (version 9.1, SAS Institute). Significance was set at P < 0.05. Data are presented as means ± SEM.

Results

Of the 69 participants (MOS beverage, n = 35; placebo beverage, n = 34) enrolled in the weight maintenance study, 54 men and women completed the study up to 11 wk (MOS beverage, n = 29; placebo beverage, n = 25) and 50 completed all MRI measurements (MOS beverage, n = 27; placebo beverage, n = 23) (Supplemental Fig. 1). There were no differences in baseline characteristics between the placebo and MOS groups and no difference between those who dropped out and those who completed the study (Table 1). Reasons for not completing the study included: the start of Metformin, a medication that is known to affect body weight (n = 1), dislike of study beverage (n = 1), work-related demands (n = 3), and loss to follow-up (n = 10). Compliance with beverage consumption was self-reported and all completers of the study within each beverage group reported ≥85% compliance with daily beverage consumption.

Table 1. Baseline demographic information and anthropometric characteristics at baseline

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>MOS beverage</th>
<th>Placebo beverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>All participants</td>
<td>Completers All participants</td>
</tr>
<tr>
<td>Age, y</td>
<td>46.1 ± 2.0</td>
<td>46.8 ± 2.2</td>
</tr>
<tr>
<td>Sex, n female/male</td>
<td>23/12</td>
<td>20/9</td>
</tr>
<tr>
<td>Height, cm</td>
<td>167.1 ± 4.9</td>
<td>168.5 ± 1.5</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>83.9 ± 1.8</td>
<td>82.3 ± 1.8</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>30.0 ± 0.4</td>
<td>29.9 ± 0.4</td>
</tr>
<tr>
<td>Ethnicity, n</td>
<td>W/H/O</td>
<td>14/12/6/3</td>
</tr>
</tbody>
</table>

1 Data are means ± SEM. Data were compared by using unpaired t tests. There were no significant differences between beverage groups or between all participants and completers.

2 Ethnicity was self-defined as W, non-Hispanic White; B, non-Hispanic Black; H, Hispanic; O, other.

TAT was affected by the gender x beverage x time interaction (P = 0.005); therefore, we analyzed the data separately by gender. In men, TAT was affected by the beverage x time interaction (P = 0.046) (Table 2). Also, there was a trend for the percent change in TAT to be greater among men consuming the MOS beverage (−3.0 ± 2.0%) than among men consuming the placebo beverage (2.1 ± 1.9%) (P = 0.098). In women, TAT was affected by beverage type (P = 0.026) but not by time or the beverage x time interaction.

Similarly, SAT was affected by the gender x beverage x time interaction (P = 0.005). In men, it was affected by the beverage x time interaction (P = 0.032) (Table 2). As for TAT, the percent change in total SAT tended to be greater among men consuming the MOS beverage (−3.0 ± 2.0%) than among men consuming the placebo beverage (2.0 ± 1.6%) (P = 0.069). In women, SAT was affected by beverage type (P = 0.014) but not by time or the beverage x time interaction.

Total muscle, VAT, and IMAT were not significantly affected by the gender x beverage x time or the beverage x time interaction. However, in both genders combined, trunk SAT tended to be affected by the beverage x time interaction (P = 0.082). When data were analyzed separately by gender, trunk SAT was not significantly affected by beverage type or time alone in either men or women. Also, although there was a trend for a beverage x time interaction on trunk SAT in men (P = 0.104) (Table 2), the percent changes in trunk SAT among men consuming the MOS (−1.9 ± 2.8%) and the placebo (2.2 ± 2.0%) beverages did not differ (P = 0.239).

Body weight analyses on the 54 participants who completed at least 11 wk of the study showed an effect of time (P = 0.010) and a trend for a gender x beverage x time interaction (P = 0.061) (Table 3). Because there was a strong trend for a gender x beverage x time interaction for other body composition variables and because other body composition variables were analyzed separately by gender, body weight data were also analyzed separately by gender. In men, the absolute change in body weight was not affected by beverage type or time alone; however, it tended to be affected by the beverage x time interaction (P = 0.119) (Table 3). The percent change in body weight in men consuming the MOS beverage was −1.7 ± 0.8% (P = 0.111), whereas the percent change in body weight in men consuming the placebo beverage was −0.3 ± 0.6% (P = 0.638). In women, body weight was not affected by beverage, time, or the beverage x time interaction and there was no difference in percent change in body weight between groups.

Of the participants with baseline, 6-wk, and 12-wk blood pressure measurements (MOS beverage, n = 26; placebo beverage, n = 23), systolic blood pressure tended to be affected by time (P = 0.069) but not by the beverage x time interaction. However, diastolic blood pressure was affected by the beverage x time interaction (P = 0.023) after adjusting for body weight. Participants in the MOS beverage group tended to have a reduction in diastolic blood pressure from baseline (wk 12 vs. baseline, P = 0.076), with a decrease of 4.23 ± 2.32%. Participants consuming the placebo beverage had an increase in diastolic blood pressure from baseline to wk 12 of 5.31 ± 5.1% (P = 0.049).

Feelings of appetite, hunger, satiety, and desire to eat were not affected by time, beverage, or the beverage x time interaction in the participants who completed baseline, 6-wk, and 12-wk visual analogue scales (MOS beverage, n = 23; placebo beverage, n = 20).
Discussion

Our results showing reductions in total body volume and body weight in men with coffee MOS consumption adds to the limited literature investigating the effects of MOS on body composition in humans (1,10,17,18). Our study distinguishes itself from previous studies, because it is the first to our knowledge to be conducted in a mixed racial American population.

Our body composition findings using MRI tend to support previous clinical studies examining the effects of MOS on TAT and SAT reduction (1,10); however, we found no significant effect of beverage × time on VAT as seen in previous studies in which participants received 3 (1,10) to 6 g/d (10) of MOS. It is worth noting that previous studies had an equal number of men and women. It is possible that the greater proportion of men in these studies allowed significant changes in VAT to be detected in the whole group, whereas the smaller number of men in our study did not provide sufficient power to detect such differences, because we found significant gender × beverage × time effects on many of our variables.

Differences in adipose tissue volumes were not detected among women. Interestingly, there are gender differences in fat metabolism (19); women store fat more efficiently than men (20) and men have a higher rate of basal fat oxidation (21). Taken together, these observations suggest that women may protect their fat stores more strongly than men and may not be as responsive to a thermogenic agent as men. Future studies should examine the thermogenic effects of MOS in men and women to determine whether gender differences in energy and fat metabolism could explain the different effects on body composition between genders. However, gender differences in body composition changes with consumption of a thermogenic agent may not be specific to MOS. We have previously proposed that women may not respond as well to the thermogenesis-enhancing effects of medium-chain triglycerides as men (22). Medium-chain triglycerides raise fat oxidation and the thermic effect of food to a greater extent than long-chain triglycerides in both men and women (23,24) yet lead to significant changes in body composition only in men (23). Similarly, epigallocatechin gallate does not reduce fat mass in women (25,26), but a similar study in men found greater reductions in body fat mass and subcutaneous fat area compared with control (27). If MOS exert their effects on body composition through a similar mechanism as medium-chain triglycerides and epigallocatechin gallate, it is possible that gender differences in thermogenic responses to foods may explain the gender differences observed in this study.

Participants consuming the MOS beverage showed a trend toward reductions in diastolic blood pressure. An earlier study in normotensive individuals consuming 6 g of MOS/d for 12 wk showed no significant decrease in blood pressure (1). However, MOS significantly suppressed elevated blood pressure in hypertensive Dahl salt-sensitive rats (11). More pronounced effects of MOS on blood pressure may have been observed in hypertensive individuals.

There are several strengths in the present study that are worth highlighting. First, our study was a double-blind, randomized, placebo-controlled study. Neither the participants nor the investigators involved in this study knew which coffee beverage contained MOS until after all of the data were analyzed. Second, the 12-wk study length is long for a weight maintenance study. Third, the dropout rate was low, only 21.7%, which is appreciably lower than a previous 12-wk study conducted by our group (28) and other groups as well (29,30). Finally, the use of MRI scans enabled us to assess total and regional adiposity. MRI has been shown to provide reliable measurements in obese populations (31,32) and to accurately assess sex differences in

TABLE 2  Body composition, assessed using MRI, in men consuming MOS or placebo beverages in a weight maintenance diet for 12 wk

<table>
<thead>
<tr>
<th>Body compartment</th>
<th>MOS beverage, n = 8</th>
<th>Placebo beverage, n = 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>12 wk</td>
</tr>
<tr>
<td>TAT</td>
<td>29.4 ± 0.9</td>
<td>28.4 ± 0.9</td>
</tr>
<tr>
<td>SAT</td>
<td>23.1 ± 0.6</td>
<td>22.3 ± 0.6</td>
</tr>
<tr>
<td>VAT</td>
<td>4.7 ± 0.6</td>
<td>4.5 ± 0.6</td>
</tr>
<tr>
<td>Trunk SAT</td>
<td>14.9 ± 1.1</td>
<td>14.5 ± 1.1</td>
</tr>
<tr>
<td>Total body volume</td>
<td>92.3 ± 3.7</td>
<td>90.0 ± 3.7</td>
</tr>
<tr>
<td>Muscle</td>
<td>33.0 ± 2.4</td>
<td>32.5 ± 2.4</td>
</tr>
<tr>
<td>IMAT</td>
<td>1.7 ± 0.1</td>
<td>1.6 ± 0.1</td>
</tr>
</tbody>
</table>

1  Data are means ± SEM. Data are adjusted for age and analyzed by using a mixed-measures model of variance, which showed a gender × beverage × time interaction on total body volume (P = 0.057), TAT (P = 0.005), and SAT (P = 0.005). *Different from baseline, P = 0.005.

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TABLE 3  Body weight in men and women consuming MOS or placebo beverages as part of a weight-maintaining diet for 12 wk

<table>
<thead>
<tr>
<th>Participants</th>
<th>MOS beverage</th>
<th>Placebo beverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>n = 29</td>
<td>n = 25</td>
</tr>
<tr>
<td>Wk 0</td>
<td>85.1 ± 0.3</td>
<td>84.5 ± 0.3</td>
</tr>
<tr>
<td>Wk 6</td>
<td>85.3 ± 0.3</td>
<td>84.3 ± 0.3</td>
</tr>
<tr>
<td>Wk 12</td>
<td>84.3 ± 0.3*</td>
<td>84.1 ± 0.3</td>
</tr>
<tr>
<td>Change (12–0)</td>
<td>−0.8 ± 0.3</td>
<td>−0.5 ± 0.3</td>
</tr>
<tr>
<td>Men</td>
<td>n = 9</td>
<td>n = 11</td>
</tr>
<tr>
<td>Wk 0</td>
<td>93.7 ± 0.6</td>
<td>91.7 ± 0.5</td>
</tr>
<tr>
<td>Wk 6</td>
<td>93.9 ± 0.6</td>
<td>91.5 ± 0.5</td>
</tr>
<tr>
<td>Wk 12</td>
<td>92.1 ± 0.6*</td>
<td>91.4 ± 0.5</td>
</tr>
<tr>
<td>Change (12–0)</td>
<td>−1.6 ± 0.6</td>
<td>−0.3 ± 0.5</td>
</tr>
<tr>
<td>Women</td>
<td>n = 20</td>
<td>n = 14</td>
</tr>
<tr>
<td>Wk 0</td>
<td>80.8 ± 0.3</td>
<td>79.6 ± 0.5</td>
</tr>
<tr>
<td>Wk 6</td>
<td>80.29 ± 0.4</td>
<td>79.3 ± 0.5</td>
</tr>
<tr>
<td>Wk 12</td>
<td>80.14 ± 0.4</td>
<td>79.0 ± 0.5</td>
</tr>
<tr>
<td>Change (12–0)</td>
<td>0.01 ± 0.3</td>
<td>−0.6 ± 0.4</td>
</tr>
</tbody>
</table>

1  Data are means ± SEM. Data are adjusted for age and analyzed by using a mixed-measures model of variance, which showed a trend for a gender × beverage × time interaction on body weight (P = 0.062). *Different from baseline, P = 0.01.
lean and adipose tissue distribution (33). When we compared the effects of the beverages on adiposity at the L4-L5 slice, as reported in other studies (1,10,17,18), we did not detect differences between groups, whereas whole-body data revealed differences in changes in body composition between groups (data not shown). Lastly, MRI also provided us with information on IMAT, a novel adipose tissue depot that has been related to metabolic risk (34).

A limitation of this study is our lack of knowledge of the foods consumed by the participants during the study. Approximately two-thirds of participants who provided baseline and endpoint food records were defined as underreporters (35), leaving useful food record data for only 16.6% of our participants and making an accurate estimation of food intake impossible. Underreporting is a common occurrence in studies documenting food intake (36). However, our body composition data provide an objective measure of changes in energy balance. We did not assess the caffeine intake and smoking habits of the participants in this study. However, all participants were instructed to maintain their habitual caffeine intake. Nonetheless, it is possible that caffeine intakes decreased during the study because of the supplementation with coffee-flavored beverages. This should have occurred randomly and equally in both groups. Moreover, we estimate smoking prevalence to be very low in this study, based on recollection from study personnel and smoking prevalence rates in New York City. In 2006, smoking prevalence was 17.5% overall and 15.3% in women (37). Nevertheless, we cannot exclude the possibility that smoking prevalence differed between groups and changed throughout the duration of the study.

Another limitation worth noting is our sample size after dividing the groups by gender for our analyses. Although we had sufficient power to detect group differences in some measurements in men, we may not have had enough power to detect group differences for other measurements because only 18 men completed both MRI scans. Future studies should power on gender separately to obtain an adequate sample size. Moreover, our data were presented without adjustments for comparisons. However, we only had a few preplanned comparisons such as differences between groups at each time point and differences within groups relative to baseline.

In conclusion, our study contributes to the limited body of research examining the effects of coffee MOS on body composition in overweight individuals. Consumption of coffee MOS can have a beneficial effect on energy balance, shifting to a negative energy balance in men, when consumed as part of a free-living, weight-maintaining diet. However, more research is needed to further confirm gender differences in the effects of MOS on adipose tissue reduction and confirm the mechanisms of action of MOS in modulating energy balance.

Acknowledgments
M-P.S-O. designed the research; M-P.S-O. and T.S. conducted research; M-P.S-O. and T.S. analyzed data; M-P.S-O. and T.S. wrote the paper; M-P.S-O. had primary responsibility for final content; and K.H.R. and R.M.B. provided study beverages. All authors read and approved the final manuscript.

Literature Cited