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Adopting a Mediterranean-Style Eating Pattern with Different Amounts of Lean Unprocessed Red Meat Does Not Influence Short-Term Subjective Personal Well-Being in Adults who Are Overweight or Obese

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ABSTRACT

Background: Reducing red meat intake is commonly recommended. Limited observational studies suggest that healthy eating patterns with red meat are associated with improved quality of life.

Objective: This article presents the secondary objectives of a previous randomized crossover controlled feeding trial, which was to assess the effects of following a Mediterranean-style eating pattern (Med-Pattern) with different amounts of red meat on indexes of personal well-being (i.e., perceived quality of life, mood, and sleep) in adults who are overweight or obese. We hypothesized that following a Med-Pattern would improve outcomes, independent of red meat intake amount.

Methods: Forty-one participants [mean ± SD age: 46 ± 2 y; body mass index (kg/m^2): 30.5 ± 0.6; $n = 28$ women, $n = 13$ men] were provided Med-Pattern foods for two 5-wk periods separated by 4 wk of self-selected eating. The Med-Red Pattern contained ~500 g/wk (typical US intake), and the Med-Control Pattern contained ~200 g/wk (commonly recommended intake in heart-healthy eating patterns) of lean, unprocessed beef or pork compensated mainly with poultry and dairy. Baseline and postintervention outcomes measured included perceived quality of life via the Medical Outcomes Study 36-Item Short Form Health Survey Version 2 (SF-36v2), daily mood states via the Profile of Mood States (POMS), sleep perceptions via the Pittsburgh Sleep Quality Index, and sleep patterns via actigraphy. Data were analyzed via a doubly repeated-measures ANOVA adjusted for age, sex, and body mass at each time point.

Results: Following a Med-Pattern did not change domains of physical health, mental health, total mood disturbances, sleep perceptions, and sleep patterns but did improve subdomains of physical health role limitations (SF-36v2: 93.6% at baseline and 96.7% postintervention; $P = 0.038$), vitality (SF-36v2: 57.9% at baseline and 63.0% postintervention; $P = 0.020$), and fatigue (POMS: 2.9 arbitrary units at baseline and 2.5 arbitrary units postintervention; $P = 0.039$). There were no differences between Med-Red and Med-Control Patterns (time × pattern, P-interaction > 0.05).

Conclusion: Following a Med-Pattern independent of lean, unprocessed red meat intake may not be an effective short-term strategy to meaningfully improve indexes of personal well-being in adults who are overweight or obese. This trial was registered at clinicaltrials.gov as NCT02573129. *J Nutr* 2018;148:1917–1923.

Keywords: pork, beef, unprocessed meat, vitality, health-related quality of life, sleep, mood, actigraphy, overweight/obese adults

Introduction

Comprehensive literature assessments show that unprocessed red meat consumption is neutral to cardiovascular disease development (1–3) and associated risk factors (4, 5). Evidence suggests that lean unprocessed red meat can be consumed in a healthy eating pattern, such as a Dietary Approaches to Stop Hypertension (DASH) or a Mediterranean-style pattern (Med-Pattern), to improve cardiovascular disease risk factor profiles (6–9). Yet, it is still commonly recommended to adopt an eating pattern that is low in red meat (10).

Observational research suggests that healthy eating patterns including low to moderate intakes of red meat are associated with improved quality of life (11, 12) and may lower the

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risk of depression (13–15). Conclusions about independent associations between red meat intake and quality of life or mental health outcomes are inconsistent (16), but some research suggests a lower risk of depressive symptoms when red meat is consumed in an otherwise plant-based eating pattern (17). A systematic review of dietary counseling interventions for individuals without clinical mental health diagnoses showed that recommendations to lower red meat consumption were less likely to improve depression and anxiety symptoms than were typical-intake controls (18). However, there is a paucity of controlled feeding trials that assessed effects of consuming lean unprocessed red meat in the context of healthy eating patterns on multiple indexes of global personal well-being in adults who are overweight or obese and at risk of developing chronic diseases.

We previously reported that following a Med-Pattern with ~500 g lean, unprocessed red meat/wk improves cardiovascular disease risk factor profiles in adults who are overweight or obese in a randomized controlled feeding trial (19). The secondary objectives of that trial, presented in this article, were to assess effects of following a Med-Pattern with red meat amounts that are typical of US residents (~500 g/wk) (20, 21) or commonly recommended in heart-healthy eating patterns (~200 g/wk) (22, 23) on multiple indexes of personal well-being. We hypothesized that following a Med-Pattern would improve indexes of personal well-being, including perceived quality of life, daily mood states, and sleep. We also hypothesized that the inclusion of higher-than-recommended amounts of red meat, consumed as lean unprocessed beef and pork, would not influence Med-Pattern–induced improvements in personal well-being.

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Supplemental Tables 1–4 are available from the "Supplementary data" link in the online posting of this article and from the same link in the online table of contents at https://academic.oup.com/jn/.

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Abbreviations used: AU, arbitrary units; Med-Control Pattern, Mediterranean-style eating pattern with ~200 g of lean, unprocessed red meat/wk; Med-Pattern, Mediterranean-style eating pattern; Med-Red Pattern, Mediterranean-style eating pattern with ~500 g of lean, unprocessed red meat/wk; POMS, Profile of Mood States questionnaire; PSQI, Pittsburgh Sleep Quality Index; SF-36v2, Medical Outcomes Study 36-Item Short Form Health Survey Version 2; WASO, wake after sleep onset.

Methods

Ethics. The study protocol and all study documents were approved by Purdue University's Biomedical Institutional Review Board (institutional review board protocol 1501015662). Each participant provided written informed consent and received a monetary stipend. The study was conducted July 2015 through December 2016 and is registered at clinicaltrials.gov (NCT02573129).

Experimental design. The experimental design was a 16-wk randomized, crossover, investigator-blinded, controlled feeding study. Participants consumed a Med-Pattern for two 5-wk interventions separated by a washout period of ≥4 wk during which participants resumed their self-selected unrestricted eating patterns. Personal well-being outcomes, as described below, were measured during both baseline weeks while participants consumed their self-selected unrestricted eating pattern and during the last week of each Med-Pattern intervention. Participants were randomly assigned using an online randomization plan generator (http://www.randomization.com/).

Participant recruitment. Male and female volunteers [BMI (in kg/m^2): 25–37; age: 30–69 y] were recruited from the Greater Lafayette, Indiana community via local advertisements (paper flyers and campus e-mail listserv). Participants were excluded if they habitually consumed a Med-Pattern, as indicated by a score >5 on the 14-item Mediterranean Diet Assessment Tool (24). Possible scores range from 0 to 14 points. Inclusion criteria were nonsmoking, nondiabetic, self-reported weight stability (±4.5 kg), and consistent physical activity for 3 mo before starting the study. Participants were not excluded if they were previously diagnosed with a mental health disorder as long as the condition and/or all medications were stable for ≥6 mo before and throughout the study. Participant depression scores were calculated at baseline 1 using the Patient Health Questionnaire-9 (25).

Dietary intervention. All foods were prepared and provided to participants during the dietary interventions by the NIH-supported Indiana Clinical Research Center Bionutrition Facility at Purdue University. The Prevención con Dieta Mediterránea (PREDIMED) protocol (26) was used to design the menus, which contained either ~500 g (Med-Red Pattern) or ~200 g (Med-Control Pattern) of lean, unprocessed beef or pork/wk but similar amounts of seafood and legumes. Further adjustments were required to match energy and macronutrients via manipulation of predominantly poultry and dairy sources. Micronutrients were targeted to be ±15% between Med-Patterns, calculated via a Linear Index Model (27) Subjects were given the option to consume 150 mL of self-selected dry red wine daily. Menus were designed to maintain participants' baseline 1 body mass. Participants completed daily menu check-off lists to record self-reported deviations from prescribed menus. Detailed descriptions of the Med-Patterns have been previously published (19) and are available in **Supplemental Tables 1** and **2**.

Perceived quality of life. Participants completed the Medical Outcomes Study 36-Item Short Form Health Survey Version 2 (SF-36v2), questionnaire about the previous 4 wk (28, 29). The SF-36v2 measures physical health (perceived physical function, role limitations due to physical health, bodily pain, and general health) and mental health (vitality, social functioning, role limitations due to emotional health, and general mental health); 100% is optimal.

Daily mood. Participants completed the Profile of Mood States questionnaire (POMS) every waking hour for 3 d, and 3-d mean composite scores were calculated (30).

Indexes of sleep. Participants completed the Pittsburgh Sleep Quality Index (PSQI) (31, 32) about the previous 4 wk. A higher global sleep score [0–21 arbitrary units (AU)]) indicates poorer sleep; a global sleep score ≥5 AU is classified as "poor sleep" (31). Analyses were

performed on all participants ($n = 38$) and a subset of those classified as poor sleepers ($n = 16$).

Wrist-worn actigraphy (Actiwatch 2; Phillips Respironics) and sleep and wake times were recorded for ≤4 weekdays and weeknights. Actigraphy measurements were taken at 30-s intervals. The actigraphs were scored using the manufacturer's algorithm set at medium sensitivity, with the rest intervals set manually based on *1*) when the indicator button was pressed, *2*) recorded sleep and wake times, or *3*) algorithm default. Assessed variables included time spent in bed, time spent sleeping, sleep efficacy (percentage of time spent in bed sleeping), onset latency (amount of time to fall asleep once in bed), and total number of minutes awake after sleep onset (WASO). Three participants' actigraphy data were excluded from analyses due to nonstudy-related circadian shifts ($n = 2$) or Actiwatch malfunction at >1 time point ($n = 1$). We measured 475 nights of actigraphy in 38 participants, but 71 (15%) nights were not usable due to Actiwatch malfunction or nonstudy-related activities that interfered with the participants' regular sleep schedule. Analyses were performed on all participants ($n = 38$) and a subset of those with ≥3 nights of usable data ($n = 15$).

Power calculations. A priori power calculations (G∗Power version 3.1.9.2; Heinrich-Heine-Universität, Düsseldorf, Germany) showed that 40 participants provided >90% power to detect changes in perceived vitality on the SF-36v2 while adopting a Med-Pattern as observed previously (33). We hypothesized that including higher amounts of red meat would not influence changes in overall well-being. A priori power calculations showed that 40 participants provided >85% power to detect a differential response between the Med-Red Pattern and the Med-Control Pattern that is equal to half of the SD of the difference in responses (Cohen's $d = 0.5$; medium effect size) (34).

Statistical analysis. A doubly repeated-measures ANOVA model was used to assess the following items: *1*) main effects of time (baseline compared with post; 1-tailed due to directional hypothesis), *2*) time × pattern (Med-Red Pattern changes compared with Med-Control Pattern changes; 2-tailed), *3*) post hoc pattern–specific effects (within Med-Red Pattern and within Med-Control Pattern; 1-tailed due to directional hypothesis) when time × pattern $P < 0.05$, *4*) Med-Red Pattern compared with Med-Control Pattern postmeasurements and Med-Red Pattern compared with Med-Control Pattern baseline measurements using the slice statement to assess the cross-sectional effects of each Med-Pattern (time × pattern sliced by time; 2-tailed), and *5*) baseline 1 compared with baseline 2 measurements using the slice statement to determine if participants' baseline 1 status was reestablished at baseline 2 (time × trial sliced by time; 2-tailed). This analysis was completed by invoking the Proc Mixed procedure in SAS (SAS Institute). Age, sex (due to possible confounding), and body mass at each time point [due to previously noted differences over time between Med-Red Pattern and Med-Control Pattern (19)] were included in the model with a random participant effect. Results are presented as least-square means ± SEMs. All P values were Tukey-Kramer corrected for multiple comparisons within each outcome variable; significance was set at $P < 0.05$. Sleep-related outcomes were further Benjamini-Hochberg corrected to limit the family-wise error rate due to the exploratory nature of this study objective (35).

Results

Participant characteristics. Forty-one participants completed both Med-Pattern interventions (see **Figure 1**). At baseline, participants had poor perceived general health and vitality but were good sleepers, according to the PSQI, and slept ~7 h/night (see **Table 1**), on average. According to the Patient Health Questionnaire-9 at baseline 1, 36 participants were minimally to mildly depressed (3 were taking antidepressant medication), 3 participants were moderately depressed (1 was taking antidepressant medication), 1 participant was severely depressed (taking antidepressant medication), and 1 participant had missing data but reported taking antidepressant medication.

Dietary intakes. Mediterranean Diet Assessment Tool scores increased from 4 AU at baseline to 12 and 13 AU (≥200% increase) for the Med-Red Pattern and Med-Control Pattern menus, respectively. Participants reported ≥95% compliance to prescribed menus. Details of the prescribed menus are shown in Supplemental Tables 1 and 2.

Perceived quality of life via SF-36v2. Following a Med-Pattern, independent of red meat intake, improved the physical health subdomain of role limitations due to physical health (93.6% at baseline and 96.7% postintervention; $P = 0.038$) and the mental health subdomain of vitality (57.9% at baseline and 63.0% postintervention; $P = 0.020$; see **Figure 2**). There were no changes in global physical health, global mental health, or the subdomains of physical functioning, bodily pain, general health, social functioning, role limitations due to emotional health (i.e., role emotional), or mental health. Postintervention values did not differ between the Med-Red Pattern and the Med-Control Pattern for any SF-36v2 outcomes.

Daily mood via POMS. Following a Med-Pattern, independent of red meat intake, lessened fatigue (2.9 AU at baseline and 2.5 AU postintervention out of 3 AU; $P = 0.039$; see **Supplemental Table 3**). There were no changes in total mood disturbances or the subdomains of tension, depression, anger, vigor, and confusion. Postintervention values did not differ between the Med-Red Pattern and the Med-Control Pattern for any POMS outcomes.

Indexes of sleep. According to the PQSI, perceived sleep quality of all participants ($n = 38$) improved with adoption of a Med-Pattern (1.1 AU at baseline to 0.9 AU postintervention; $P = 0.003$; see **Supplemental Table 4**), independent of red meat intake. However, this result was not robust to Benjamini-Hochberg correction for multiple comparisons. Furthermore, this effect was not present in the subset of "poor sleepers" ($n = 16$). Global sleep score, duration, disturbance, latency, daytime dysfunction, efficiency, and sleeping medication usage did not change in all participants or in the subset of "poor sleepers" with consumption of a Med-Pattern. Postintervention values did not differ between the Med-Red Pattern and the Med-Control Pattern for any PSQI outcomes.

Nighttime actigraphy outcomes were largely unchanged with the consumption of a Med-Pattern, independent of red meat intake, for all participants ($n = 38$) and for the subset of those with ≥3 nights of usable data ($n = 15$). WASO decreased with the Med-Red Pattern but not with the Med-Control Pattern. However, the number of baseline WASO minutes was higher with the Med-Red Pattern than with the Med-Control Pattern. There were trends for time spent in bed and time spent sleeping to increase with the Med-Control Pattern but not the Med-Red Pattern, but these were not robust to Benjamini-Hochberg correction for multiple comparisons. Postintervention values did not differ between the Med-Red Pattern and the Med-Control Pattern for any actigraphy outcomes (see **Table 2**).

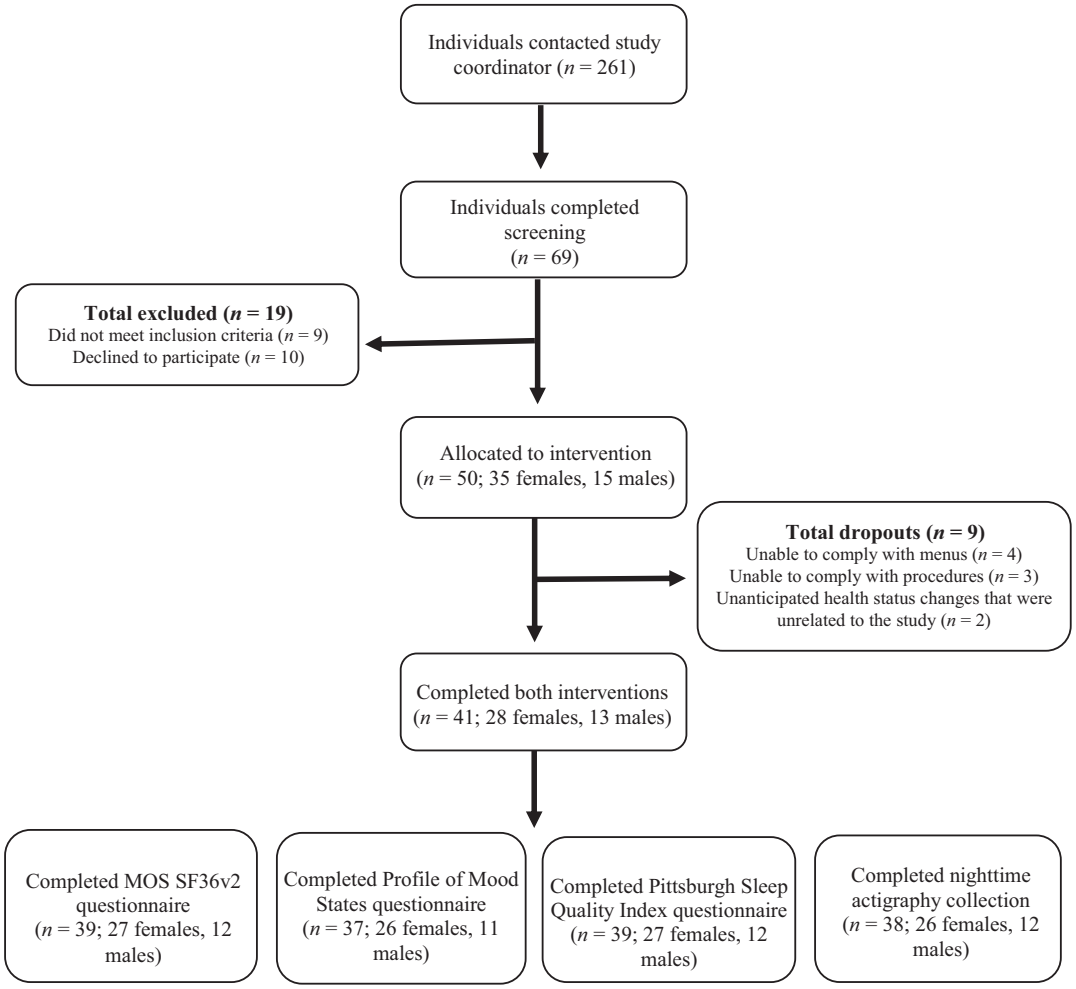

FIGURE 1 Recruitment for a randomized, crossover, controlled trial in which adults who are overweight or obese consumed a Mediterranean-style eating pattern with different amounts of lean, unprocessed red meat. MOS SF-36v2, Medical Outcomes Study 36-Item Short Form Health Survey Version 2.

Discussion

Following healthy eating patterns that are low in red meat is commonly recommended to reduce cardiometabolic disease risk in the United States. However, our previous results (19), supported by other research (6–9, 36), showed that healthy eating patterns with lean, unprocessed red meat have cardiometabolic benefits for adults who are overweight or obese. It is important to consider how the recommendation to reduce red meat intake influences outcomes beyond indexes

TABLE 1 Baseline characteristics of participants following a Mediterranean-style eating pattern with different amounts of lean, unprocessed red meat[1]

Variable	Med-Red Pattern	Med-Control Pattern
Age, y	46 ± 10	46 ± 10
BMI, kg/m^2	30.5 ± 3.5	30.3 ± 3.5
Global sleep score,[2] AU	5.2 ± 3.1	5.0 ± 2.5
Time spent sleeping/night,[3] min	397 ± 42	396 ± 54
Sleep efficiency,[3] %	85.3 ± 5.4	85.1 ± 6.5
WASO,[3] min	40 ± 14	39 ± 19
Total mood disturbances,[4] AU	102.8 ± 9.7	101.4 ± 9.0
Perceived general health,[5] %	71.4 ± 17.7	74.7 ± 14.7
Perceived vitality,[5] %	61.7 ± 20.0	57.0 ± 19.0

[1]Values are means ± SDs, n = 41. There was no difference between baseline measurements for these outcomes (P > 0.05). AU, arbitrary units; Med-Control Pattern, Mediterranean-style eating pattern with ~200 g of lean, unprocessed red meat/wk; Med-Red Pattern, Mediterranean-style eating pattern with ~500 g of lean, unprocessed red meat/wk; WASO, wake after sleep onset.
[2]Measured with the Pittsburgh Sleep Quality Index; ≥5 out of 21 indicates a "poor sleeper."
[3]Measured by wrist-worn actigraphy.
[4]Measured with the Profile of Moods State questionnaire; range: 100–176, with 100 indicating no mood disturbances.
[5]Measured with the Medical Outcomes Study 36-Item Short Form Health Survey Version 2; composite scores out of 100%.

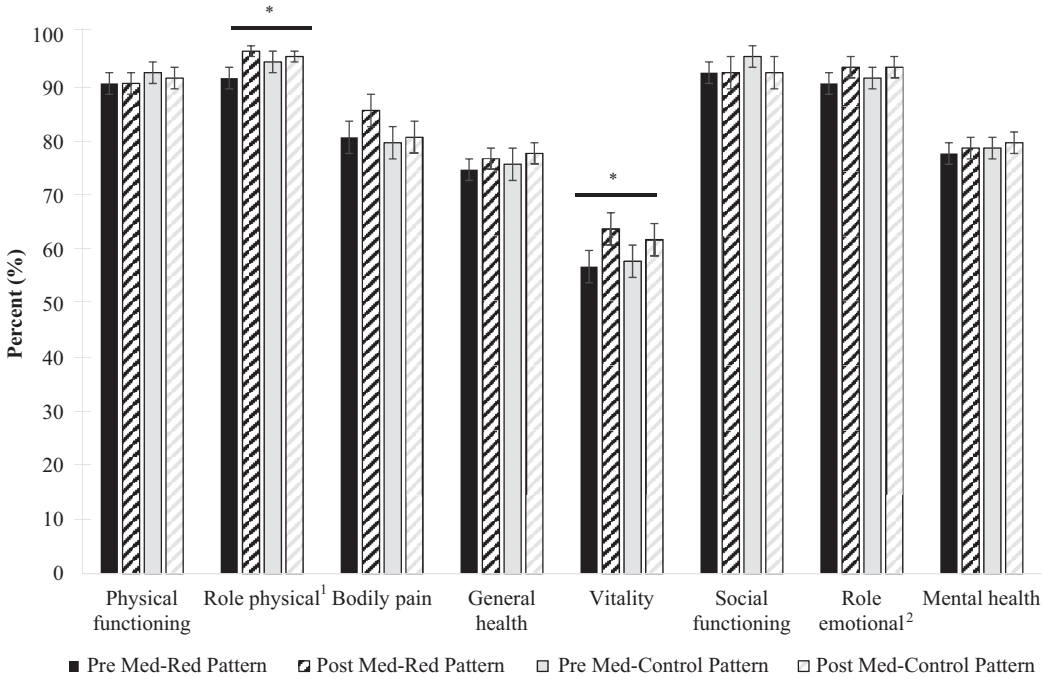

FIGURE 2 Changes in perceived quality of life in overweight or obese adults after 5 wk of following a Mediterranean-style eating pattern with different amounts of lean, unprocessed red meat measured via the Medical Outcomes Study 36-Item Short Form Health Survey Version 2. Values are least square means ± SEMs, $n = 39$. All values were extracted from a doubly repeated-measures ANOVA adjusted for age, sex, and body mass at each time point. *Indicates that postintervention values differ from baseline, $P < 0.05$. There were no differences between the Med-Red Pattern and the Med-Control Pattern. [1]Role limitations due to physical health; [2]role limitations due to emotional health. Med-Control Pattern, Mediterranean-style eating pattern with ~200 g of lean, unprocessed red meat/wk; Med-Red Pattern, Mediterranean-style eating pattern with ~500 g of lean unprocessed red meat/wk.

of cardiometabolic health. In particular, personal well-being ramifications should be considered given the associations between red meat–containing healthy eating patterns and high quality of life (11, 12) and better mental health symptoms (13). The current results show that adopting a Med-Pattern, independent of red meat intake, may not meaningfully influence indexes of personal well-being in the short term.

Our present results suggest that the adoption of a Med-Pattern, independent of red meat intake, increases participants' energy level (i.e., increased vitality, decreased role limitations due to physical health, and decreased fatigue). These results support observational research that suggests that higher adherence to a Med-Pattern allowing ≤150 g total red meat/d is associated with higher vitality scores than is lower adherence (11, 37). However, vitality differences reported between the lowest and highest adherence quintiles were modest (<10%) and the vitality scores of the highest adherence quintile were poor (<70 out of 100%). Similarly, results from longer-term (12-wk) randomized controlled trials using similar Med-Patterns showed improvements of ~11–15% in vitality scores and postintervention scores remained <70% (33, 38). The vitality scores reported in these studies are similar to the changes (5% increase from baseline) and end of intervention values (63% at postintervention) documented in our study. Vitality scores are commonly lowest and have the most room for improvement out of all quality of life parameters, as shown in the mentioned studies as well as ours. Although statistically significant, the clinical relevance of these modest

TABLE 2 Changes in sleep patterns of adults who are overweight or obese after 5 wk of following a Mediterranean dietary pattern with different amounts of lean, unprocessed red meat[1]

	Med-Red Pattern				Med-Control Pattern				*P*	
	Baseline ($n = 34$)	Post ($n = 35$)	Change	Within-pattern *P*[2]	Baseline ($n = 36$)	Post ($n = 37$)	Change	Within-pattern *P*[2]	Time	Time × pattern
Time in bed, min	442 ± 10	431 ± 9	−12 ± 10	0.023	427 ± 10	447 ± 9	20 ± 10	0.012	0.31	0.006
Time sleeping, min	401 ± 9	393 ± 9	−8 ± 9	0.21	388 ± 9	409 ± 9	21 ± 9	0.016	0.21	0.008
Sleep efficiency, %	85 ± 1	85 ± 1	0 ± 1	N/A	84 ± 1	85 ± 1	1 ± 1	N/A	0.34	0.40
WASO, min	37 ± 2[†]	33 ± 2	−4 ± 1	0.005	34 ± 2	35 ± 2	1 ± 1	0.17	0.15	<0.001*
Onset latency, min	17 ± 2	17 ± 3	0 ± 3	N/A	15 ± 2	16 ± 3	1 ± 3	N/A	0.41	0.77

[1]Values are least-square means ± SEMs. All values were extracted from a doubly repeated-measures ANOVA adjusted for age, sex, and body mass at each time point. An average of 3 nights of data were analyzed at each time point. * *P* value robust to Benjamini-Hochberg correction for multiple comparisons. [†]Difference in baseline values robust to Benjamini-Hochberg correction for multiple comparisons. Med-Control Pattern, Mediterranean-style eating pattern with ~200 g of lean, unprocessed red meat/wk; Med-Red Pattern, Mediterranean-style eating pattern with ~500 g of lean, unprocessed red meat/wk; N/A, not assessed; WASO, wake after sleep onset.
[2]Post hoc pattern-specific effects were analyzed when time × pattern, $P < 0.05$.

improvements should be interpreted with caution when making dietary recommendations to improve personal well-being.

Effects of adopting healthy eating patterns on mental health are inconsistent. A systematic review of randomized controlled trials noted that various healthy eating patterns were effective at improving depressive symptoms in ~50% of studies (18). Dietary interventions that were focused on reducing red meat, fat, or cholesterol intake were less likely to improve depressive symptoms than typical-intake control interventions (18). Our results showed that adopting a Med-Pattern did not improve mental health (except for slight improvements in vitality) and depression scores in the short-term, with or without reductions in red meat intake. The majority of studies included in the previously mentioned systematic review (18), as well as our study, assessed indexes of personal well-being as secondary outcomes in participants who were mentally healthy. At baseline, our participants had good mental health (~80% out of 100% on the SF-36v2) with low levels of depressive mood states (<2 out of 32 AU on the POMS). Therefore, our null results are likely attributable to there being little room for improvement in these outcomes. There is need for investigation with regard to how healthy eating patterns, particularly with recommendations to reduce red meat intake, affect individuals with poor mental health [1 in 6 US adults (39)].

Poor sleep quantity and quality are independently associated with an increased risk of obesity (40), cardiometabolic disease (41, 42), and depression (43). Over the past few decades, sleep duration of individuals living in the United States has decreased and approximately one-third report sleeping <6 h/night (44). The 2015 Dietary Guidelines Advisory Committee emphasized the need for more research on how dietary intakes affect sleep in concert with cardiometabolic heath (45). Therefore, we explored this paradigm within our tightly controlled feeding trial using survey-measured and machine-measured indexes of sleep. We reported little effect of adopting a Med-Pattern on short-term changes in indexes of sleep, possibly due to the short intervention duration or lack of statistical power to detect changes. Our post hoc power calculations showed that we were >95% powered to detect a large effect size (Cohen's $d = -0.83$) between baseline and postintervention measurements of perceived sleep quality (PSQI) but <20% powered to detect small-to-medium effect sizes in global sleep scores (PQSI) or sleep efficiency (actigraphy). Adequately powered, longer-term randomized controlled trials are needed to investigate whether healthy eating pattern interventions, such as a Med-Pattern, can meaningfully improve indexes of sleep, particularly in individuals with poor sleep patterns.

To our knowledge, this study is the first contribution to the literature about the effects of following healthy eating patterns with different amounts of red meat on indexes of personal well-being. The majority of published research on this topic consists of observational cohort studies that assigned Med-Pattern scoring systems to FFQ data or randomized controlled trials that were dietary-counseling based. This study, although short in duration, was a tightly controlled randomized trial in which all foods and beverages were prepared and provided to participants. This feature is strengthened by a ≥95% self-reported dietary compliance rate and a low participant drop-out percentage (<18%). The inclusion and exclusion criteria of this study were designed to achieve the primary goal of assessing cardiometabolic changes, as previously published (19), and did not include measures of quality of life, mental health, or sleep quality. This resulted in a convenience sample of participants who were fair sleepers and mentally healthy, which was likely a contributor to the largely null results.

Our results support previous literature which shows that the effects of adopting healthy eating patterns, such as a Med-Pattern, on personal well-being are modest and inconsistent. Furthermore, reducing red meat intake does not enhance improvements in indexes of personal well-being induced by adopting a Med-Pattern. There is a need to assess how adopting healthy eating patterns, with and without recommendations to reduce red meat intake, influences long-term changes in perceived quality of life, daily mood, and measures of sleep in populations with poor mental health and dysregulated sleep patterns.

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