Menopause and hormone therapy in relation to dietary intake, physical activity, and sleep, and meeting lifestyle guidelines

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Abstract

Objective: Menopause and hormone therapy (HT) may influence modifiable health behaviors (MHBs), but their independent and combined effects are not well understood. This study examined dietary intake, physical activity, and sleep, overall and in relation to guidelines, by menopausal and HT status.

Methods: This cross-sectional analysis used self-reported data from 10,381 females from the Canadian Longitudinal Study on Aging, classified into four groups: (1) pre/perimenopausal, (2) postmenopausal/never HT, (3) postmenopausal/current HT, or (4) postmenopausal/past HT. MHBs were self-reported. Diet was grouped into six categories; physical activity included walking/light, moderate-vigorous, and strength-based (min/wk); sleep was average nightly duration. Primary analyses used linear mixed models to compare MHBs across groups, and binary logistic regressions assessed meeting physical activity and sleep guidelines, adjusting for sociodemographic and lifestyle factors. When significant, secondary analyses for pairwise comparisons were conducted.

Results: Postmenopausal females who never used HT reported lower intake of fruit/vegetables ($P = 0.012$). Never-HT users were also 19% less likely to meet strength-based activity guidelines ($P = 0.049$). Sleep duration was shorter in postmenopausal females who had never used HT or had used HT in the past, compared to pre/perimenopausal females ($P = 0.001$, $P = 0.035$). The likelihood of meeting sleep guidelines was 14% lower in never, 26% lower in current, and 24% lower in past HT users compared with pre/perimenopausal females ($P = 0.048$, $P = 0.004$, $P = 0.002$).

Conclusion: Menopausal and HT status are related to differences in MHBs, including meeting established physical activity and sleep guidelines. Findings highlight the need to consider hormonal and life-stage factors in strategies to support healthy aging of females.

Key Words: Chronic disease prevention/control, Estrogens, Menopause, Middle aged, Progesterone, Women's health.

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A quarter million females reach menopause each year, and ~5.6 million females are currently postmenopausal in Canada—a state in which females are expected to spend about one third of their lives.[1] During the menopause transition, there is a marked increase in the risk of chronic

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diseases[2,3] and a high occurrence of vasomotor and urogenital symptoms.[4,5] The use of exogenous ovarian sex hormones through hormone therapy (HT) in menopausal females is often used as a treatment option to negate the occurrence of menopausal symptoms.[6] HT use has been reported in ~30% of females during or after the menopause transition[7] and may relate to improved health outcomes such as reduced risk of chronic diseases and all-cause mortality.[8-12] However, whether HT affects health outcomes and chronic disease risk directly or indirectly through altered health behaviors is unclear.

Modifiable health behaviors (MHBs) such as dietary intake, physical activity, and sleep are actions or choices that individuals can change to modify their health and chronic disease risk. Thus, characterizing MHBs in aging females is important for informing targeted disease risk prevention strategies during and after the menopause transition. Previous research has shown that MHBs may be altered across the menopause transition or in relation to HT. For example, some research suggests that postmenopausal females consume a more healthful diet than premenopausal females, with higher intakes of fiber, protein, and micronutrients, particularly among HT users.[13] However, post-menopause is also associated with greater fasting hunger and desire to eat, indicating a potential increase in appetite despite improvements in dietary intake.[14] Some longitudinal studies report decreased activity and increased sedentary time during and after the menopause transition.[15,16] Other findings show higher physical activity levels in postmenopausal HT users.[17] Similarly, sleep duration has been reported as both shorter[18] and longer in postmenopausal females,[19] with some studies indicating longer sleep among HT users[19] and others finding no significant differences.[20,21] These inconsistencies in findings limit our ability to determine definitive underlying mechanisms through which endogenous and exogenous sex hormones influence health behaviors, and ultimately complicate efforts to support chronic disease prevention and healthy aging.

While there is moderate evidence suggesting that MHBs may vary by menopausal or HT status, no studies have examined whether these differences impact the liklihood of meeting public health guidelines —a critical gap given the potential role of MHBs in chronic disease risk modulation. Furthermore, very few studies have considered both menopausal and HT status within the same study, which limits our ability to understand the independent and combined effects of menopause and HT on health-related outcomes. In addition, much of the existing data are limited by small sample sizes. This study aimed to address these knowledge gaps by characterizing MHBs in general and in relation to current public health guidelines in females according to menopausal and HT status.

METHODS

This secondary data analysis is part of a larger project examining the role of menopause and HT on dietary intake, physical activity, sleep, and metabolic health among aging females in Canada. The project was approved by the University of British Columbia Clinical Research Ethics Board (#H23-01748) on August 21, 2023. Data used in this secondary analysis are from the Comprehensive Cohort from the Canadian Longitudinal Study on Aging (CLSA), which is an observational, longitudinal study that includes data from over 50,000 participants aged 45-85 years across the 10 Canadian provinces.[22,23] This study used data collected at baseline between 2011 and 2015.[22]

Population

Participants were excluded from the CLSA if they were unable to communicate in either English or French, considered cognitively impaired, lived in the three territories, were full-time members of the Canadian Armed Forces, lived in long-term care institutions, or lived on Indigenous reservations or settlements.[22] The subsample used for the current analyses consisted of participants who identified their sex as female and had known menopausal status and HT use history. Exclusion criteria included females who were pre/perimenopausal and reported using HT, had missing menopause or HT data, or had breast, ovarian, or other female genital cancers. Because surgical menopause may have different health implications, participants who indicated they had a hysterectomy were excluded from analyses due to lack of CLSA information on hysterectomy reason, age of procedure, and type of hysterectomy (precluding the ability to determine the participants' hormonal profile).

Females were grouped into one of the four following menopause/HT groups: (1) pre/perimenopausal, (2) postmenopausal/never HT, (3) postmenopausal/current HT, or (4) postmenopausal/past HT. Participants were asked, "Have you gone through menopause, meaning that your menstrual periods stopped for at least one year and did not restart?" Those who answered "no" were considered "pre/perimenopausal," and participants who answered "yes" were considered postmenopausal. ostmenopausal females were further grouped by HT history using responses to "Have you ever used any HT, sometimes called HT, for any reason?" Postmenopausal females who answered "no" were classified as "postmenopausal/never HT." Those who answered "yes" were further dichotomized according to recency of HT use. Specifically, age of HT initiation and number of years of HT use were compared with participant's age at the time of data collection. Those whose sum of age of HT initiation plus the number of years of HT use was within 0.5 years of participant age were classified as "postmenopausal with current HT use," and those whose summed age of initiation plus number of years of HT use was more than 0.5 years to the participant age were characterized as "postmenopausal with past HT use." In other words, those who currently use HT or stopped HT within the past six months were considered current HT users. Those who did not know, refused to answer, or had no answer to CLSA questions for HT use, initiation, or length of use were excluded. In addition, those who were classified as pre/perimenopausal, but reported using HT, were also excluded due to the inability to determine a clear hormonal milieu.

Descriptive Data

The CLSA collected participant data on race, where response options included "White," "Black," "Chinese," etc. In our analyses, participants were grouped as "White" and "Non-White" to support distributed sample sizes, similar to previous research.[24] The CLSA also collected data on chronological age, marital status, education level, and household income through study-specific questionnaires. Alcohol intake was categorized according to three groups: never, < 1 drink/mo, and > 1 drink/mo. Smoking status was assessed using a derived variable from the CLSA, identifying if participants were current, past, or never smokers. Body weight was measured through 140-10 HealthWeigh digital physician scale, and height was measured through Seca 213 stadiometer. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared.

Dietary intake

The CLSA collected dietary intake data using a food frequency questionnaire called the Short Diet Questionnaire, which assessed the frequency of consumption for 30 foods and six beverages, with an emphasis on those related to aging and bone health.[25,26] In our analyses, these 36 items were grouped into food groups of "grains," "fruit and vegetables," "proteins," "dairy," "fats," and "processed foods," similar to food groups in the 2007 Canadian Food Guide,[27] and methodology in previous research[28] (Supplemental Table 1, Supplemental Digital Content 1, http://links.lww.com/MENO/B519).

Physical activity

To characterize physical activity, the CLSA used the Physical Activity Scale for the Elderly,[29] which was initially developed for use in older adults but has also been used in studies in middle-aged populations.[30-32] This survey asks questions regarding participant frequency (never, 1-2 d, 3-4 d, 5-7 d) and duration (< 30 min, between 30 min and < 1 h, between 1 h and < 2 h, between 2 h and < 4 h, or 4 h or more) in walking, light, moderate, and vigorous-intensity aerobic activities, strength-based activities, as well as time spent sitting and walking. To compare activity levels across groups, mid-point values were derived from the frequency and duration of walking, light, moderate, vigorous, and strength-based activity. These values were then converted to minutes/day, which was subsequently multiplied by seven to obtain minutes per week in each activity category, similar to previous studies.[33-35]

We compared physical activity levels to the Canadian 24-Hour Movement Guidelines[36] using minutes/week for moderate-vigorous activity and number of days spent in strength-based activity per week. Participants who reported engaging in ≥ 150 min/wk of moderate-vigorous activity or > 2 d/wk of strength-based activity were considered to be meeting the respective guidelines.

Sleep duration

Sleep duration from the CLSA was determined by asking participants, "During the past month, on average, how many hours of actual sleep did you get at night?", which was recorded as a continuous numerical value. The present analyses used this response in the analyses without additional calculations. To assess the meeting of guidelines, sleep duration was compared with the National Sleep Foundation guidelines recommendations for older adults.[37] Participants were classified as meeting the sleep guidelines (7-8 h) or not meeting the guidelines (< 7 or > 8 h).

Statistical analyses

Data cleaning and comparison of sociodemographic and descriptive variables were conducted using RStudio[38] software (version 2023.09.1). All other statistical analyses were conducted using IBM SPSS software (version 30.0.0.0 [172]). Due to the large sample size, Shapiro-Wilk or Kolmogorov-Smirnov tests of normality were not chosen, because minor deviations from normality were expected to result in significance. Rather, distribution of data was assessed using histograms and quantile-quantile plots. MHB responses that were greater than four standard deviations (SDs) from the mean for each food group, and those that were three SDs from the mean for physical activity levels and sleep duration were considered outcome outliers and excluded. These cutoffs were determined through visual inspection of the data and practical considerations of what constitutes plausible values for dietary intake, physical activity, and sleep. For all analyses, type 1 error rate (α) was set to 0.05.

Descriptive and sociodemographic data were compared across groups using analysis of variance for continuous variables (age, BMI), and χ^2 analyses for categorical variables (race, alcohol intake, smoking status, marital status, education level, household income). Descriptive values for MHB outcomes (adjusted for age) were assessed across groups through analysis of covariance. In analyses comparing the four groups, the pre/perimenopausal group was used as the reference group to focus our analyses and because it represents the baseline hormonal profile against which differences associated with menopausal status and hormone therapy use can be assessed. For a primary analysis, linear mixed models (LMMs) with unstructured covariance were used to assess MHBs (food groups, physical activity levels, and sleep duration) between pre/perimenopausal females and the postmenopausal groups (ie, those who have never used HT, those who currently use HT, and those who have used HT in the past). The dependent variable consisted of the MHB (eg, food group, physical activity level, or sleep duration), and menopause/HT group was the fixed effect. Covariates were included where appropriate, as described below. Continuous covariates (ie, age, BMI) were modeled as linear terms, and categorical covariates (ie, race, alcohol intake, smoking status, marital status, education, household income) were dummy coded. When model residuals did not appear normally distributed, the dependent variable was log-transformed to meet model assumptions, and the LMM was re-run. Secondary analyses were conducted in cases where significant effects were observed. Post hoc pairwise comparisons of estimated marginal means (with Bonferroni adjustment for multiple comparisons) were conducted and interpreted to identify specific differences among groups. The proportion of females who met the recommendations for public health guidelines for physical activity or sleep was compared using separate binary logistic regressions. For each model, a binary outcome variable (1 = met guidelines, 0 = did not meet guidelines) was regressed against menopause/HT group and relevant covariates.

Each LMM and binary logistic regression was conducted three times. The first crude model did not include covariates. Due to the expected lower age in the pre/perimenopausal group compared with the postmenopausal groups, each model was conducted a second time, adjusted for age. To account for effects of other descriptive and sociodemographic variables on each MHB, models were conducted a third time, as a fully adjusted model to include all demographic variables as covariates (ie, age, BMI, race, alcohol intake, smoking status, marital status, education, and household income). To account for potential nonlinear associations between age and MHBs and reduce the risk of residual confounding, models 2 and 3 included both linear and quadratic (age^2) terms to account for potential nonlinear associations of age. For brevity and clarity, this study used the fully adjusted model for interpretation. The crude and age-adjusted models are presented as supplementary tables (Supplemental Tables 2-5, Supplemental Digital Content 2, http://links.lww.com/MENO/B520, Supplemental Digital Content 3 http://links.lww.com/MENO/B521, Supplemental Digital Content 4, http://links.lww.com/MENO/B522, Supplemental Digital Content 5, http://links.lww.com/MENO/B523).

The statistical power for this analysis was based on previously published data among a large cohort of premenopausal and postmenopausal Australian females, in which a greater proportion of postmenopausal females (61%) met the guidelines for vegetable/legume intake compared with premenopausal females (57%).[39] Thus, our analyses were expected to have >95% power (minimum sample size n ≈ 215 per group) to detect an effect size of 0.1414 (ie, proportion of females meeting guidelines for food groups important for health, like vegetables). Although the present study did not investigate the proportion of females meeting dietary guidelines (due to the limitations of the dietary questionnaire used in the CLSA), effect size estimations based on dietary intake were expected to be less pronounced compared with differences in physical activity or metabolic health.[40] Consequently, this approach provided a more conservative estimate of the necessary sample size.

RESULTS

Population characteristics

There were 30,097 participants in the entire comprehensive cohort. After applying exclusion criteria, 10,381 females were included in the present analyses (Fig. 1). Of the 10,381 included females, most participants were classified as postmenopausal/never HT (n = 5,185), and the smallest group was postmenopausal/current HT (n = 713; Fig. 1).

The overall median (interquartile range) age was 60 (15) years in the entire sample. As expected, the pre/perimenopausal group was younger than other groups ($P < 0.001$; Table 1). On average, participants had a BMI in the "overweight" category (BMI: 26.6 [7.3] kg/m^2), mostly identified as White (96%), consumed alcohol >1x/mo (71%), were past smokers (55%), married or in common-law relationships (62%), completed post-secondary education (77%), and had a household income ranging $50,000-$99,000 (32%).

Differences in modifiable health behaviors between menopausal/hormone therapy groups

After adjusting for age, in terms of dietary intake, there were descriptive differences across groups in consumption of fruits and vegetables ($P < 0.001$), proteins ($P < 0.001$), dairy ($P = 0.015$), fats ($P = 0.004$), and processed foods groups ($P < 0.001$; Table 2). Physical activity levels also varied across menopause/HT groups, in which walking/light and strength-based activity varied across groups (both $P < 0.001$). Sleep was also different across groups ($P < 0.001$). Notably, postmenopausal current HT users had the longest average sleep duration.

After accounting for all covariates in model 3, there were main effects of group on intake of fruit and vegetables, and proteins (Table 3). In secondary analyses with post hoc adjustment, fruit and vegetable intake was significantly lower in the postmenopausal/never HT group ($\beta = -0.05 \pm 0.02$, $P = 0.012$) compared with the pre/perimenopausal group (Table 4). Although there was an overall main effect of intake of the protein food group, there were no differences in intake across the menopause/HT groups. After adjusting for all covariates, there were no differences in grains, dairy, fats, or processed food intake between menopausal/HT groups (all $P > 0.05$).

In fully adjusted models, there were no main effects of menopause/HT group on walking/light, moderate-vigorous, or strength-based physical activity (Table 3). There were main effects of group on sleep duration in primary analyses (Table 3). After adjusting for multiple comparisons in secondary post hoc analyses, sleep was significantly lower in postmenopausal never and past HT users ($\beta = -0.16 \pm 0.04$, $P = 0.001$; $\beta = -0.14 \pm 0.05$, $P = 0.035$) compared with the pre/perimenopausal group (Table 4).

Meeting the public health guidelines across menopausal/hormone therapy groups

Of the females with data for moderate-vigorous and strength-based physical activity across all menopausal/HT groups (n = 9,933, and n = 9,929, respectively), 23.0% (n = 2,287) met the guidelines for moderate-vigorous physical activity (≥150 min/wk), and 16.0% (n = 1,586) met the guidelines for strength-based activity (>2 times/wk; Supplemental Table 6, Supplemental Digital Content 6,

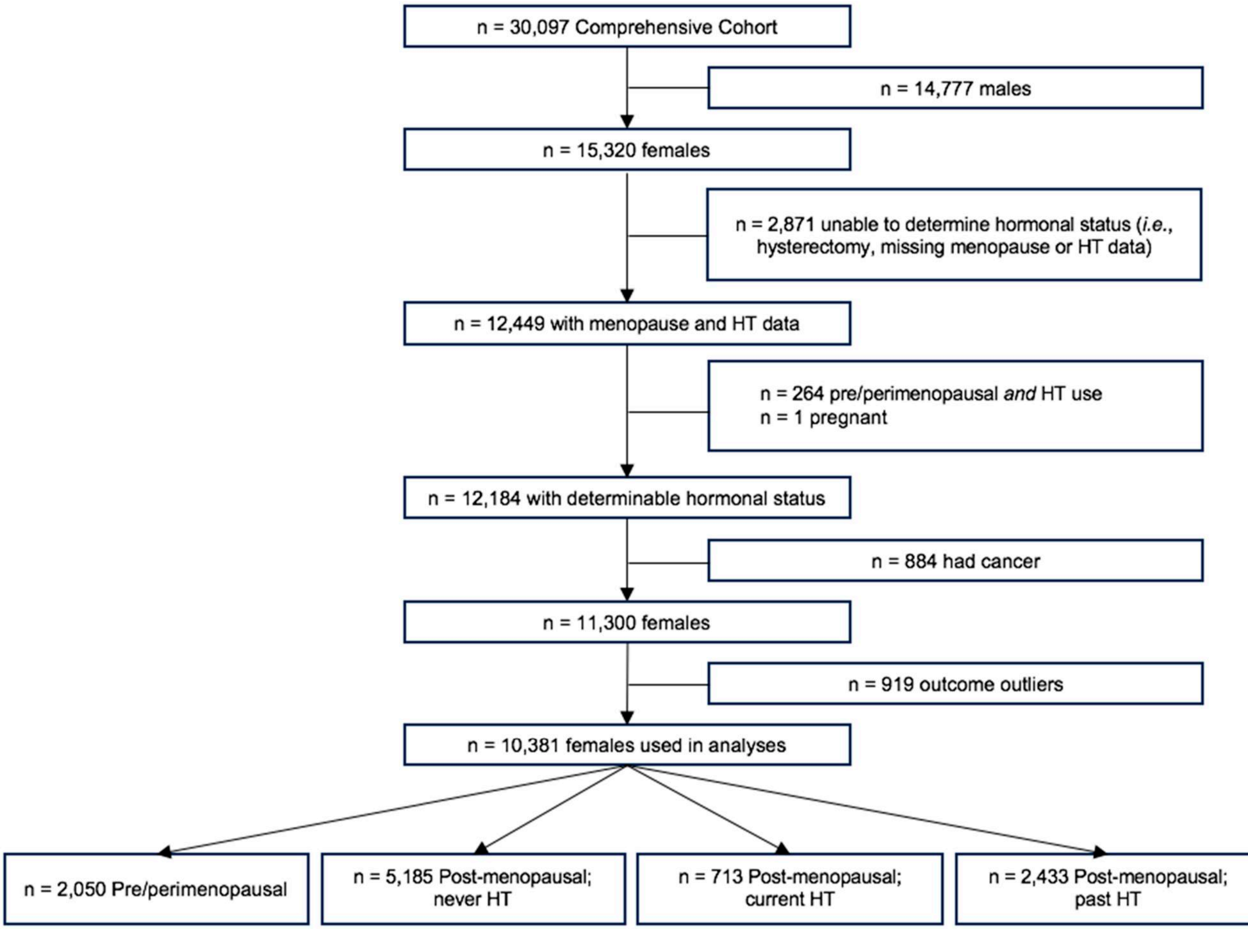

FIG. 1. Consort diagram of participants included and excluded from analysis. Male participants were excluded. Those reporting hysterectomy or missing menopause or HT data, reported using HT and were pre/perimenopausal, pregnant, or had history of breast, ovarian, or other female genital cancers were excluded from analysis. Individuals with dietary intake, physical activity, and sleep duration levels that fell in outlier range were also excluded. The resulting 10,381 participants were included and classified by menopause and HT status. HT, hormone therapy.

http://links.lww.com/MENO/B524). The overall intercept of the fully adjusted model for moderate-vigorous physical activity was not significant. However, the postmenopausal/never HT group were 19.0% less likely to meet the guidelines compared with pre/perimenopausal females (odds ratio [OR]: 0.81, 95% CI: 0.66-1.00, $P = 0.049$; Table 5).

Of those who had data for sleep duration (n = 10,357), 58% (n = 6,000) met the recommendations of 7-8 hours of sleep per night (Supplemental Table 7, Supplemental Digital Content 7, http://links.lww.com/MENO/B525). The likelihood of meeting sleep guidelines was 14.0% (OR: 0.86, 95% CI: 0.74-1.00, $P = 0.048$) lower in never, 26.0% (OR: 0.74, 95% CI: 0.61-0.91, $P = 0.004$) lower in current, and 24.0% (OR: 0.76, 95% CI: 0.64-0.91, $P = 0.002$) lower in past HT users compared with pre/perimenopausal females (Table 6). When assessing those who were under or over the guidelines, 10.3% of postmenopausal/current HT users report sleeping more than 8 h/night, compared with 3.9% of pre/perimenopausal females sleeping more than 8 h/night; among never HT users, 5.0% were above the guidelines; in past HT users, 6.9% were above and 36.7% were below the sleep guidelines (Supplemental Table 7, Supplemental Digital Content 7, http://links.lww.com/MENO/B525).

DISCUSSION

The overall aim of this project was to assess dietary intake, physical activity, and sleep in relation to menopause and use of HT. We found that postmenopausal females who have never used HT consumed less fruit and vegetables compared with pre/perimenopausal females. The levels of physical activity did not differ in postmenopausal groups compared with pre/perimenopausal females, but there were lower levels of meeting of the guidelines for strength-based activity in postmenopausal/never HT users. Sleep duration was lower in postmenopausal never and past HT groups compared with pre/perimenopausal females, and all postmenopausal fe-

TABLE 1. Baseline population characteristics

	Total (N = 10,381)	Pre/perimenopausal (n = 2,050)	Postmenopausal; never HT (n = 5,185)	Postmenopausal; current HT (n = 713)	Postmenopausal; past HT (n = 2,433)	*P*
Age, y[a]	60.0 (15.0)	49.0 (5.0)	61.0 (13.0)	60.0 (9.0)	68.0 (11.0)	**< 0.001**
BMI, kg/m^2[a]	26.6 (7.3)[b]	26.0 (7.7)[c]	27.0 (7.6)[d]	25.6 (5.7)[e]	26.7 (6.6)[f]	**< 0.001**
Race						**< 0.001**
White	9,956 (95.9)	1,923 (93.8)	4,953 (95.5)	70 (98.7)	2,376 (97.7)	
Non-White	426 (4.1)	127 (6.2)	232 (4.5)	9 (1.3)	57 (2.3)	
Alcohol intake						**< 0.001**
> 1 drink/mo	7,318 (70.5)	1,514 (73.9)	3,457 (66.7)	563 (79.0)	1,784 (73.3)	
< 1 drink/mo	1,576 (15.2)	281 (13.7)	882 (17.0)	79 (11.1)	334 (13.7)	
Never	1,482 (14.3)	253 (12.3)	846 (16.3)	71 (10.0)	312 (12.8)	
Missing	5 (0.1)	2 (0.1)	0	0	3 (0.1)	
Smoking status						**< 0.001**
Current	896 (8.6)	187 (9.1)	491 (9.5)	59 (8.3)	159 (6.5)	
Past	5,738 (55.3)	1,020 (49.8)	2,795 (53.9)	438 (61.4)	1,487 (61.0)	
Never	3,687 (35.5)	831 (40.5)	1,871 (36.1)	213 (29.9)	772 (31.7)	
Missing	61 (0.6)	12 (0.6)	28 (0.5)	3 (0.4)	17 (0.7)	
Marital status						**< 0.001**
Single/never married	1,042 (10.0)	222 (10.8)	555 (10.7)	76 (10.7)	189 (7.8)	
Married/ common law	6,412 (61.8)	1,519 (74.1)	3,042 (58.7)	464 (65.1)	1,387 (57.0)	
Widowed	1,220 (11.8)	37 (1.8)	710 (13.7)	48 (6.7)	425 (17.5)	
Separate/ divorced	1,703 (16.4)	271 (13.2)	876 (16.9)	125 (17.5)	431 (17.7)	
Missing	4 (0.0)	1 (0.1)	2 (0.0)	0	1 (0.0)	
Education Level						**< 0.001**
< secondary school graduation	512 (4.9)	35 (1.7)	286 (5.5)	34 (4.8)	157 (6.5)	
Secondary school graduation	1,069 (10.3)	130 (6.3)	602 (11.6)	76 (10.7)	261 (10.7)	
Some post-secondary education	783 (7.5)	113 (5.5)	426 (8.2)	41 (5.8)	203 (8.3)	
Post-secondary degree/ diploma	8,005 (77.1)	1,771 (86.4)	3,866 (74.6)	558 (78.3)	1,816 (74.4)	
Missing	12 (0.1)	1 (0.1)	5 (0.1)	4 (0.6)	2 (0.1)	
Household income, CAD/y						**< 0.001**
< $20,000	590 (5.7)	75 (3.7)	326 (6.3)	45 (6.3)	144 (5.9)	
$20,000-$49,999	2,411 (23.2)	208 (10.1)	1,351 (26.1)	136 (19.1)	716 (29.4)	
$50,000-$99,999	3,368 (32.4)	601 (29.3)	1,684 (32.5)	229 (32.1)	854 (35.1)	
$100,000-$149,999	1,760 (17.0)	522 (25.5)	795 (15.3)	144 (20.2)	299 (12.3)	
≥ $150,000	1,484 (14.3)	554 (27.0)	621 (12.0)	111 (15.6)	198 (8.1)	
Missing	768 (7.4)	90 (4.4)	408 (7.9)	48 (6.7)	222 (9.1)	

BMI, body mass index; CAD, Canadian dollars; HT, hormone therapy.
[a]Data presented as median (interquartile range). All other data are presented as number (%). Bolded *P*-values are significant. Significance was determined using analysis of variance for continuous variables (age, BMI) or χ^2 analyses for categorical variables.
[b]n = 10,340 (41 N/A values).
[c]n = 2,045 (5 N/A values).
[d]n = 5,159 (26 N/A values).
[e]n = 709 (4 N/A values).
[f]n = 2,427 (6 N/A values).

males were less likely to meet sleep guidelines compared with pre/perimenopausal females, regardless of HT use.

Our findings align with previous findings reporting lower intakes of fruits in postmenopausal females compared with premenopausal females.[13] However, other studies have found no differences in fruit and vegetable intakes across menopausal status,[41] and, in some cases, postmenopausal females consumed more fiber[14] and were more likely to meet guidelines for vegetable and legume intake,[39] suggesting a higher propensity to consume a more healthful diet after menopause. Ovarian hormone fluctuations in estrogens and progesterone throughout the menstrual cycle have been demonstrated to affect appetite, including wanting of certain foods, cravings, and emotional eating.[42-44] Although the current analyses did not assess ovarian hormones, the relatively lower and

TABLE 2. MHBs across menopause/HT groups

Variable	Total (N = 10,381)	Pre/ perimenopausal (n = 2,050)	Postmenopausal; never HT (n = 5,185)	Postmenopausal; current HT (n = 713)	Postmenopausal; past HT (n = 2,433)	*P*
Dietary intake (frequency eaten/d)						
Grains	1.13 ± 0.73	0.98 ± 0.69	1.15 ± 0.73	1.08 ± 0.73	1.20 ± 0.73	0.471
Fruits and vegetables	4.39 ± 1.80	4.48 ± 1.86	4.31 ± 1.79	4.46 ± 1.75	4.44 ± 1.76	**< 0.001**
Proteins	2.08 ± 0.78	2.10 ± 0.78	2.05 ± 0.78	2.18 ± 0.80	2.09 ± 0.76	**< 0.001**
Dairy	2.10 ± 1.08	2.06 ± 1.06	2.07 ± 1.07	2.17 ± 1.13	2.16 ± 1.09	**0.015**
Fats	1.11 ± 0.72	1.08 ± 0.72	1.10 ± 0.72	1.12 ± 0.73	1.15 ± 0.71	**0.004**
Processed foods	1.10 ± 0.74	1.15 ± 0.74	1.08 ± 0.73	1.14 ± 0.82	1.10 ± 0.73	**< 0.001**
Physical activity (minutes/wk)						
Walking/light PA	288.74 ± 265.17	274.53 ± 252.41	291.42 ± 267.38	306.89 ± 280.14	289.54 ± 265.98	**< 0.001**
Moderate-vigorous PA	91.33 ± 154.30	107.68 ± 158.21	88.66 ± 154.26	104.69 ± 168.84	79.42 ± 145.02	0.087
Strength-based PA	31.05 ± 66.83	33.97 ± 70.26	28.21 ± 64.12	35.63 ± 68.20	33.27 ± 68.82	**< 0.001**
Sleep (h/night)						
Sleep duration	6.84 ± 1.18	6.82 ± 1.11	6.81 ± 1.17	7.04 ± 1.25	6.87 ± 1.21	**< 0.001**

Data are presented as mean ± SD. Bold *P*-values indicate statistical significance across groups, using ANCOVA adjusted for age.
HT, hormone therapy; MHB, modifiable health behavior; PA, physical activity.

more stable levels of estradiol and progesterone expected in the postmenopausal females who have never used HT could relate to reduced orexigenic hormone effects and influence dietary intake, potentially contributing to lower intakes of the fruit and vegetables group. Concurrently, it is possible that HT use resulted in a more stable hormonal profile with higher levels of ovarian hormones similar to pre/perimenopausal females, resulting in increased hunger, and lack of differences in food group intakes. To our knowledge, little to no research has assessed differences in dietary intake between those who have never used HT versus those with past HT use. Our findings suggest that there may be long-term effects of exogenous hormones that support consumption of fruit/vegetables in a postmenopausal state, even after cessation of HT use. Furthermore, older females may be more likely to underreport energy intake,[45] which could contribute to lower reports of some food groups.

TABLE 3. Main effects of menopausal and HT groups on diet, physical activity, and sleep outcomes

	Model 3	
	F	*P*
Food group intake		
Grains	0.95	0.417
Fruits and vegetables	4.34	**< 0.001**
Proteins	6.50	**< 0.001**
Dairy	1.94	0.120
Fats	0.99	0.396
Processed foods	1.00	0.394
PA		
Walking/light PA	1.11	0.342
Moderate-vigorous PA	1.03	0.378
Strength-based PA	1.85	0.137
Sleep		
Sleep duration	9.83	**< 0.001**

Model 3 = Age, body mass index, race, alcohol intake, smoking status, marital status, education level, and household income included in the model. Significance was determined using linear mixed models. F-statistic represents the contribution of menopause/HT status on each MHB outcome. Bolded *P*-values are significant.
HT, hormone therapy; PA, physical activity.

The lower intake of fruit and vegetables in postmenopausal/never HT users may also reflect a broader difference in health engagement (ie, the "healthy user bias"), rather than isolated dietary shifts related to menopause alone. Previous research has found that HT users were more likely to engage in more health-supporting behaviors, including more frequent health screenings, supplement use, higher self-esteem, lower blood pressure, and lower risk of diabetes and cardiovascular disease, even before HT initiation.[46,47] Thus, the females in the current analyses identified as postmenopausal with current or past HT use may be more health literate and consciously aim to eat more fruit and vegetables than those who have never used HT.

The present study found that there were no differences in walking/light, moderate-vigorous, or strength-based physical activity levels in postmenopausal females compared with pre/perimenopausal females. However, postmenopausal/never HT females were predicted to meet guidelines for strength-based physical activity less than pre/perimenopausal females. These findings are similar to a previous study that found moderate and vigorous physical activity did not differ across menopausal status.[48] However, these findings differ from previous studies that found either lower[49] or high physical activity levels in those who use HT compared with those who do not,[17] and studies reporting increases in high-level physical activity levels in postmenopausal females compared with premenopausal females.[50] Postmenopausal females may be more conscious of their unique physiological circumstance of menopause and have been reported to have lower perception of body image compared with perimenopausal females.[51,52] While speculative, it is pos-

TABLE 4. Post hoc comparisons of MHBs across menopausal and HT groups

	Model 3[a]	
	β ± SE	*P*
Grains (frequency eaten/d)		
Postmenopausal; never HT	0.01 ± 0.03	1.000
Postmenopausal; current HT	−0.05 ± 0.04	1.000
Postmenopausal; past HT	0.00 ± 0.04	1.000
Fruits and vegetables (frequency eaten/d)		
Postmenopausal; never HT	−0.05 ± 0.02	**0.012**
Postmenopausal; current HT	−0.02 ± 0.02	1.000
Postmenopausal; past HT	−0.03 ± 0.02	0.791
Proteins (frequency eaten/d)		
Postmenopausal; never HT	−0.02 ± 0.02	1.000
Postmenopausal; current HT	0.05 ± 0.02	0.103
Postmenopausal; past HT	0.01 ± 0.02	1.000
Dairy (frequency eaten/d)		
Postmenopausal; never HT	0.01 ± 0.02	1.000
Postmenopausal; current HT	0.07 ± 0.03	0.200
Postmenopausal; past HT	0.03 ± 0.03	1.000
Fats (frequency eaten/d)		
Postmenopausal; never HT	−0.05 ± 0.03	0.790
Postmenopausal; current HT	−0.02 ± 0.04	1.000
Postmenopausal; past HT	−0.03 ± 0.04	1.000
Processed foods (frequency eaten/d)		
Postmenopausal; never HT	−0.03 ± 0.03	1.000
Postmenopausal; current HT	0.02 ± 0.04	1.000
Postmenopausal; past HT	−0.02 ± 0.04	1.000
Light PA (minutes/wk)		
Postmenopausal; never HT	−0.01 ± 0.04	1.000
Postmenopausal; current HT	−0.004 ± 0.05	1.000
Postmenopausal; past HT	0.05 ± 0.05	1.000
Moderate-vigorous PA (minutes/wk)		
Postmenopausal; never HT	0.03 ± 0.05	1.000
Postmenopausal; current HT	0.06 ± 0.07	1.000
Postmenopausal; past HT	−0.03 ± 0.06	1.000
Strength-based PA (minutes/wk)		
Postmenopausal; never HT	−0.12 ± 0.05	0.210
Postmenopausal; current HT	−0.11 ± 0.07	0.700
Postmenopausal; past HT	−0.07 ± 0.07	1.000
Sleep (hours/d)		
Postmenopausal; never HT	−0.16 ± 0.04	**0.001**
Postmenopausal; current HT	0.05 ± 0.06	1.000
Postmenopausal; past HT	−0.14 ± 0.05	**0.035**

Pre/perimenopausal is the reference group; bolded *P*-values represent those that were significant in reference to the reference group. *P*-values are Bonferroni-adjusted for multiple comparisons.

HT, hormone therapy; MHB, modifiable health behavior.

[a]Age, body mass index, race, alcohol intake, smoking status, marital status, education level, and household income included in the model.

sible that heightened awareness of body dissatisfaction associated with menopausal changes may have motivated maintenance in participation of exercises among postmenopausal females to a similar level in pre/perimenopausal females. Although age was included as a covariate in the present analyses, age-related lifestyle factors may have also contributed to the lack of differences between pre/perimenopausal and postmenopausal females. For example, there were more widowed or separated/divorced (and therefore likely living alone) postmenopausal females than there were pre/perimenopausal females (Table 1). Time constraints experienced by younger females (pre/perimenopausal group) attributed to job-related and family-related burden, and in older females (postmenopausal/past HT group) occurrence of age-related frailty and poorer physical function may contribute to lower or similar physical activity levels between groups.[53-56]

TABLE 5. Effects of menopausal and HT status on meeting the guidelines for moderate-vigorous and strength-based physical activity

	Model 3[a]		
	β ± SE	OR (95% CI)	*P*
Moderate-vigorous activity			
Model intercept			0.670
Postmenopausal; never HT	0.04 ± 0.09	1.05 (0.88-1.24)	0.619
Postmenopausal; current HT	0.01 ± 0.12	1.01 (0.80-1.28)	0.929
Postmenopausal; past HT	−0.03 ± 0.11	0.97 (0.78-1.20)	0.761
Strength-based activity			
Model intercept			**0.018**
Postmenopausal; never HT	−0.21 ± 0.11	0.81 (0.66-1.00)	**0.049**
Postmenopausal; current HT	−0.14 ± 0.14	0.87 (0.66-1.14)	0.314
Postmenopausal; past HT	−0.03 ± 0.13	0.97 (0.76-1.24)	0.826

Bolded *P*-values are significant.

Significance was determined through binary logistic regressions.

Data are in reference to the pre/perimenopausal group.

HT, hormone therapy; OR, odds ratio.

[a]Includes age, body mass index, race, alcohol intake, smoking status, marital status, education level, and household income as covariates.

Despite lack of differences in strength-based physical activity on a continuous scale, the lower predicted adherence to meeting the strength-based physical activity guidelines in those who have never used HT may be related to estrogen decline. Estrogen supports and preserves bone and muscle function and strength, and reduced estrogen associated with post-menopause (without HT use) is associated with increased risk of musculoskeletal injury.[57,58] Relative to the pre/perimenopausal group, this increased injury risk and lower muscle strength may be related to post-menopause/never HT users meeting strength-based activity guidelines less, compared with the lack of differences in meeting guidelines among HT current and past users. It is possible that current HT users may have higher levels of estrogen and, therefore, better muscle strength, while past HT users may experience sustained effects of previous HT use that support ongoing engagement in strength-based activity. These mechanisms

TABLE 6. Effects of menopausal and HT status on meeting the guidelines for sleep

	Model 3[a]		
	β ± SE	OR (95% CI)	*P*
Sleep			
Model intercept			**0.005**
Postmenopausal; never HT	−0.15 ± 0.08	0.86 (0.74-1.00)	**0.048**
Postmenopausal; current HT	−0.30 ± 0.10	0.74 (0.61-0.91)	**0.004**
Postmenopausal; past HT	−0.28 ± 0.09	0.76 (0.64-0.91)	**0.002**

Bolded *P*-values are significant. Significance was determined through binary logistic regression. Data are in reference to the pre/perimenopausal group.

HT, hormone therapy; OR, odds ratio.

[a]Includes age, body mass index, race, alcohol intake, smoking status, marital status, education level, and household income as covariates.

may affect consistency of strength-based activity rather than overall activity volume, thus resulting in differences in meeting strength-based physical activity guidelines. Furthermore, lower adherence to strength-based physical activity guidelines in the postmenopausal/never HT group may also be related to the aforementioned health literacy and consciousness experienced by HT users.[46,47] Because physical activity is important in preventing chronic conditions[59,60] and may alleviate some menopausal symptoms,[50] future research may consider both hormonal status and broader life-stage factors that influence health behavior to better negate chronic disease risk during and after the menopause transition.

We found that sleep duration was lower in postmenopausal females who do not use HT (ie, never and past HT users), and that all postmenopausal groups were predicted to meet sleep guidelines less compared with pre/perimenopausal females. The shorter sleep duration of the postmenopausal/never HT group is similar to previous research.[18,19] These findings may be related to elevated follicle-stimulating hormone levels, as expected in postmenopausal females who do not use HT, and the lower estradiol levels associated with menopause, which have been associated with poorer sleep.[61,62] In addition, menopause-related vasomotor and urogenital symptoms can contribute to sleep disturbances, but these symptoms may be alleviated by HT, thereby improving sleep indirectly, and may have resulted in similar sleep duration to pre/perimenopausal females.[19,63] While we did not find differences in sleep duration on a continuous scale in current HT users, our findings of all postmenopausal groups being less likely to meet the sleep guidelines may be attributed to the fact that more HT users reported sleep that exceeded the guidelines. The National Sleep Foundation guidelines recommend achieving 7-9 hours of sleep for those 24-65 years old, and 7-8 hours for those aged ≥65 years.[37] Our definition of "meeting guidelines" for sleep was 7-8 hours, in line with the guidelines for those aged 65 or older.[37] Some females in these groups may be younger than 65 years old, for whom this narrower range may not accurately reflect whether their sleep met age-appropriate guidelines. Nonetheless, obtaining too much sleep has been associated with negative effects on health.[37,64] Therefore, how adherence to sleep guidelines varies across menopause and HT status warrants further investigation to ensure sleep behaviors support health across the menopause transition.

To our knowledge, this is the first study to assess meeting of national guidelines for physical activity and sleep according to menopause status and HT in a large cohort of middle-aged and older females. Furthermore, the current study was strengthened through the use of a large sample size and assessment of both menopause and HT status. In addition, many previous studies group females dichotomously as HT users or non-users. Our study further categorized females as having never used HT, currently using HT, or have used HT in the past (but not currently using), which may provide insight on longer-term effects of HT on MHBs. However, some limitations should be considered. Firstly, there is limited information about menopausal and HT status in the CLSA, such as last menstrual period, cycle regularity, or other information to differentiate those who were premenopausal versus perimenopausal. The analysis was also limited to information on sex, with no data on gender identity, and, therefore, conclusions on the impact of possible gender roles on these results cannot be determined. The minimal racial diversity of this study's participant population restricts the applicability of our results to more diverse populations. Future research should aim to include a broader demographic representation to determine if similar findings would result among different racial groups. Although our approach to deriving physical activity levels was similar to previous research,[33-35] to our knowledge, this method has not been used to compare activity patterns to physical activity guidelines and may limit comparability with existing estimates. Data on all MHBs were also collected with questionnaires, which are prone to recall biases.[65] Furthermore, our analyses were cross-sectional and, therefore, may not capture how MHBs may evolve over time. Future longitudinal research may uncover more nuanced relationships between MHBs and menopausal and HT status.

CONCLUSION

In conclusion, our findings suggest that menopause and HT are associated with MHBs in midlife and older females. Patterns of dietary intake, physical activity, and sleep appear to differ across menopausal and HT groups, reflecting multifaceted relationships among biological changes with health behaviors. MHBs can be readily adapted to accommodate individual needs and provide promising avenues for improving health outcomes. It is also important to consider the possibility of healthy user bias in these findings, in which females who use HT or are more engaged in health care may differ systematically from non-HT users with respect to socioeconomic resources, access to care, and health literacy. Although we adjusted for many sociodemographic covariates, unmeasured factors may remain unaccounted for in this observational data. Nonetheless, given the increased risk of chronic disease after menopause, identifying underlying mechanisms between these MHBs and both endogenous and exogenous hormones may offer valuable strategies to support healthy aging in females. Longitudinal research is needed to clarify how health behaviors may change over time and to inform tailored public health strategies that may consider hormonal status and broader life contexts to promote healthy aging in females.

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REFERENCES

1. Palacios S, Henderson VW, Siseles N, Tan D, Villaseca P. Age of menopause and impact of climacteric symptoms by geographical region. *Climacteric* 2010;13:419-428. doi:10.3109/13697137.2010.507886
2. Santoro N, Epperson CN, Mathews SB. Menopausal symptoms and their management. *Endocrinol Metab Clin North Am* 2015;44: 497-515. doi:10.1016/j.ecl.2015.05.001
3. Lobo RA, Davis SR, De Villiers TJ, et al. Prevention of diseases after menopause. *Climacteric* 2014;17:540-556. doi:10.3109/13697137.2014.933411.
4. *National Institutes of Health State-of-the-Science Conference Statement: Management of Menopause-Related Symptoms*. NIH Consens State Sci Statements 2005; 1–38.
5. DiBonaventura M, Luo X, Moffatt M, Bushmakin AG, Kumar M, Bobula J. The association between vulvovaginal atrophy symptoms and quality of life among postmenopausal women in the United States and Western Europe. *J Womens Health* 2015;24:713-722. doi:10.1089/jwh.2014.5177
6. Zhang GQ, Chen JL, Luo Y, et al. Menopausal hormone therapy and women's health: an umbrella review. *PLoS Med* 2021;18: e1003731. doi:10.1371/journal.pmed.1003731
7. Costanian C, Edgell H, Ardern CI, Tamim H. Hormone therapy use in the canadian longitudinal study on aging: a cross-sectional analysis. *Menopause* 2018;25:46. doi:10.1097/GME.0000000000000954
8. Hodis HN, Mack WJ. The timing hypothesis and hormone replacement therapy: a paradigm shift in the primary prevention of coronary heart disease in women. Part 1: comparison of therapeutic efficacy. *J Am Geriatr Soc* 2013;61:1005-1010. doi:10.1111/jgs.12140
9. Cauley JA, Robbins J, Chen Z, et al. Effects of estrogen plus progestin on risk of fracture and bone mineral density: the women's health initiative randomized trial. *JAMA* 2003;290:1729. doi:10.1001/jama.290.13.1729
10. Gosset A, Pouillès JM, Trémollieres F. Menopausal hormone therapy for the management of osteoporosis. *Best Pract Res Clin Endocrinol Metab* 2021;35:101551. doi:10.1016/j.beem.2021.101551
11. Schierbeck LL, Rejnmark L, Tofteng CL, et al. Effect of hormone replacement therapy on cardiovascular events in recently postmenopausal women: randomised trial. *Brit Med J* 2012;345: e6409-e6409. doi:10.1136/bmj.e6409
12. Hodis HN, Mack WJ. Menopausal hormone replacement therapy and reduction of all-cause mortality and cardiovascular disease: it is about time and timing. *Cancer J* 2022;28:208-223. doi:10.1097/PPO.0000000000000591
13. Bhurosy T, Jeewon R. Food habits, socioeconomic status and body mass index among premenopausal and post-menopausal women in M auritius. *J Human Nutrition Diet* 2013;26:114-122. doi:10.1111/jhn.12100
14. Duval K, Prud'homme D, Rabasa-Lhoret R, et al. Effects of the menopausal transition on dietary intake and appetite: a MONET Group Study. *Eur J Clin Nutr* 2014;68:271-276. doi:10.1038/ejcn.2013.171
15. Lovejoy JC, Champagne CM, De Jonge L, Xie H, Smith SR. Increased visceral fat and decreased energy expenditure during the menopausal transition. *Int J Obes* 2008;32:949-958. doi:10.1038/ijo.2008.25
16. Duval K, Prud'homme D, Rabasa-Lhoret R, et al. Effects of the menopausal transition on energy expenditure: a MONET group study. *Eur J Clin Nutr* 2013;67:407-411. doi:10.1038/ejcn.2013.33
17. Andersen RE, Crespo CJ, Franckowiak SC, Walston JD. Leisure-time activity among older U.S. women in relation to hormone-replacement-therapy initiation. *J Aging Phys Act* 2003;11:82-89. doi:10.1123/japa.11.1.82
18. Gaston SA, Park YM, McWhorter KL, Sandler DP, Jackson CL. Multiple poor sleep characteristics and metabolic abnormalities consistent with metabolic syndrome among white, black, and Hispanic/Latina women: modification by menopausal status. *Diabetol Metab Syndr* 2019;11:17. doi:10.1186/s13098-019-0413-2
19. Young T, Rabago D, Zgierska A, Austin D, Finn L. Objective and subjective sleep quality in premenopausal, perimenopausal, and postmenopausal women in the wisconsin sleep cohort study. *Sleep* 2003;26:667-672. doi:10.1093/sleep/26.6.667
20. Kalleinen N, Polo-Kantola P, Himanen SL, et al. Sleep and the menopause – do postmenopausal women experience worse sleep than premenopausal women? *Menopause Int* 2008;14:97-104. doi:10.1258/mi.2008.008013
21. Zolfaghari S, Yao C, Thompson C, et al. Effects of menopause on sleep quality and sleep disorders: Canadian Longitudinal Study on Aging. *Menopause* 2020;27:295-304. doi:10.1097/GME.0000000000001462
22. Raina P, Wolfson C, Kirkland S, et al. Cohort profile: the Canadian longitudinal study on aging (CLSA). *Int J Epidemiol* 2019;48: 1752-1753j. doi:10.1093/ije/dyz173
23. Raina PS, Wolfson C, Kirkland SA, et al. The Canadian longitudinal study on aging (CLSA). *Can J Aging* 2009;28:221-229. doi:10.1017/S0714980809990055
24. Hammond NG, Stinchcombe A. Prospective associations between physical activity and memory in the canadian longitudinal study on aging: examining social determinants. *Res Aging* 2022;44:709-723. doi:10.1177/01640275211070001
25. Shatenstein B, Payette H. Evaluation of the relative validity of the short diet questionnaire for assessing usual consumption frequencies of selected nutrients and foods. *Nutrients* 2015;7:6362-6374. doi:10.3390/nu7085282
26. Gilsing A, Mayhew AJ, Payette H, et al. Validity and reliability of a short diet questionnaire to estimate dietary intake in older adults in a subsample of the canadian longitudinal study on aging. *Nutrients* 2018;10:1522. doi:10.3390/nu10101522
27. Katamay SW, Esslinger KA, Vigneault M, et al. Eating well with Canada's Food Guide: development of the food intake pattern. *Nutr Rev.* 2007;65:155–166. doi:10.1111/j.1753-4887.2007.tb00295.x.
28. Tessier AJ, Presse N, Rahme E, Ferland G, Bherer L, Chevalier S. Milk, yogurt, and cheese intake is positively associated with cognitive executive functions in older adults of the canadian longitudinal study on aging. *J Gerontol A Biol Sci Med Sci* 2021;76: 2223-2231. doi:10.1093/gerona/glab165
29. Washburn RA, Smith KW, Jette AM, Janney CA. The physical activity scale for the elderly (PASE): development and evaluation. *J Clin Epidemiol* 1993;46:153-162. doi:10.1016/0895-4356(93)90053-4
30. Boysen G, Krarup LH, Zeng X, et al. ExStroke pilot trial of the effect of repeated instructions to improve physical activity after ischaemic stroke: a multinational randomised controlled clinical trial. *Brit Med J* 2009;339:b2810. doi:10.1136/bmj.b2810
31. Segal NA, Torner JC, Yang M, Curtis JR, Felson DT, Nevitt MC. Multicenter Osteoarthritis Study Group. Muscle mass is more strongly related to hip bone mineral density than is quadriceps strength or lower activity level in adults over age 50 year. *J Clin Densitom* 2008;11:503-510. doi:10.1016/j.jocd.2008.03.001
32. Goldstein MG, Pinto BM, Marcus BH, et al. Physician-based physical activity counseling for middle-aged and older adults: a

randomized trial. *Ann Behav Med* 1999;21:40-47. doi:10.1007/BF02895032
33. Palazuelos-González RA, Oude Voshaar RC, Liefbroer AC, Smidt N. Impact of physical activities, sedentarism, and sleep on depression and psychological distress-prospective findings of the Canadian longitudinal study on aging. *J Affect Disord* 2025;385: 119413. doi:10.1016/j.jad.2025.119413
34. Dogra S, Good J, Buman MP, Gardiner PA, Stickland MK, Copeland JL. Movement behaviours are associated with lung function in middle-aged and older adults: a cross-sectional analysis of the Canadian longitudinal study on aging. *BMC Public Health* 2018;18:818. doi:10.1186/s12889-018-5739-4
35. O'Brien MW, Theou O. Relation between frailty and hypertension is partially mediated by physical activity among males and females in the Canadian Longitudinal Study on Aging. *Am J Physiol Heart Circulatory Physiol* 2024;327:H108-H117. doi:10.1152/ajpheart.00179.2024
36. Canadian Society for Exercise Physiology. *Canadian 24-Hour Movement Guidelines for Adults Aged 18-64 Years: An Integration of Physical Activity, Sedentary Behaviour, and Sleep.* 2021. Accessed February 10, 2024. https://csepguidelines.ca/guidelines/adults-18-64/
37. Hirshkowitz M, Whiton K, Albert SM, et al. National Sleep Foundation's updated sleep duration recommendations: final report. *Sleep Health* 2015;1:233-243. doi:10.1016/j.sleh.2015.10.004
38. Posit team. RStudio: Integrated Development Environment for R. Posit Software, PBC, Boston, MA. 2025. http://www.posit.co/
39. Ball K, Mishra GD, Thane CW, Hodge A. How well do Australian women comply with dietary guidelines? *Public Health Nutr* 2004;7: 443-452. doi:10.1079/PHN2003538
40. Macdonald HM, New SA, Campbell MK, Reid DM. Longitudinal changes in weight in perimenopausal and early postmenopausal women: effects of dietary energy intake, energy expenditure, dietary calcium intake and hormone replacement therapy. *Int J Obes* 2003; 27:669-676. doi:10.1038/sj.ijo.0802283
41. Reimer RA, Debert CT, House JL, Poulin MJ. Dietary and metabolic differences in pre- versus postmenopausal women taking or not taking hormone replacement therapy. *Physiol Behav* 2005;84: 303-312. doi:10.1016/j.physbeh.2004.12.011
42. Klump KL, Keel PK, Racine SE, et al. The interactive effects of estrogen and progesterone on changes in emotional eating across the menstrual cycle. *J Abnorm Psychol* 2013;122:131-137. doi:10.1037/a0029524
43. Hirschberg AL. Sex hormones, appetite and eating behaviour in women. *Maturitas* 2012;71:248-256. doi:10.1016/j.maturitas.2011.12.016
44. Gorczyca AM, Sjaarda LA, Mitchell EM, et al. Changes in macronutrient, micronutrient, and food group intakes throughout the menstrual cycle in healthy, premenopausal women. *Eur J Nutr* 2016;55:1181-1188. doi:10.1007/s00394-015-0931-0
45. Briefel RR, Sempos CT, McDowell MA, Chien S, Alaimo K. Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *Am J Clin Nutr* 1997;65:1203S-1209S. doi:10.1093/ajcn/65.4.1203S
46. Gleason CE, Dowling NM, Friedman E, Wharton W, Asthana S. Using predictors of hormone therapy use to model the healthy user bias: how does healthy user status influence cognitive effects of hormone therapy? *Menopause* 2012;19:524-533. doi:10.1097/gme.0b013e318238ff2c
47. Rödström K, Bengtsson C, Lissner L, Björkelund C. Pre-existing risk factor profiles in users and non-users of hormone replacement therapy: prospective cohort study in Gothenburg, Sweden. *Gen Pract* 1999;319:890-893. doi:10.1136/bmj.319.7214.890
48. Sternfeld B, Bhat AK, Wang H, Sharp T, Quesenberry CP. Menopause, physical activity, and body composition/fat distribution in midlife women. *Med Sci Sports Exercise* 2005;37: 1195-1202. doi:10.1249/01.mss.0000170083.41186.b1
49. Macêdo PRS, Macêdo SGGF, Velez MP, Câmara SMA. Menopause hormone therapy and physical performance: The Canadian Longitudinal Study on Aging. *Maturitas* 2024;184: 107959. doi:10.1016/j.maturitas.2024.107959
50. Dąbrowska-Galas M, Dąbrowska J, Ptaszkowski K, Plinta R. High physical activity level may reduce menopausal symptoms. *Medicina (B Aires)* 2019;55:466. doi:10.3390/medicina55080466
51. Gümüşsoy S, Öztürk R, Keskin G, Özlem Yıldırım G. Effects of surgical and natural menopause on body image, self-esteem, and dyadic adjustment: a descriptive and comparative study. *Clin Nurs Res* 2023;32:712-722. doi:10.1177/10547738221114588
52. Schoppen S, Carbajal A, Pérez-Granados AM, Vivas F, Vaquero MP. Food, energy and macronutrient intake of postmenopausal women from a menopause program. *Nutr Hosp* 2005;20:101-109.
53. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001;56: M146-M157. doi:10.1093/gerona/56.3.M146
54. Perrig-Chiello P, Höpflinger F. Aging parents and their middle-aged children: demographic and psychosocial challenges. *Eur J Ageing* 2005;2:183-191. doi:10.1007/s10433-005-0003-z
55. Statistics Canada *Table 14-10-0060-01 Retirement age by class of worker, annual.* Government of Canada; 2025. doi:10.25318/1410006001-eng
56. Doan T, Yu P, LaBond C, Gong C, Strazdins L. Time for physical activity: different, unequal, gendered. *J Health Soc Behav* 2022;63: 37-54. doi:10.1177/00221465211028910
57. Chidi-Ogbolu N, Baar K. Effect of estrogen on musculoskeletal performance and injury risk. *Front Physiol* 2019;9:1834. doi:10.3389/fphys.2018.01834
58. Kodete CS, Thuraka B, Pasupuleti V, Malisetty S. Hormonal influences on skeletal muscle function in women across life stages: a systematic review. *Muscles* 2024;3:271-286. doi:10.3390/muscles3030024
59. Geraci A, Calvani R, Ferri E, Marzetti E, Arosio B, Cesari M. Sarcopenia and menopause: the role of estradiol. *Front Endocrinol* 2021;12:682012. doi:10.3389/fendo.2021.682012
60. Beitz R, Dören M. Physical activity and postmenopausal health. *British Menopause Society Journal* 2004;10:70-74. doi:10.1258/136218004774202382
61. Kravitz HM, Janssen I, Santoro N, et al. Relationship of day-to-day reproductive hormone levels to sleep in midlife women. *Arch Intern Med* 2005;165:2370. doi:10.1001/archinte.165.20.2370
62. Kravitz HM, Zhao X, Bromberger JT, et al. Sleep disturbance during the menopausal transition in a multi-ethnic community sample of women. *Sleep* 2008;31:979-990. doi:10.5665/sleep/31.7.979
63. Cintron D, Lahr BD, Bailey KR, et al. Effects of oral versus transdermal menopausal hormone treatments on self-reported sleep domains and their association with vasomotor symptoms in recently menopausal women enrolled in the Kronos Early Estrogen Prevention Study (KEEPS). *Menopause* 2018;25:145-153. doi:10.1097/GME.0000000000000971
64. Janssen I, Clarke AE, Carson V, et al. A systematic review of compositional data analysis studies examining associations between sleep, sedentary behaviour, and physical activity with health outcomes in adults. *Appl Physiol Nutr Metab* 2020;45:S248-S257. doi:10.1139/apnm-2020-0160
65. Althubaiti A. Information bias in health research: definition, pitfalls, and adjustment methods. *JMDH* 2016;20:211-217. doi:10.2147/JMDH.S104807

