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Effects of ethinyl estradiol-containing oral contraception and other factors on body composition and muscle strength among young healthy females in Finland—A cross-sectional study

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ABSTRACT

Objective: The aim of this cross-sectional study was to determine the association of hormonal contraception and other life-style factors and habits affecting body composition (BC) and muscle strength.

Study design: We measured the body composition of 400 healthy Finnish women (aged 20–40 years) using total body dual energy x-ray absorptiometry (TB-DXA) as well as grip strength (GS [kPa]) with a hand-held dynamometer and knee extension strength (KES [kg]) between 2011 and 2014. Investigated body composition variables were appendicular skeletal mass (ASM [kg]), body mass index (BMI [kg/m^2]), relative skeletal muscle index (RSMI [ASM/m^2]), total lean mass (TLM [kg]), skeletal muscle index (SMI [TLM/weight × 100]) and fat-%. Participants filled out a questionnaire concerning life-style factors and habits: hormonal contraception, physical activity, alcohol consumption, age, pregnancies, smoking and self-assessed health that were also adjusting factors in the covariate model. We investigated the effects of hormonal contraception and other life-style factors and habits on body composition and muscle strength using AN(C)OVA in the analyses.

Results: Women using hormonal contraception with the combination of ethinyl estradiol + progestogen had significantly lower mean ASM (18.0), RSMI (6.5), TLM (40.8) ($p < 0.01$) and GS (34.6) ($p < 0.001$) compared to the women not using hormonal contraception with mean values of ASM (18.8), RSMI (6.7), TLM (42.6) and GS (36.9). After adjustment ASM (18.3), SMI (64.3), GS (35.2) ($p < 0.05$), RSMI (6.6) and TLM (41.2) ($p < 0.01$) were significantly lower and fat-% (31.4) higher ($p < 0.05$) compared to women not using hormonal contraception with mean values of ASM (19.0), SMI (66.1), GS (36.7), RSMI (6.8), TLM (42.7) and fat-% (29.8).

Conclusion: Use of ethinyl estradiol + progestogen-containing hormonal contraception may have negative association with muscle mass and strength.

Introduction

Body composition varies from adolescence to adulthood and further in to old age [1]. The shares of muscle and bone mass are relatively high in early adulthood and decrease with age [1,2], while the proportion of fat mass increases with age [1]. Decreased muscle and bone mass increases the risk of physical impairments, frailty and fractures [2–4].

Among the female population, hormonal contraception (HC) is widely used along with non-hormonal methods of contraception. The most used HC methods in Finland are systemic ethinyl estradiol (EE) + progestogen and EE + cypreterone acetate combined oral contraceptives (COC), progestogen only pills, subcutaneous implants or intrauterine devices (IUD) with progestogen as well as vaginal rings with estrogen + progestogen [5].

Use of depot medroxyprogesterone acetate (DMPA) has been previously associated with higher fat mass [6–8] and simultaneous use of estrogen may lessen the effects of DMPA [8]. Furthermore, use of DMPA has been reported to decrease bone mass [9,10], which is reversible if the use of DMPA is discontinued [10]. In addition, current use and use history of DMPA has been recently

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associated with increased fracture risk [11]. Another recently published study suggests that in comparison with hormonal IUD, copper IUD and hormonal subcutaneous implant did not significantly affect body weight and composition during a 12-month follow-up [12]. However, studies concerning effects of life-style factors and habits on body composition (BC) and muscle strength among young females are few and far between.

The aim of this study was to examine the effects of HC as well as other life-style factors and habits on BC and muscle strength among healthy young Finnish women.

Materials and methods

Study population and enquiry data

The study population consisted of 400 healthy young females living in Kuopio, Eastern Finland. We assembled the study population between May 2011 and June 2014 using electronic and conventional paper flyers inviting the students and staff of the University of Eastern Finland, Kuopio, Kuopio University Hospital and Savonia University of Applied Sciences, Kuopio to participate in the study. The inclusion criteria were: 1) no chronic diseases or continuous medication (excluding contraceptives); 2) no orthopaedic or other major implants within the body; 3) age 20–40 years; 4) no current pregnancy; 5) no previous ovariectomy (uni- or bilateral). Trained study nurses checked these validity criteria prior to the measurements. In addition, all participants declared that they were not pregnant at the time and gave informed consent for the study. The study population planned to recruit participants according to equally distributed quartiles (20–24, 25–29, 30–34, 35–40 years, n = 100/quartile). The ethical committee of the University of Eastern Finland and Kuopio University Hospital approved the study protocol. We gathered the study population to form a reference population for later comparison of postmenopausal women (from the OSTPRE study) and healthy young Finnish females. However, the primary aim of the research was to investigate the effects of HC and other life-style factors and habits on body composition and muscle strength.

Participants completed a short enquiry same day prior to measurements including questions of general life-style factors such as alcohol consumption, self-assessed health, smoking, physical activity, pregnancies and use of HC. We asked about *alcohol intake* with the question: "How many servings of alcohol do you consume weekly?" and then categorised responses as "None", "More than one, but less than three" and "Three or more servings" for the analyses. We asked about *self-assessed health* with the options "Excellent", "Good", "Moderate", "Poor" and "Very poor" and finally categorised responses as "Moderate", "Good" and "Excellent" for the analyses since none of the participants assessed their health below "Moderate". We asked about *smoking habits* with the options "Continuously", "Occasionally" and "Not at all" and dichotomised responses into "Not at all" and "Occasionally or continuously" for the analyses. We asked about *physical exercise* with question, "How many times per week do you perform physical exercise leading to sweating and heavy breathing?" with the options "Daily", "4–6 times per week", "2–3 times per week", "1 time per week", "Less than once" and divided responses into categorised variable in which "1 time per week" and "less than once" were combined into the single category of "once a week or less". The questionnaire also included a self-reported question on the *number of pregnancies* (excluding miscarriages), which we categorised into "No pregnancy", "One pregnancy" and "Two or more pregnancies" for the analyses. Finally, we collected information about the *use of HC* (oral, vaginal, subcutaneous or intrauterine) and the brand name of the contraception. We categorised women in four groups according to use of contraception "No use", "systemic progestogen (progestogen only pills and subcutaneous implants)", "hormonal IUD" and "EE + progestogen (including oral and vaginal contraceptives)". In addition, we divided the group reporting "EE + progestogen COC" into subgroups according to the amount of EE: "15 μg ≤ EE≤20 μg i.e. low-dose" and" 25 μg ≤ EE≤35 μg i.e. standard-dose". Furthermore, we replaced separate use of HC with use of EE in the covariate model since using hormonal contraception and "use of EE" in the same model causes high collinearity. Women using IUD or systemic progestogen (N = 69) were excluded from the EE dose-dependent analysis. Invalid information was obtained from five participants concerning the use of HC and was therefore excluded from all HC analyses. None of the study subjects used injectable DMPA contraception and one study subject used copper IUD, which we included in the "No use" group.

Total body dual energy x-ray absorptiometry (TB-DXA) and muscle strength measurements

Trained study nurses carried out TB-DXA measurements between 2011 and 2014 at the Kuopio Musculoskeletal Research Unit (KMRU), University of Eastern Finland, Kuopio, Finland. This study used a Lunar Prodigy DXA to measure the first 204 participants and later on a Lunar iDXA replaced the Lunar Prodigy DXA for the last 196 measurements with the imaging and analysis protocols provided by the manufacturer (Lunar Co, Madison, WI, USA), as described earlier [13,14]. Study nurses performed quality standards according to the manufacturer instructions. The reproducibility of this method has been reported previously [15–17]. We used information from the BC (lean mass, fat mass and bone mass) measurements to build key dependent variables. Based on the recommendation of several working groups for the definition of sarcopenia [18,19] we used the following indicators for sarcopenia: Sum of lean mass of both arms and legs defined *appendicular skeletal mass (ASM)* [19]. We calculated *skeletal mass index (SMI)* by dividing total lean mass with body weight and multiplying by 100 [19] as well as *relative skeletal muscle index* (RSMI) by dividing ASM by the square of height [20–22]. Fat mass divided by body weight defined *fat percent (fat-%)* as well as weight divided by the square of height (kg/m^2) defined *body mass index* (BMI). TB-DXA measurement provided information of *total lean mass* (TLM)(kg).

We measured *grip strength* (GS) of the dominant hand with a hand-held dynamometer (Jamar; Saehan corporation, Masan, Korea) and reported in kPa. To calculate a mean GS, each participant had one attempt to perform three valid GS measurements and we used a knee extensor bench to measure *knee extension strength* (KES) and reported KES in kg (Metitur, Finland) [23]. We calculated mean KES using three valid results from both legs and excluded women that did not succeed in performing a full set of either GS or KES measurements separately from GS or KES groups. We measured the weight of each participant with a calibrated scale (Philips Type HF 351/00) and reported in kg as well as height using a calibrated stadiometer (Harpenden stadiometer) and reported in cm.

Statistical methods

For statistical analyses we used the Statistical Package for Social Sciences (SPSS ver. 24, SPSS Inc., Chicago, Illinois, USA) for Macintosh. We used the general linear model (GLM) ANOVA method to describe the statistical differences between the groups with a Least Significant Difference (LSD) test for comparison of multiple groups. In the covariate analysis, we entered all the following variables simultaneously into the model: alcohol consumption, self-assessed health, smoking, physical activity, pregnancies, age and use of HC.

Results

Table 1 presents the characteristics of the study population (n = 400). The mean age was 30.4 (±6.1). Almost half of the women (47.3%) reported no use of HC and out of those who did use HC, 6.3% used systemic progestogen, 11.1% IUD and 35.2% COC. In all, 19.7% used low-dose OC (15 μg ≤ EE≤20 μg) and 15.4% used standard-dose OC (25 μg ≤ EE≤35 μg).

Body composition

Table 2 presents the analysis of variance (ANOVA) and Table 3 the multivariate model (ANCOVA) of the effect of HC and other risk factors on BC. Mean TLM for the population was 42.1 kg (standard deviation [SD] 5.0 kg), ASM 18.6 kg (2.7 kg) and fat percent 29.5% (7.0%). Mean GS was 36.2 kPa (5.4 kPa) and KES 49.8 kg (10.0 kg).

Table 1
Characteristics of the study population (n = 400).

A) Continuous variables	Mean	SD
Age (years)	30.4	6.1
Anthropometric measurements:		
Height (cm)	166.6	5.9
Weight (kg)	64.1	11.2
BMI (kg / m^2)	23.1	3.7
Dual-energy x-ray absorptiometry:		
Appendicular skeletal mass (ASM [kg])	18.6	2.7
Relative skeletal muscle index (RSMI [ASM / m^2])	6.7	0.8
Skeletal mass index (SMI [TLM / weight (kg) × 100])	66.4	7.1
Fat percent (%)	29.5	7.0
Total lean mass (TLM [kg])	42.1	5.0
Grip strength (GS [kPa])	36.2	5.4
Knee extension strength (KES [kg])	49.8	10.0
Total bone mass (kg)	2.5	0.3
Total bone mineral density (BMD [g/cm^2])	1.2	0.1
B) Categorical variables	%	
Use of hormonal contraception		
No	47.3	
Yes		
Systemic progestogen (mini-pills and subcutaneous implants)	6.3	
Intrauterine device with progestogen	11.1	
Combination of ethinyl estradiol and progestogen (pills or ring)	35.2	
Use of ethinyl estradiol (EE) according to EE dose of OC		
No use	57.4	
Yes		
Low-dose; 15 μg ≤ EE ≤ 20μg	23.9	
Standard-dose; 25 μg ≤ EE ≤ 35μg	18.7	
Physical activity (times/week)		
Once a week or less	11.8	
2 – 3 times per week	42.0	
4 – 6 times per week	37.5	
Daily	8.8	
Alcohol consumption (servings/week)		
None	49.5	
1 or 2 servings	32.0	
Three or more servings	18.5	
Age (years)		
20 to 24	23.5	
25 to 29	24.8	
30 to 34	23.0	
35 to 40	28.7	
Pregnancies		
None	59.5	
One	10.5	
Two or more	30.0	
Smoking status		
Non-smoker	88.5	
Occasionally or daily	11.5	
Self-assessed health		
Moderate	8.3	
Good	58.8	
Very good	33.0	

Hormonal contraception

Women who used systemic progestogen did not differ with regard to any BC variable compared to women not using HC.

Users of hormonal IUD had higher BMI ($p < 0.01$), RSMI, fat-% ($p < 0.05$) and lower SMI ($p < 0.05$) in comparison with women not using HC. Higher fat-% and lower SMI ($p < 0.05$) remained significant among IUD users after adjustments.

Women who used a combination of EE + progestogen had lower ASM, RSMI, TLM ($p < 0.01$) and GS ($p < 0.001$) compared to non-users of HC. After adjustment ASM, SMI, GS ($p < 0.05$), RSMI and TLM ($p < 0.01$) prevailed significantly lower and fat-% higher ($p < 0.05$) compared to the women not using HC.

Dose of ethinyl estradiol

In the univariate model (Table 2), women who used a low-dose EE (15 μg ≤ EE≤20 μg) had lower ASM ($p < 0.05$), RSMI, TLM ($p < 0.01$) and GS ($p < 0.001$) compared to the women not using HC.

Women who used a standard-dose EE (25 μg ≤ EE≤35 μg) also had lower ASM, RSMI, KES, TLM ($p < 0.05$) and GS ($p < 0.01$) in compared to women not using HC. There was no difference in BMI, SMI and fat-% between groups according to use of EE-containing OC (Table 2).

After adjustment for multiple covariates, users of low-dose EE had lower RSMI, SMI, GS and TLM ($p < 0.05$) compared to women not using HC. Standard-dose users had lower ASM, RSMI, GS, KES and TLM ($p < 0.05$) in comparison to women not using HC.

Physical activity

Women who exercised 2–3 times per week had higher ASM, RSMI ($p < 0.01$), SMI, GS, KES ($p < 0.05$) and TLM ($p < 0.001$) and lower fat-% ($p < 0.05$) compared to the least physically active group (Table 2). Adjustment for multiple covariates did not diminish the differences and higher ASM, RSMI, TLM ($p < 0.01$), SMI, GS, KES ($p < 0.05$) and lower fat-% ($p < 0.05$) remained significant after adjustments (Table 3). Women exercising 4–6 times per week had the same kind of differences in their BC profile compared to the least-active group in univariate and multivariate models (Tables 2 and 3). Furthermore, women who exercised daily had related differences but did not differ in GS compared to the least-active group (Tables 2 and 3). There were no differences in BMI in comparison of women who exercised once a week or less with the more active groups (Tables 2 and 3).

The interactive term of physical activity and HC, as well as amount of EE used, was not significant in any of the BC variables ($p > 0.6$ in all).

Other life-style factors and habits

Tables 2 and 3 present effects of alcohol consumption, age, pregnancies, smoking and self-assessed health on BC. Those who smoked had a higher BMI and fat-% ($p < 0.01$) compared to women not smoking. Adjustment for multiple covariates did not alter the differences. Older age had an extensive effect on BC (Tables 2 and 3) compared to the youngest quartile. Alcohol consumption did not have an effect on BC or muscle strength in the multivariate model.

Women who assessed their health as “very good” had lower BMI, fat-% and higher SMI ($p < 0.001$) in comparison to women with “moderate” self-assessed health. Higher SMI and lower fat-% ($p < 0.001$) remained significant as well as lower BMI ($p < 0.01$).

Table 2
Life-style factors and habits affecting body composition (BC) and muscle strength among the healthy Finnish female population (20–40 years old). Analysis of variance (n = 400), univariate model.

Univariate model	ASM (95% CI)	BMI (95% CI)	RSMI (95% CI)	SMI (95% CI)	Fat-% (95% CI)	GS (95% CI)	KES (95% CI)	TLM (95% CI)	Age (95% CI)
Hormonal contraception									
No use †	18.8 (18.4–19.2)	23.1 (22.6–23.7)	6.7 (6.6–6.9)	66.9 (65.9–68.0)	29.1 (28.1–30.1)	36.9 (36.2–37.7)	50.2 (48.8–51.7)	42.6 (41.9–43.3)	31.4 (30.6–32.2)
Systemic progestogen	18.7 (17.6–19.7)	23.1 (21.7–24.6)	6.9 (6.6–7.2)	67.5 (64.7–70.3)	28.6 (25.8–31.3)	37.3 (35.2–39.3)	51.7 (47.8–55.6)	42.0 (40.0–43.9)	29.6 (27.4–31.8)
IUD	19.7 (18.9–20.5)	24.8 (23.7–25.9)**	7.0 (6.8–7.3)*	64.2 (62.1–66.3)*	32.0 (29.9–34.1)*	37.2 (35.6–38.8)	52.5 (49.6–55.5)	43.8 (42.4–45.3)	35.5 (33.9–37.2)***
EE + Progestogen	18.0 (17.5–18.4)**	22.4 (21.8–23.0)	6.5 (6.3–6.6)**	66.2 (65.0–67.4)	29.6 (28.5–30.8)	34.6 (33.8–35.5)***	48.1 (46.5–49.8)	40.8 (40.0–41.7)**	27.7 (26.8–28.7)***
Use of EE containing oral contraception									
No Use †	18.8 (18.4–19.2)	23.1 (22.6–23.7)	6.7 (6.6–6.9)	66.9 (65.9–68.0)	29.1 (28.1–30.1)	36.9 (36.2–37.7)	50.2 (48.8–51.7)	42.6 (41.9–43.3)	31.4 (30.7–32.2)
15 μg ≤ EE ≤ 20μg	18.0 (17.4–18.6)*	22.4 (21.6–23.2)	6.5 (6.3–6.6)**	66.0 (64.4–67.6)	29.6 (28.0–31.2)	34.5 (33.3–35.7)***	48.8 (46.6–51.1)	40.7 (39.6–41.9)**	26.9 (25.6–28.2)***
25 μg ≤ EE ≤ 35μg	18.0 (17.3–18.6)*	22.4 (21.5–23.3)	6.5 (6.3–6.7)*	66.3 (64.5–68.1)	29.7 (27.9–31.4)	34.8 (33.5–36.1)**	47.2 (44.7–49.8)*	40.9 (39.7–42.2)*	28.8 (27.3–30.3)**
Physical activity (times/week)									
Once a week or less †	17.1 (16.3–17.8)	23.1 (22.1–24.2)	6.2 (6.0–6.4)	62.3 (60.3–64.2)	33.6 (31.7–35.5)	34.3 (32.8–35.9)	44.5 (41.7–47.3)	39.0 (37.6–40.4)	30.4 (28.7–32.1)
2–3 times	18.4 (18.0–18.8)**	23.4 (22.9–24.0)	6.6 (6.5–6.7)**	64.9 (63.9–65.9)*	31.1 (30.1–32.1)*	36.5 (35.7–37.3)*	48.5 (47.0–49.9)*	41.7 (41.0–42.4)***	31.6 (30.7–32.5)
4–6 times	19.2 (18.8–19.6)***	22.9 (22.3–23.5)	6.9 (6.7–7.0)***	68.3 (67.2–69.3)***	27.8 (26.8–28.9)***	36.8 (35.9–37.6)**	52.5 (50.9–54.0)***	43.2 (42.4–44.0)***	29.8 (28.8–30.7)
Daily	19.0 (18.2–19.9)***	22.1 (20.9–23.3)	6.9 (6.6–7.1)***	71.3 (69.1–73.6)***	24.6 (22.4–26.8)***	34.9 (33.2–36.7)	51.6 (48.4–54.8)**	43.1 (41.5–44.8)***	28.1 (26.1–30.1)
Alcohol use (servings/week)									
None †	18.8 (18.4–19.2)	23.1 (22.6–23.6)	6.8 (6.7–6.9)	67.0 (66.0–68.0)	29.0 (28.0–30.0)	36.2 (35.4–36.9)	50.3 (48.9–51.7)	42.4 (41.7–43.1)	29.9 (29.1–30.8)
1 or 2 servings	18.3 (17.9–18.8)	22.7 (22.1–23.3)	6.6 (6.4–6.7)*	66.4 (65.1–67.6)	29.6 (28.3–30.8)	35.8 (34.8–36.7)	49.1 (47.4–50.9)	41.5 (40.6–42.4)	31.2 (30.2–32.3)
Three or more servings	18.6 (18.0–19.2)	23.7 (22.9–23.5)	6.7 (6.5–6.9)	64.9 (63.2–66.5)*	31.0 (29.4–32.6)*	36.9 (35.7–38.2)	49.5 (47.2–51.8)	42.2 (41.0–43.3)	30.5 (29.1–31.9)
Age (years)									
20 to 24 †	17.7 (17.2–18.2)	21.9 (21.1–22.6)	6.4 (6.2–6.5)	67.5 (66.1–68.9)	28.0 (26.6–29.4)	34.1 (33.1–35.2)	46.0 (44.0–48.0)	40.6 (39.6–41.6)	
25 to 29	18.4 (17.9–18.9)	22.6 (22.0–23.3)	6.7 (6.6–6.9)**	67.5 (66.1–68.9)	28.6 (27.2–30.0)	35.4 (34.4–36.5)	50.5 (48.6–52.5)**	41.4 (40.4–42.4)	
30 to 34	18.9 (18.3–19.4)**	22.9 (22.1–23.6)	6.7 (6.5–6.8)*	66.4 (64.9–67.8)	29.7 (28.2–31.1)	36.7 (35.7–37.8)***	51.3 (49.2–53.3)***	42.5 (41.5–43.5)**	
35 to 40	19.3 (18.9–19.8)***	24.6 (23.9–25.2)***	6.9 (6.8–7.1)***	64.6 (63.3–65.9)**	31.6 (30.3–32.8)***	38.1 (37.2–39.1)***	51.0 (49.2–52.8)***	43.5 (42.6–44.4)***	
Pregnancies									
None †	18.4 (18.1–18.8)	22.7 (22.2–23.1)	6.6 (6.5–6.7)	67.0 (66.1–67.9)	28.8 (28.0–29.7)	35.4 (34.7–36.1)	49.5 (48.2–50.8)	41.7 (41.1–42.4)	27.3 (26.7–27.9)
One	18.3 (17.5–19.1)	22.4 (21.3–23.5)	6.6 (6.3–6.8)	66.5 (64.4–68.7)	29.4 (27.2–31.5)	36.2 (34.6–37.8)	49.3 (46.2–52.3)	41.1 (39.6–42.6)	32.8 (31.3–34.2)***
Two or more	19.1 (18.6–19.6)*	24.1 (23.4–24.7)***	6.8 (6.7–7.0)*	65.2 (63.9–66.4)*	31.1 (29.8–32.3)**	37.7 (36.8–38.7)***	50.6 (48.8–52.4)	43.1 (42.2–44.0)*	35.8 (35.0–36.7)***
Smoking									
No †	18.5 (18.3–18.8)	22.9 (22.5–23.2)	6.7 (6.6–6.7)	66.8 (66.1–67.5)	29.2 (28.5–29.9)	36.1 (35.5–36.6)	49.5 (48.5–50.6)	42.0 (41.5–42.5)	30.5 (29.8–31.1)
Occasionally or daily	19.2 (18.4–20.0)	24.7 (23.6–25.7)**	6.9 (6.7–7.2)*	63.5 (61.4–65.5)**	32.4 (30.4–34.4)**	37.2 (35.7–38.8)	51.9 (49.0–54.8)	42.8 (41.3–44.2)	30.4 (28.7–32.2)
Self-assessed health									
Moderate †	18.2 (17.2–19.1)	24.5 (23.3–25.8)	6.6 (6.3–6.9)	61.3 (59.0–63.6)	34.4 (32.2–36.7)	34.8 (33.0–36.7)	46.8 (43.4–50.2)	40.9 (39.2–42.6)	29.8 (27.7–31.9)
Good	18.5 (18.1–18.8)	23.4 (22.9–23.8)	6.7 (6.6–6.8)	65.5 (64.6–66.4)***	30.5 (29.6–31.3)**	36.2 (35.5–36.8)	50.0 (48.7–51.3)	41.8 (41.2–42.5)	31.0 (30.3–31.8)
Very good	19.0 (18.5–19.4)	22.2 (21.6–22.8)***	6.8 (6.6–6.9)	69.3 (68.2–70.5)***	26.7 (25.6–27.9)***	36.6 (35.7–37.5)	50.1 (48.4–51.8)	42.8 (42.0–43.7)*	29.6 (28.5–30.6)

Comparison is made by comparing groups to the first group of the variable marked with †.
Significance in ANOVA (Least significant difference – LSD) $p < 0.05$=*, $p < 0.01$=**, $p < 0.001$=***.
ASM = Appendicular skeletal mass (kg).
BMI = Body mass index (kg/m^2).
RSMI = Relative skeletal muscle index (ASM/m^2).
SMI = Skeletal mass index (Total lean mass/weight x 100).
Fat-%=Fat percent (%).
GS = Grip strength (kPa).
KES = Knee extension strength (kg).
TLM = Total lean mass (kg).
EE = Ethinyl estradiol.
IUD = Progestogen containing intrauterine device.

Table 3
Life-style factors and habits affecting body composition (BC) and muscle strength among the healthy Finnish female population (20–40 years old). Analysis of variance (n = 400), multivariate model.

Adjusted model	ASM (95% CI)	BMI (95% CI)	RSMI (95% CI)	SMI (95% CI)	Fat-% (95% CI)	GS (95% CI)	KES (95% CI)	TLM (95% CI)
Hormonal contraception								
No use †	19.0	23.7	6.8	66.1	29.8	36.7	50.4	42.7
	(18.4–19.6)	(22.8–24.5)	(6.7–7.0)	(64.5–67.6)	(28.3–31.4)	(35.5–38.0)	(48.1–52.7)	(41.5–43.8)
Systemic progestogen	18.8	23.4	6.9	66.8	29.1	37.4	51.4	42.1
	(17.7–19.9)	(21.9–25.0)	(6.6–7.2)	(64.0–69.7)	(26.3–31.9)	(35.2–39.7)	(47.1–55.7)	(40.0–44.2)
IUD	19.4	24.7	7.0	63.7	32.2	35.7	51.6	43.0
	(18.4–20.3)	(23.4–26.0)	(6.7–7.3)	(61.4–66.1)*	(29.8–34.5)*	(33.8–37.5)	(48.1–55.1)	(41.2–44.7)
EE + Progestogen	18.3	23.4	6.6	64.3	31.4	35.2	48.6	41.2
	(17.6–19.0)*	(22.5–24.3)	(6.4–6.8)**	(62.5–66.0)*	(29.7–33.2)*	(33.8–36.6)*	(46.0–51.2)	(39.9–42.4)**
Physical activity (times/week)								
Once a week or less †	17.4	23.8	6.4	61.2	34.6	34.9	45.6	39.4
	(16.6–18.3)	(22.7–25.0)	(6.1–6.6)	(59.1–63.3)	(32.5–36.7)	(33.2–36.6)	(42.4–48.7)	(37.8–41.0)
2–3 times	18.7	24.0	6.8	64.0	31.8	36.7	49.0	41.9
	(18.0–19.3)**	(23.1–24.8)	(6.6–7.0)**	(62.4–65.6)*	(30.3–33.4)*	(35.4–38.0)*	(46.6–51.4)*	(40.7–43.0)**
4–6 times	19.6	23.8	7.1	66.8	29.2	37.5	53.6	43.7
	(18.9–20.4)***	(22.9–24.8)	(6.9–7.3)***	(65.0–68.6)***	(27.5–31.0)***	(36.1–38.9)**	(51.0–56.3)***	(42.4–45.0)***
Daily	19.6	23.6	7.1	68.9	26.9	36.0	53.8	43.9
	(18.6–20.7)***	(22.1–25.0)	(6.8–7.4)***	(66.3–71.6)***	(24.3–29.5)***	(33.9–38.2)	(49.8–57.8)***	(41.9–45.9)***
Alcohol use (servings/week)								
None †	19.1	24.0	6.9	65.4	30.6	36.2	50.9	42.5
	(18.4–19.7)	(23.1–24.8)	(6.7–7.1)	(63.8–67.0)	(29.0–32.1)	(34.9–37.5)	(48.6–53.3)	(41.3–43.7)
1 or 2 servings	18.7	23.4	6.8	65.7	30.1	35.7	50.1	41.8
	(18.0–19.4)	(22.4–24.3)	(6.5–7.0)	(63.9–67.5)	(28.4–31.8)	(34.3–37.2)	(47.5–52.8)	(40.5–43.2)
Three or more servings	18.8	24.1	6.8	64.6	31.2	36.8	50.4	42.3
	(18.0–19.6)	(23.0–25.2)	(6.6–7.1)	(62.6–66.6)	(29.2–33.2)	(35.2–38.5)	(47.4–53.4)	(40.8–43.8)
Age (years)								
20 to 24 †	18.0	22.6	6.6	66.7	28.8	34.9	46.9	40.9
	(17.2–18.9)	(21.5–23.8)	(6.3–6.8)	(64.5–68.8)	(26.7–30.9)	(33.1–36.6)	(43.7–50.1)	(39.3–42.5)
25 to 29	18.5	23.5	6.8	65.9	30.1	35.5	50.9	41.4
	(17.8–19.3)	(22.5–24.5)	(6.6–7.1)*	(64.0–67.9)	(28.2–32.0)	(34.0–37.1)	(48.1–53.8)**	(40.0–42.8)
30 to 34	19.3	23.7	6.9	65.5	30.5	36.9	52.6	43.0
	(18.5–20.0)**	(22.7–24.7)	(6.6–7.1)*	(63.6–67.4)	(28.6–32.3)	(35.4–38.4)*	(49.8–55.3)***	(41.6–44.4)**
35 to 40	19.6	25.4	7.0	62.8	33.2	37.8	51.6	43.6
	(18.8–20.3)**	(24.4–26.4)***	(6.8–7.3)***	(60.9–64.7)***	(31.3–35.0)***	(36.3–39.3)**	(48.8–54.4)**	(42.2–44.9)**
Pregnancies								
None †	19.0	24.4	6.9	64.0	31.9	35.8	51.0	42.5
	(18.4–19.6)	(23.6–25.3)	(6.7–7.0)	(62.4–65.6)	(30.3–33.4)	(34.6–37.1)	(48.6–53.3)	(41.3–43.7)
One	18.5	23.0	6.7	66.1	29.6	36.0	49.8	41.4
	(17.6–19.5)	(21.7–24.3)*	(6.5–7.0)	(63.8–68.5)	(27.3–31.9)	(34.2–37.9)	(46.3–53.3)	(39.7–43.2)
Two or more	19.0	24.0	6.9	65.6	30.5	37.0	50.7	42.7
	(18.2–19.8)	(23.0–25.1)	(6.7–7.1)	(63.6–67.5)	(28.5–32.4)	(35.4–38.5)	(47.8–53.7)	(41.3–44.2)
Smoking								
No †	18.5	22.9	6.7	66.7	29.2	35.8	49.4	41.7
	(17.9–19.0)	(22.2–23.6)	(6.5–6.8)	(65.4–68.1)	(27.9–30.5)	(34.8–36.9)	(47.4–51.4)	(40.7–42.7)
Occasionally or daily	19.3	24.7	7.0	63.7	32.1	36.7	51.6	42.7
	(18.4–20.1)	(23.5–25.9)**	(6.7–7.2)*	(61.5–65.9)**	(29.9–34.3)**	(34.9–38.5)	(48.3–54.9)	(41.1–44.4)
Self-assessed health								
Moderate †	19.1	25.1	6.9	62.6	33.2	35.9	50.7	42.5
	(18.1–20.1)	(23.7–26.5)	(6.6–7.2)	(60.0–65.1)	(30.7–35.7)	(33.8–37.9)	(46.9–54.5)	(40.6–44.4)
Good	18.5	23.6	6.7	65.2	30.6	36.0	50.7	41.6
	(17.9–19.1)	(22.8–24.4)*	(6.6–6.9)	(63.8–66.7)*	(29.2–32.0)*	(34.8–37.1)	(48.5–52.9)	(40.5–42.7)
Very good	19.0	22.7	6.8	67.9	28.1	37.0	50.1	42.5
	(18.3–19.7)	(21.8–23.7)**	(6.6–7.0)	(66.1–69.7)***	(26.3–29.8)***	(35.6–38.4)	(47.5–52.8)	(41.2–43.8)

All groups are compared to the to the first group within the variable marked with †. Variables are adjusted for all the other variables listed above on left.
Significance in multivariate ANOVA (Least significant difference – LSD) $p < 0.05$=*,$p < 0.01$=**, $p < 0.001$=***.
ASM = Appendicular skeletal mass (kg).
BMI = Body mass index (kg/m^2).
RSMI = Relative skeletal muscle index (ASM/m^2).
SMI = Skeletal mass index (Total lean mass/weight x 100).
Fat-%=Fat percent (%).
GS = Grip strength (kPa).
KES = Knee extension strength (kg).
TLM = Total lean mass (kg).
EE = Ethinyl estradiol.
IUD = Progestogen containing intrauterine device.

Comment

The present cross-sectional study investigated life-style factors and habits affecting BC and muscle strength among healthy Finnish women aged 20–40 years. Women who used COC were significantly younger in comparison to women who did not use HC. Younger women had lower muscle strength compared to the older participants. Moreover, women that used COC had lower muscle mass and weaker GS compared to women not using HC. Even though the COC-using women were younger the independent effect of EE + progestogen contraception remained significant after adjustments. Use of oral progestogen did not have an effect on BC profile or

muscle strength. Use of low- and standard-dose EE was associated with lower TLM and weaker GS. Adjustment for multiple covariates did not alter the differences. Furthermore, those who used standard-dose EE had lower KES and the difference persisted after adjustments. Both low and standard-dose EE groups had lower relative skeletal muscle index compared to women not using EE.

There are no other cross-sectional studies with a relatively large young female population concerning life-style factors and habits affecting BC and muscle strength as far as we know. Prospective studies have been presented previously concerning use of HC [6–12]. The effect of DMPA on BC has been under the scope of previous research efforts. It has been suggested that use of DMPA is associated with increased fat mass [6–8] but combined use of estrogen may lessen this effect [8]. An investigation suggests that the use of a combination of EE + chlormadinone acetate has a decreasing effect on fat mass when estimating BC with multifrequency bioelectrical impedance analysis [24]. In addition, a previous study reports that use of standard-dose EE does not cause fat or weight gain among young female runners [25]. Moreover, a recently published cohort study suggests that use of HC is associated with higher risk of breast cancer in women between 15–49 years old [26]. Even though the present study does not focus on the association of HC and breast cancer, it is important to knowledge that the hormonal contraception is associated with increased risk for breast cancer.

Moreover, this study found that physical activity is associated with higher muscle mass and strength, as well as lower fat mass. However, women who exercised daily did not have better GS than those who exercised once a week or less, even though they had higher KES. Previous studies suggest that physical activity and exercise have an association with increased total lean mass [27,28], muscle strength [29,30] and decreased fat mass [30,27]. In this study, older age seemed to have a positive association with fat and muscle mass, as well as muscle strength among women aged between 20–40 years old. Use of alcohol did not have an effect to BC. However, a previous study suggests an association between daily use of alcohol and increased adiposity, despite low average alcohol consumption [31]. Women who smoked occasionally or daily tended to have a higher BMI, appendicular skeletal mass and fat percent. Smoking did not have an effect on total lean mass. High self-assessed health has been previously associated with better physical performance [32]. Those who assessed their health as “good” or “very good” had higher SMI, lower BMI and fat percent in the adjusted model but did not differ in muscle strength measurements.

A strength of the present study is the relatively large homogenous study population with strictly controlled BC and muscle strength measurements, as well as detailed information about life style factors and habits. In addition we used a DXA scanner, which is considered to be the gold-standard measurement of BC [33].

In conclusion, use of EE-containing COC may have negative effects on muscle mass and strength, but an increasing effect on fat mass. This study is cross-sectional and does not take into account how long women have been using HC. Furthermore, depending on the amount of EE consumed, various EE dosages may have different effects on BC. Therefore, this matter requires more comprehensive long-term investigation and a randomised controlled study design.

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