A)

lm(formula = poor.bone ~ low.calc, data = bh)

Residuals:

Min 1Q Median 3Q Max

-0.21627 -0.09459 -0.09459 -0.09459 0.90541

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 0.094585 0.008621 10.972 < 2e-16 \*\*\*

low.calc 0.121681 0.016575 7.341 3.07e-13 \*\*\*

Residual standard error: 0.3293 on 1998 degrees of freedom

Multiple R-squared: 0.02626, Adjusted R-squared: 0.02578

F-statistic: 53.89 on 1 and 1998 DF, p-value: 3.069e-13

The crude effect of low calcium intake on bone health is overall a significant model (F = 53.89, p < 0.001) indicating low calcium intake predicting poor bone health. In the binomial model, log(1) unit of low.calc will lead to log(0.122) unit of increase in poor bone health (p < 0.001).

B)

glm(formula = poor.bone ~ phy.index, family = binomial, data = bh)

Coefficients:

Estimate Std. Error z value Pr(>|z|)

(Intercept) -1.179836 0.263814 -4.472 7.74e-06 \*\*\*

phy.index -0.018986 0.006637 -2.860 0.00423 \*\*

glm(formula = low.calc ~ phy.index, family = binomial, data = bh)

Coefficients:

Estimate Std. Error z value Pr(>|z|)

(Intercept) 0.472908 0.203418 2.325 0.0201 \*

phy.index -0.037544 0.005154 -7.284 3.23e-13 \*\*\*

Physical activity index being the confounders for the effect of calcium intake on bone health as indicated in the above; the p values for two coefficients are both significant (p < 0.001, p < 0.01).

C)

lm(formula = poor.bone ~ low.calc \* male, data = bh)

lm(formula = poor.bone ~ low.calc + male, data = bh)

(Intercept) 0.06476 0.01131 5.726 1.19e-08 \*\*\*

low.calc 0.12151 0.01651 7.359 2.70e-13 \*\*\* main effects

male 0.05945 0.01467 4.052 5.26e-05 \*\*\* main effects

low.calc:male 0.12082 0.03292 3.670 0.000249 \*\*\* interaction effect

Residual standard error: 0.327 on 1996 degrees of freedom

Multiple R-squared: 0.04068, Adjusted R-squared: 0.03924

F-statistic: 28.21 on 3 and 1996 DF, p-value: < 2.2e-16

The result suggests moderation effect of sex on calcium intake on bone health, p < 0.001 while the coefficient for sex (B=0.12, p < 0.001) and calcium intake (B = 0.059, p< 0.001) are both significant.

lm(formula = poor.bone ~ low.calc \* age, data = bh)

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) -0.0016585 0.0954928 -0.017 0.986

low.calc 0.1159639 0.1855998 0.625 0.532

age 0.0107314 0.0106041 1.012 0.312

low.calc:age 0.0005651 0.0205157 0.028 0.978

The result suggests moderation effect of age on calcium intake on bone health does not hold, as the interaction term is not significant, p = 0.978.

D)

lm(formula = poor.bone ~ low.calc \* male + age + phy.index + bmi + low.income, data = bh)

Coefficients:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Estimate | S.E | t | p | 5% CI | 95%CI |
| (Intercept) | -0.14707 | 0.099141 | -1.48344 | 0.138116 | -0.34139 | 0.047247 |
| low.calc | 0.058964 | 0.023418 | 2.51784 | 0.011886 | 0.013064 | 0.104864 |
| male | 0.028195 | 0.017066 | 1.65212 | 0.098668 | -0.00525 | 0.061644 |
| age | 0.010363 | 0.008982 | 1.153769 | 0.248733 | -0.00724 | 0.027968 |
| phy.index | -0.00132 | 0.000729 | -1.80552 | 0.071144 | -0.00275 | 0.000113 |
| bmi | 0.007042 | 0.001832 | 3.845009 | 0.000124 | 0.003452 | 0.010632 |
| low.income | -0.01545 | 0.019465 | -0.79393 | 0.42733 | -0.0536 | 0.022697 |
| low.calc:male | 0.115419 | 0.032819 | 3.516888 | 0.000446 | 0.051095 | 0.179744 |

Residual standard error: 0.3257 on 1992 degrees of freedom

Multiple R-squared: 0.05016, Adjusted R-squared: 0.04683

F-statistic: 15.03 on 7 and 1992 DF, p-value: < 2.2e-16

The result has shown that the model with variables of calcium intake (B = -0.147, p = 0.012), sex (B = 0.028, p = 0.099), age (B = 0.01, p = 0.25), physical index (B = -0.001, p = 0.071), bmi (B = 0.07, p < 0.001), low household income (B = 0.015, p = 0.42), calcium intake (B = 0.12, p < 0.001). CI for each variables are respectively reported.

**E)**

lm(formula = poor.bone ~ low.calc + age + phy.index + bmi + low.income, data = bh, subset = (male == 1))

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) -0.3701744 0.1522893 -2.431 0.015244 \*

low.calc 0.1741874 0.0254821 6.836 1.42e-11 \*\*\*

age 0.0278159 0.0136372 2.040 0.041642 \*

phy.index -0.0009597 0.0011030 -0.870 0.384484

bmi 0.0100992 0.0028695 3.519 0.000452 \*\*\*

low.income -0.0315763 0.0293077 -1.077 0.281558

Residual standard error: 0.3528 on 999 degrees of freedom

Multiple R-squared: 0.06602, Adjusted R-squared: 0.06135

F-statistic: 14.12 on 5 and 999 DF, p-value: 2.271e-13

lm(formula = poor.bone ~ low.calc + age + phy.index + bmi + low.income, data = bh, subset = (male == 0))

Coefficients:

Estimate Std. Error t value Pr(>|t|)

(Intercept) 0.0929475 0.1260485 0.737 0.46106

low.calc 0.0569789 0.0213648 2.667 0.00778 \*\*

age -0.0067214 0.0116356 -0.578 0.56363

phy.index -0.0016776 0.0009486 -1.769 0.07727 .

bmi 0.0042947 0.0022997 1.868 0.06212 .

low.income -0.0001752 0.0254312 -0.007 0.99450

Residual standard error: 0.2952 on 989 degrees of freedom

Multiple R-squared: 0.01533, Adjusted R-squared: 0.01035

F-statistic: 3.079 on 5 and 989 DF, p-value: 0.009164

The result has shown that the final model is significant (F = 14.12, p < 0.001) in the male subgroup, in which calcium intake (B = 0.174, p < 0.001), age (B = 0.0278, p < 0.05), and bmi (B = 0.01, p < 0.001) are significant. While in the female subgroup, only calcium intake is significant (B = 0.057, P < 0.01).

F)

fit lwr upr

0.248802 -0.3933217 0.8909257

The probability of poor bone health is 24.9%, with rate range of -0.39 to 0.89.

G)

Result in A has shown that low calcium intake will lead to poor bone health, while result in F, on the contrary, shows that even an individual with low calcium intake, his or her poor bone health still depends on other variables such as age, gender, physical activity, bmi, and household income.

The crude effect of low calcium intake on bone health is overall a significant model (F = 53.89, p < 0.001) indicating low calcium intake predicting poor bone health. In the binomial model, log(1) unit of low.calc will lead to log(0.122) unit of increase in poor bone health (p < 0.001).

Even though the confounders (sex and physical activity) are identified, there are no measures being made to deal with the confounders. The moderation effect of sex is found to adjust the relationship between calcium intake and bone health. While moderation effect of age is not significant.

In the final model, the result has shown that the model with variables of calcium intake (B = -0.147, p = 0.012), sex (B = 0.028, p = 0.099), age (B = 0.01, p = 0.25), physical index (B = -0.001, p = 0.071), bmi (B = 0.07, p < 0.001), low household income (B = 0.015, p = 0.42), calcium intake (B = 0.12, p < 0.001). CI for each variables are respectively reported. Final model in gender subgroups have been reported separately: for the male group, calcium intake (B = 0.174, p < 0.001), age (B = 0.0278, p < 0.05), and bmi (B = 0.01, p < 0.001) are significant. While in the female subgroup, only calcium intake is significant (B = 0.057, P < 0.01).

msm <- read.csv("exam\_question2.csv")

# a)

msm$logOR <- log(msm$OR)

ecig$se.logOR <- (log(ecig$OR.ub)-log(ecig$OR.lb))/(2\*1.96)

msm.fe <- rma(yi=prev, sei=comorbid.s, slab=study, method="FE", data=msm)

# Q3

bh <- read.csv("exam\_question3.csv")

# a

summary(lm(poor.bone~low.calc, data=bh))

# b

pairs(bh)

summary(glm(poor.bone~phy.index, data=bh, family=binomial))

summary(glm(low.calc~phy.index, data=bh, family=binomial))

# c

summary(lm(poor.bone~low.calc\*male,data=bh))

summary(lm(poor.bone~low.calc+male,data=bh))

summary(lm(poor.bone~low.calc\*age,data=bh))

summary(lm(poor.bone~low.calc+age,data=bh))

# d

bh.d=summary(lm(poor.bone~low.calc\*male+age+phy.index+bmi+low.income, data=bh))

hb = as.vector(coef(bh.d)[,1]+coef(bh.d)[,2]\*1.96)

lb = as.vector(coef(bh.d)[,1]-coef(bh.d)[,2]\*1.96)

cbind(coef(bh.d),lb,hb)

# e

summary(lm(poor.bone~low.calc+age+phy.index+bmi+low.income, data=bh, subset=(male==1)))

summary(lm(poor.bone~low.calc+age+phy.index+bmi+low.income, data=bh, subset=(male==0)))

# f

bh.f=lm(poor.bone~low.calc\*male+age+phy.index+bmi+low.income, data=bh)

data <- data.frame(age=10,male=1, phy.index=65,bmi=mean(bh$bmi),low.income=1,low.calc=1)

predict(bh.f, data, interval="prediction")