Interaction with both forms

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```
# simulate hyt, age, and physical activity among 500 individuals
set.seed(1000)
# age standardized
age = rnorm(500, mean = 0, sd = 1)

age2g <- age < 1.0 # dichotomize age into older and younger group

# physical activity standardized
physical = rnorm(500, mean = 0, sd = 1)

# assumed interaction effect between age2g and physical activity
lp = -2 + 0.68 * age2g - 2 * physical - 3*age2g*physical
link_lp = exp(lp)/(1 + exp(lp))

# generate hypertension binary outcome
hyt = (runif(500) < link_lp)

# correct model
log.int <-  glm(hyt ~ age2g + physical + age2g*physical, family=binomial)
summary(log.int)
```

```
##
## Call:
## glm(formula = hyt ~ age2g + physical + age2g * physical, family = binomial)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -2.37323  -0.29932  -0.06273   0.15375   2.65435
##
## Coefficients:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)         -2.2275     0.5176  -4.304 1.68e-05 ***
## age2gTRUE            0.9371     0.5616   1.669 0.095212 .
## physical            -1.9307     0.4977  -3.879 0.000105 ***
## age2gTRUE:physical  -3.0025     0.7311  -4.107 4.01e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 661.05  on 499  degrees of freedom
## Residual deviance: 240.35  on 496  degrees of freedom
## AIC: 248.35
```

```
##
## Number of Fisher Scoring iterations: 7
```

```
# model with age (cont. adjusted) + physical
m0.1 <- glm(hyt ~ age + physical, family=binomial)
summary(m0.1)
```

```
##
## Call:
## glm(formula = hyt ~ age + physical, family = binomial)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -2.49310  -0.35905  -0.08354   0.24546   2.51361
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -1.3958     0.1877  -7.438 1.03e-13 ***
## age          -0.6620     0.1799  -3.680 0.000233 ***
## physical     -3.7438     0.3558 -10.521  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 661.05  on 499  degrees of freedom
## Residual deviance: 271.33  on 497  degrees of freedom
## AIC: 277.33
##
## Number of Fisher Scoring iterations: 7
```

```
# model with age (cont. adjutest) + physical + physical * age2g
m0.2 <- glm(hyt ~ age + physical + physical * age2g, family=binomial)
summary(m0.2)
```

```
##
## Call:
## glm(formula = hyt ~ age + physical + physical * age2g, family = binomial)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -2.39308  -0.29848  -0.06335   0.15386   2.63418
##
## Coefficients:
##                    Estimate Std. Error z value Pr(>|z|)
## (Intercept)        -2.09978    0.65597  -3.201 0.001369 **
## age                -0.08288    0.26274  -0.315 0.752413
## physical           -1.92803    0.49766  -3.874 0.000107 ***
## age2gTRUE           0.78760    0.73543   1.071 0.284195
## physical:age2gTRUE -3.00598    0.73142  -4.110 3.96e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
```

```
##     Null deviance: 661.05  on 499  degrees of freedom
## Residual deviance: 240.25  on 495  degrees of freedom
## AIC: 250.25
##
## Number of Fisher Scoring iterations: 7
```

```
lmtest::lrtest(m0.1, m0.2)
```

```
## Likelihood ratio test
##
## Model 1: hyt ~ age + physical
## Model 2: hyt ~ age + physical + physical * age2g
##   #Df  LogLik Df Chisq Pr(>Chisq)
## 1   3 -135.67
## 2   5 -120.13  2 31.08  1.782e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# linear comparison (b0, b2, b3, b4, b5)
names(coef(m0.2))
```

```
## [1] "(Intercept)"        "age"                "physical"
## [4] "age2gTRUE"          "physical:age2gTRUE"
```

```
# we want physical effect in older age
library(multcomp)

summary(glht(m0.2, linfct = c("physical + physical:age2gTRUE = 0")))
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Fit: glm(formula = hyt ~ age + physical + physical * age2g, family = binomial)
##
## Linear Hypotheses:
##                                    Estimate Std. Error z value Pr(>|z|)
## physical + physical:age2gTRUE == 0  -4.9340     0.5358  -9.208   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```
# Show the confidence interval
mod.lh <- glht(m0.2, linfct = c("physical + physical:age2gTRUE = 0"))
confint(mod.lh)
```

```
##
##   Simultaneous Confidence Intervals
##
## Fit: glm(formula = hyt ~ age + physical + physical * age2g, family = binomial)
##
## Quantile = 1.96
## 95% family-wise confidence level
##
##
## Linear Hypotheses:
##                                    Estimate lwr     upr
## physical + physical:age2gTRUE == 0 -4.9340  -5.9842 -3.8838
```

```r
exp(-4.9340) ; exp(-5.9842); exp(-3.8838)
```

```
## [1] 0.007197655
```

```
## [1] 0.002518227
```

```
## [1] 0.0205725
```

```r
# physical effect in younger age

exp(-1.92803) ; exp(-1.92803 - 1.96 * 0.49766); exp(-1.92803 + 1.96 * 0.49766)
```

```
## [1] 0.1454344
```

```
## [1] 0.05483407
```

```
## [1] 0.3857305
```

```r
# correct effects
# linear comparison (b0, b2, b3, b4)
names(coef(log.int))
```

```
## [1] "(Intercept)"        "age2gTRUE"          "physical"
## [4] "age2gTRUE:physical"
```

```r
# we want physical effect in older age
summary(glht(log.int, linfct = c("physical + age2gTRUE:physical = 0")))
```

```
##
##   Simultaneous Tests for General Linear Hypotheses
##
## Fit: glm(formula = hyt ~ age2g + physical + age2g * physical, family = binomial)
##
## Linear Hypotheses:
##                                    Estimate Std. Error z value Pr(>|z|)
## physical + age2gTRUE:physical == 0  -4.9332     0.5355  -9.212   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## (Adjusted p values reported -- single-step method)
```

```r
# Show the confidence interval
mod.lh <- glht(log.int, linfct = c("physical + age2gTRUE:physical = 0"))
confint(mod.lh)
```

```
##
##   Simultaneous Confidence Intervals
##
## Fit: glm(formula = hyt ~ age2g + physical + age2g * physical, family = binomial)
##
## Quantile = 1.96
## 95% family-wise confidence level
##
##
## Linear Hypotheses:
##                                    Estimate lwr     upr
## physical + age2gTRUE:physical == 0 -4.9332  -5.9828 -3.8835
```

```r
exp(-4.9332) ; exp(-5.9828); exp(-3.8835)
```

```
## [1] 0.007203415
```

```
## [1] 0.002521755
## [1] 0.02057867
```

```
# physical effect in younger age

exp(-1.9307) ; exp(-1.9307 - 1.96 * 0.4977); exp(-1.9307 + 1.96 * 0.4977)
```

```
## [1] 0.1450466
## [1] 0.05468357
## [1] 0.3847321
```