

waveley_attempt

Waveley Qiu (wq2162)

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How does an athlete's measure of athletic identity affect MHC-SF, as mediated through resilience?

Latent Variable Construction

Latent Variable 1: Athletic Identity

First, let's select the variables we are interested in.

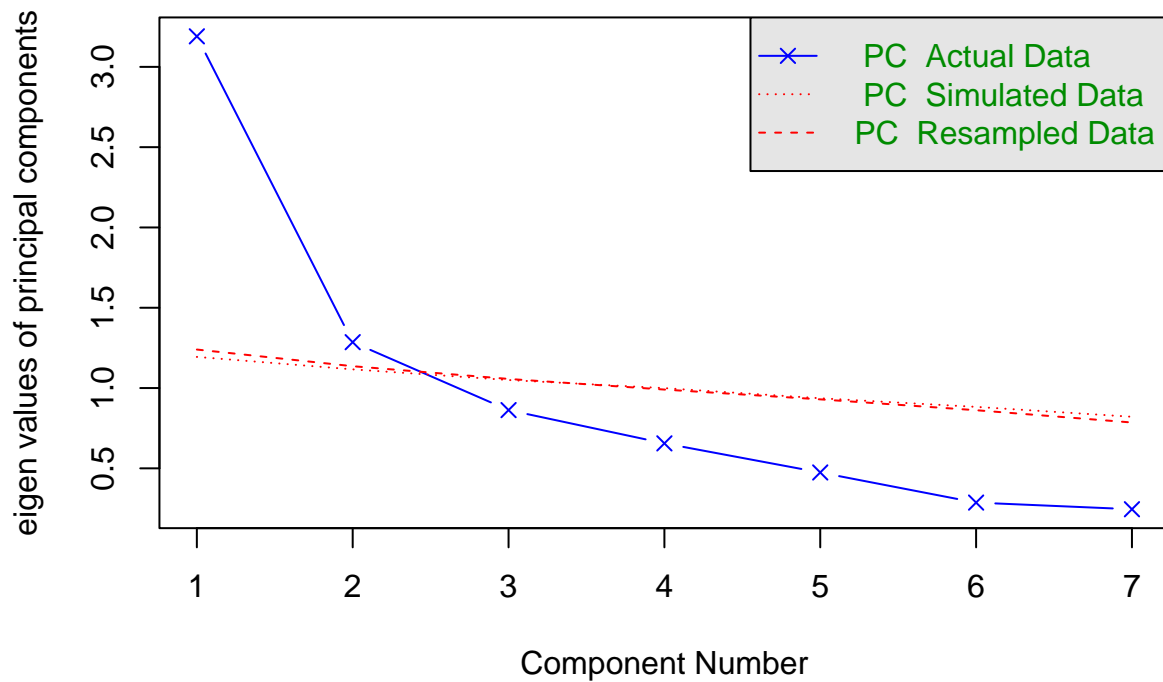
```
athletic_identity <- c("cnsdr_ath", "sprr_goals", "frnds_ath", "sprr_impt", "think_sprr", "bad_sprr", "
athletic_identity_numeric <- athletes[,athletic_identity] %>% map_df(., as.numeric)
athletic_identity_matrix <- athletic_identity_numeric %>% as.matrix()
```

Polychoric Correlations

Now, let us determine the number of factors that might underlie these variables.

```
athlete_parallel <- fa.parallel(athletic_identity_matrix, cor = "poly", fa = "pc")
```

Parallel Analysis Scree Plots



```
## Parallel analysis suggests that the number of factors = NA and the number of components = 2
athlete_parallel$pc.values
```

```
## [1] 3.1901693 1.2855443 0.8626912 0.6554703 0.4741985 0.2866577 0.2452687
```

PCA indicates that two factors underlie these variables.

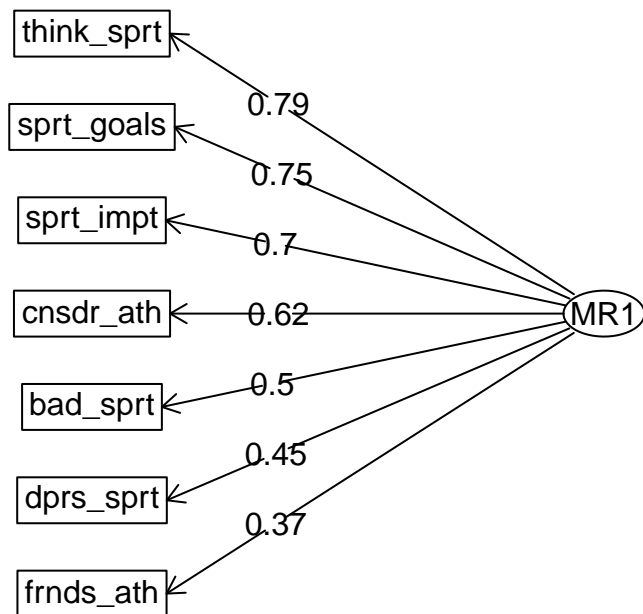
EFA

We now want to examine which variables might load on which factors. To do so, we will perform EFA on a 2-factor model, and also on 1- and 3- factor models.

Now, the 1-factor model:

```
athletic_efa1 <- fa(r = athletic_identity_matrix, nfactors = 1, cor = "poly")
fa.diagram(athletic_efa1, digits = 2, simple = TRUE)
```

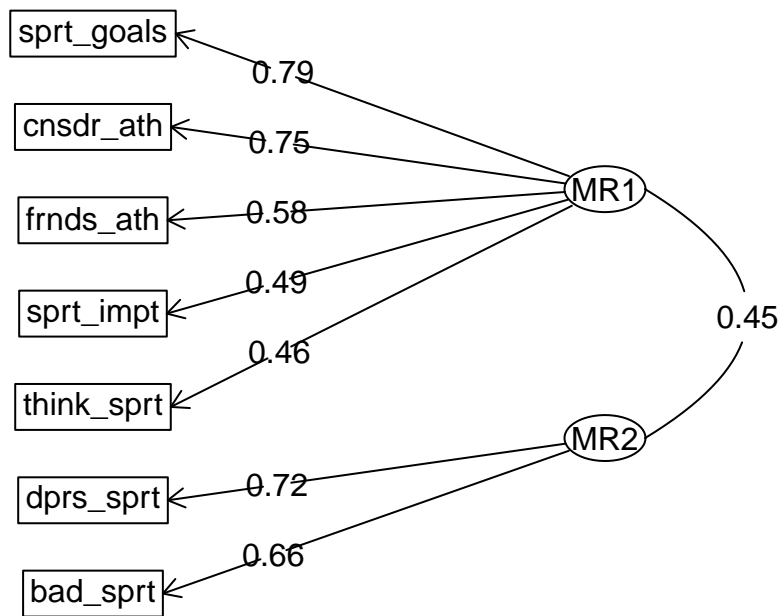
Factor Analysis



First, the 2-factor model:

```
athletic_efa2 <- fa(r = athletic_identity_matrix, nfactors = 2, cor = "poly")  
fa.diagram(athletic_efa2, digits = 2, simple = TRUE)
```

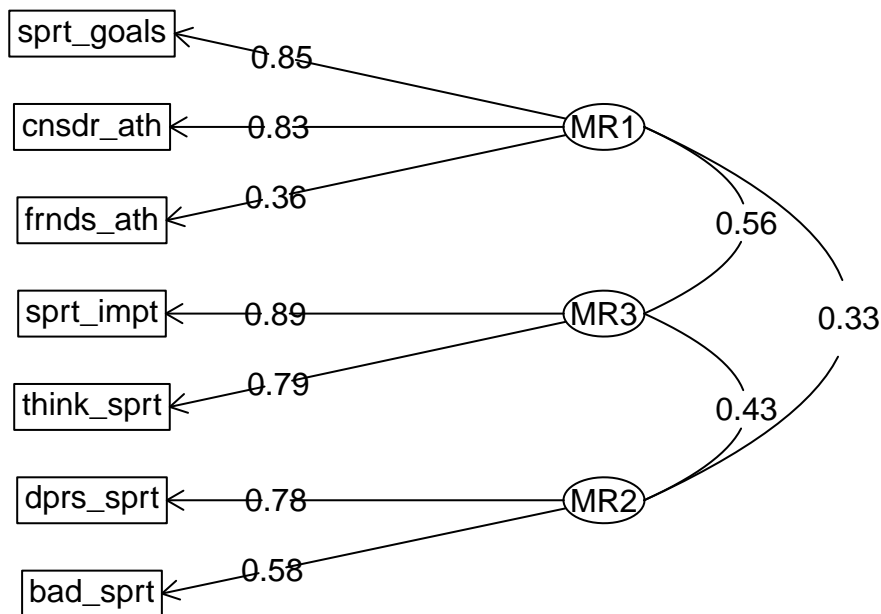
Factor Analysis



Now, the 3-factor model:

```
athletic_efa3 <- fa(r = athletic_identity_matrix, nfactors = 3, cor = "poly")  
fa.diagram(athletic_efa3, digits = 2, simple = TRUE)
```

Factor Analysis



The 3-factor model seems to fit the data the best, as it has the smallest BIC. We will proceed by using the 3-factor model for athletic_identity.

```
names <- c("1", "2", "3")
rmsea <- c(0.231, 0.234, 0.076)
bic <- c(201.72, 119.31, -8.36)
chi_sq <- c("2.3e-52", "7.1e-32", "0.025")
```

```
athletic_efa1 %>% summary()
```

```
##
## Factor analysis with Call: fa(r = athletic_identity_matrix, nfactors = 1, cor = "poly")
##
## Test of the hypothesis that 1 factor is sufficient.
## The degrees of freedom for the model is 14 and the objective function was 0.79
## The number of observations was 363 with Chi Square = 284.24 with prob < 2.3e-52
##
## The root mean square of the residuals (RMSA) is 0.12
## The df corrected root mean square of the residuals is 0.15
##
## Tucker Lewis Index of factoring reliability = 0.548
## RMSEA index = 0.231 and the 10 % confidence intervals are 0.208 0.255
## BIC = 201.72
```

```
athletic_efa2 %>% summary()
```

```
##
## Factor analysis with Call: fa(r = athletic_identity_matrix, nfactors = 2, cor = "poly")
```

```
##
## Test of the hypothesis that 2 factors are sufficient.
## The degrees of freedom for the model is 8 and the objective function was 0.47
## The number of observations was 363 with Chi Square = 166.46 with prob < 7.1e-32
##
## The root mean square of the residuals (RMSA) is 0.07
## The df corrected root mean square of the residuals is 0.12
##
## Tucker Lewis Index of factoring reliability = 0.535
## RMSEA index = 0.234 and the 10 % confidence intervals are 0.204 0.266
## BIC = 119.31
## With factor correlations of
##      MR1 MR2
## MR1 1.00 0.45
## MR2 0.45 1.00
athletic_efa3 %>% summary()

##
## Factor analysis with Call: fa(r = athletic_identity_matrix, nfactors = 3, cor = "poly")
##
## Test of the hypothesis that 3 factors are sufficient.
## The degrees of freedom for the model is 3 and the objective function was 0.03
## The number of observations was 363 with Chi Square = 9.33 with prob < 0.025
##
## The root mean square of the residuals (RMSA) is 0.01
## The df corrected root mean square of the residuals is 0.04
##
## Tucker Lewis Index of factoring reliability = 0.95
## RMSEA index = 0.076 and the 10 % confidence intervals are 0.024 0.134
## BIC = -8.36
## With factor correlations of
##      MR1 MR3 MR2
## MR1 1.00 0.56 0.33
## MR3 0.56 1.00 0.43
## MR2 0.33 0.43 1.00
tibble(
  factor = names,
  rmsea = rmsea,
  bic = bic,
  chi_sq = chi_sq
) %>% knitr::kable(col.names = c("Number of Factors", "RMSEA", "BIC", "$\\chi^2$ p-value"))
```

Number of Factors	RMSEA	BIC	χ^2 p-value
1	0.231	201.72	2.3e-52
2	0.234	119.31	7.1e-32
3	0.076	-8.36	0.025

Reliability

We now want to assess the reliability of each of these constructs.

LV 1: External Identity

```
external_identity <- c("cnsdr_ath", "sprt_goals", "frnds_ath")

external_identity_numeric <- athletes[,external_identity] %>% map_df(., as.numeric)

external_identity_matrix <- external_identity_numeric %>% as.matrix()
psych::alpha(external_identity_matrix)
```

```
##
## Reliability analysis
## Call: psych::alpha(x = external_identity_matrix)
##
##   raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
##     0.65     0.68     0.62     0.42 2.1 0.032  5.7 0.89     0.33
##
## lower alpha upper      95% confidence boundaries
## 0.59 0.65 0.72
##
## Reliability if an item is dropped:
##           raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## cnsdr_ath      0.47      0.49   0.33      0.33 0.97  0.052  NA  0.33
## sprt_goals      0.46      0.47   0.31      0.31 0.89  0.055  NA  0.31
## frnds_ath      0.75      0.76   0.61      0.61 3.15  0.025  NA  0.61
##
## Item statistics
##           n raw.r std.r r.cor r.drop mean   sd
## cnsdr_ath 356 0.79 0.82 0.71 0.53 5.9 1.11
## sprt_goals 356 0.78 0.83 0.72 0.56 6.1 0.96
## frnds_ath 356 0.76 0.70 0.41 0.35 5.2 1.38
##
## Non missing response frequency for each item
##           1 2 3 4 5 6 7 miss
## cnsdr_ath 0.01 0.01 0.03 0.05 0.24 0.33 0.35 0.02
## sprt_goals 0.00 0.00 0.02 0.03 0.20 0.35 0.40 0.02
## frnds_ath 0.01 0.04 0.06 0.10 0.31 0.29 0.17 0.02
```

Since the remove-one Chronbach's alpha indicates that reliability would improve quite a bit if `frnds_ath` is dropped, we will remove this variable from the latent variable structure for `external_identity`.

LV 2: Internal Value

```
internal_value <- c("sprt_impt", "think_sprt")

internal_value_numeric <- athletes[,internal_value] %>% map_df(., as.numeric)

internal_value_matrix <- internal_value_numeric %>% as.matrix()
psych::alpha(internal_value_matrix)
```

```
##
## Reliability analysis
## Call: psych::alpha(x = internal_value_matrix)
##
##   raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
##     0.81     0.81     0.67     0.67 4.1 0.02   5 1.4     0.67
##
## lower alpha upper      95% confidence boundaries
```

```
## 0.77 0.81 0.85
##
## Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## sprt_impt      0.67      0.67      0.45      0.67 2.1      NA      0 0.67
## think_sprt      0.68      0.67      0.45      0.67 2.1      NA      0 0.67
##
## Item statistics
##      n raw.r std.r r.cor r.drop mean sd
## sprt_impt 356 0.91 0.91 0.75 0.67 5.1 1.5
## think_sprt 356 0.92 0.91 0.75 0.67 4.9 1.5
##
## Non missing response frequency for each item
##      1 2 3 4 5 6 7 miss
## sprt_impt 0.03 0.04 0.10 0.10 0.28 0.27 0.18 0.02
## think_sprt 0.02 0.05 0.14 0.12 0.29 0.22 0.16 0.02
```

LV 3: Negative Events

```
negative_events <- c("dprs_sprt", "bad_sprt")

negative_events_numeric <- athletes[,negative_events] %>% map_df(., as.numeric)

negative_events_matrix <- negative_events_numeric %>% as.matrix()
psych::alpha(negative_events_matrix)
```

```
##
## Reliability analysis
## Call: psych::alpha(x = negative_events_matrix)
##
##      raw_alpha std.alpha G6(smc) average_r S/N ase mean sd median_r
##      0.63      0.63      0.46      0.46 1.7 0.039 5.6 1.2      0.46
##
## lower alpha upper      95% confidence boundaries
## 0.55 0.63 0.7
##
## Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## dprs_sprt      0.40      0.46      0.21      0.46 0.85      NA      0 0.46
## bad_sprt      0.53      0.46      0.21      0.46 0.85      NA      0 0.46
##
## Item statistics
##      n raw.r std.r r.cor r.drop mean sd
## dprs_sprt 356 0.83 0.85 0.58 0.46 5.7 1.3
## bad_sprt 356 0.88 0.85 0.58 0.46 5.5 1.4
##
## Non missing response frequency for each item
##      1 2 3 4 5 6 7 miss
## dprs_sprt 0.01 0.02 0.02 0.06 0.30 0.29 0.29 0.02
## bad_sprt 0.02 0.04 0.04 0.08 0.24 0.29 0.28 0.02
```

Our final model for athlete_identity is as follows:

```
external_identity = sprt_goals + cnsdr_ath internal_value = sprt_impt + think_sprt negative_events =
dprs_sprt + bad_sprt athlete_identity = external_identity + internal_value + negative_events
```


CFA

```
athlete_model <-  
'external_identity =~ sprt_goals + cnsdr_ath  
  internal_value =~ sprt_impt + think_sprt  
  negative_events =~ dprs_sprt + bad_sprt  
  athlete_identity =~ external_identity + internal_value + negative_events  
,  
  
athlete_CFA = cfa(athlete_model, data = athletic_identity_matrix,  
                  ordered = names(athletic_identity_matrix),  
                  std.lv = TRUE)  
summary(athlete_CFA, fit.measures = TRUE, rsquare = TRUE)  
  
## lavaan 0.6-10 ended normally after 39 iterations  
##  
##      Estimator                      ML  
##      Optimization method          NLMINB  
##      Number of model parameters    15  
##  
##                                     Used      Total  
##      Number of observations        356      363  
##  
## Model Test User Model:  
##  
##      Test statistic                5.234  
##      Degrees of freedom            6  
##      P-value (Chi-square)          0.514  
##  
## Model Test Baseline Model:  
##  
##      Test statistic                617.425  
##      Degrees of freedom            15  
##      P-value                      0.000  
##  
## User Model versus Baseline Model:  
##  
##      Comparative Fit Index (CFI)    1.000  
##      Tucker-Lewis Index (TLI)      1.003  
##  
## Loglikelihood and Information Criteria:  
##  
##      Loglikelihood user model (H0)    -3255.389  
##      Loglikelihood unrestricted model (H1) -3252.772  
##  
##      Akaike (AIC)                  6540.778  
##      Bayesian (BIC)                 6598.902  
##      Sample-size adjusted Bayesian (BIC) 6551.316  
##  
## Root Mean Square Error of Approximation:  
##  
##      RMSEA                        0.000  
##      90 Percent confidence interval - lower 0.000  
##      90 Percent confidence interval - upper 0.064
```

```

## P-value RMSEA <= 0.05                                0.872
##
## Standardized Root Mean Square Residual:
##
## SRMR                                                    0.017
##
## Parameter Estimates:
##
## Standard errors                                Standard
## Information                                Expected
## Information saturated (h1) model            Structured
##
## Latent Variables:
##           Estimate Std.Err z-value P(>|z|)
## external_identity =~
##   sprt_goals      0.677   0.073   9.247   0.000
##   cnsdr_ath       0.584   0.056  10.404   0.000
## internal_value =~
##   sprt_impt       0.627   0.109   5.728   0.000
##   think_sprt      0.840   0.166   5.077   0.000
## negative_events =~
##   dprs_sprt       0.625   0.078   8.053   0.000
##   bad_sprt        0.799   0.103   7.777   0.000
## athlete_identity =~
##   external_dntty   0.809   0.143   5.658   0.000
##   internal_value   1.396   0.374   3.729   0.000
##   negative_evnts   0.813   0.152   5.364   0.000
##
## Variances:
##           Estimate Std.Err z-value P(>|z|)
##   .sprt_goals      0.169   0.085   1.984   0.047
##   .cnsdr_ath       0.668   0.080   8.347   0.000
##   .sprt_impt       1.114   0.130   8.585   0.000
##   .think_sprt      0.251   0.180   1.394   0.163
##   .dprs_sprt       0.923   0.119   7.751   0.000
##   .bad_sprt        1.009   0.176   5.743   0.000
##   .external_dntty  1.000
##   .internal_value  1.000
##   .negative_evnts  1.000
##   athlete_idntty  1.000
##
## R-Square:
##           Estimate
##   sprt_goals      0.818
##   cnsdr_ath       0.458
##   sprt_impt       0.509
##   think_sprt      0.893
##   dprs_sprt       0.413
##   bad_sprt        0.512
##   external_dntty   0.396
##   internal_value   0.661
##   negative_evnts   0.398

```

Latent Variable 2: Healthy Lifestyle

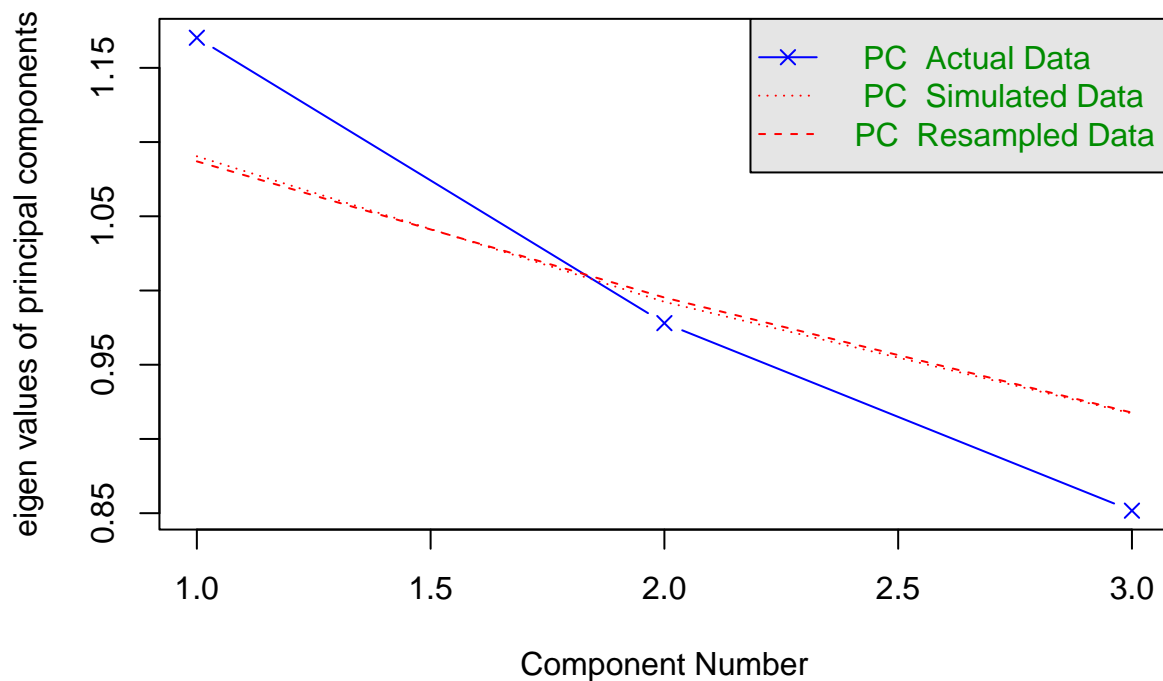
```
healthy_lifestyle <- c("hr_sleep", "smoking", "fruit_veg")  
  
healthy_life_numeric <- athletes[,healthy_lifestyle] %>% map_df(., as.numeric)  
  
healthy_life_matrix <- healthy_life_numeric %>% as.matrix()
```

Polychoric Correlations

Now, let us determine the number of factors that might underlie these variables.

```
health_parallel <- fa.parallel(healthy_life_matrix, fa = "pc")
```

Parallel Analysis Scree Plots



```
## Parallel analysis suggests that the number of factors = NA and the number of components = 1  
health_parallel$pc.values
```

```
## [1] 1.1702721 0.9780215 0.8517064
```

It appears that 1 component should underlie these three variables.

EFA

```
health_efa1 <- fa(r = healthy_life_matrix, nfactors = 1)  
fa.diagram(health_efa1, digits = 2, simple = TRUE)
```

```
health_efa2 <- fa(r = healthy_life_matrix, nfactors = 2)
fa.diagram(health_efa2, digits = 2, simple = TRUE)
```

Reliability

```
psych::alpha(healthy_life_matrix)

## Some items ( smoking ) were negatively correlated with the total scale and
## probably should be reversed.
## To do this, run the function again with the 'check.keys=TRUE' option

##
## Reliability analysis
## Call: psych::alpha(x = healthy_life_matrix)
##
##   raw_alpha std.alpha G6(smc) average_r   S/N ase mean   sd median_r
##   -0.26      -0.21   -0.12   -0.061 -0.17 0.11  3.1 0.49   -0.07
##
## lower alpha upper      95% confidence boundaries
## -0.47 -0.26 -0.04
##
## Reliability if an item is dropped:
##           raw_alpha std.alpha G6(smc) average_r   S/N alpha se var.r med.r
## hr_sleep   -0.112   -0.150  -0.070   -0.070 -0.130  0.089   NA -0.070
## smoking     0.043    0.055   0.028    0.028  0.058  0.078   NA  0.028
## fruit_veg  -0.330   -0.330  -0.142   -0.142 -0.248  0.140   NA -0.142
##
## Item statistics
##           n raw.r std.r r.cor r.drop mean sd
## hr_sleep 363  0.62  0.55  NaN -0.120 7.29 1.0
## smoking  363  0.61  0.49  NaN -0.156 1.56 1.1
## fruit_veg 363  0.31  0.59  NaN -0.033 0.55 0.5
```

Healthy lifestyle does not seem to be a reliable scale, so we will not use it in our model.

Latent Variable 3: Resilience

Finally, we will look at resilience.

```
resilience <- c("bounce", "strs_evnt", "strs_rcvr", "snap_back", "difficult", "setbacks")

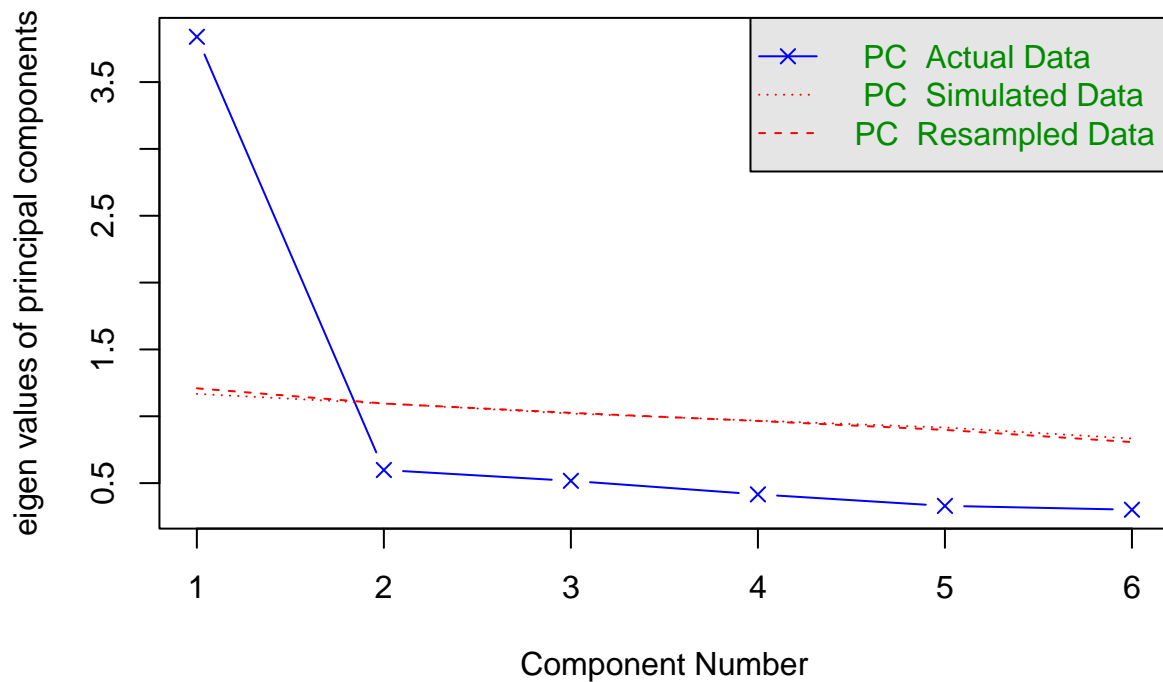
resilience_numeric <- athletes[,resilience] %>% map_df(., as.numeric)

resilience_matrix <- resilience_numeric %>% as.matrix()
```

Polychoric Correlations

```
resilience_parallel <- fa.parallel(resilience_matrix, fa = "pc")
```

Parallel Analysis Scree Plots



```
## Parallel analysis suggests that the number of factors = NA and the number of components = 1
resilience_parallel$pc.values
```

```
## [1] 3.8386245 0.5979661 0.5170194 0.4156602 0.3296245 0.3011053
```

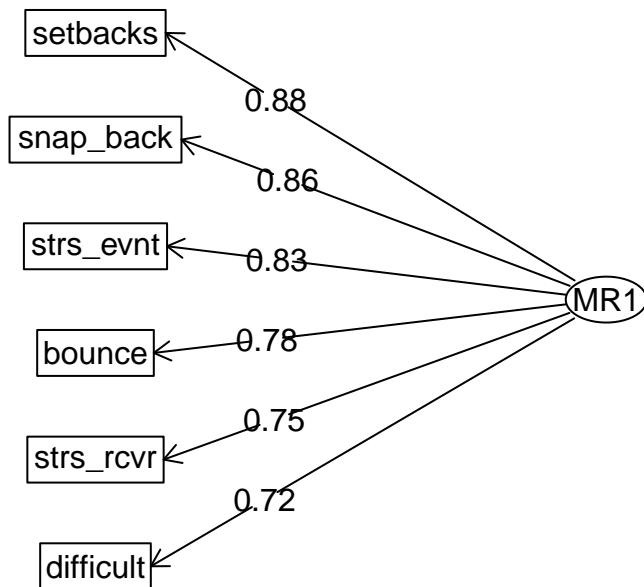
It appears that a 1-factor model will sufficiently explain the variability across these variables.

EFA

First, we can do a 1-factor EFA model:

```
resilience_efa1 <- fa(r = resilience_matrix, nfactors = 1, cor = "poly")
fa.diagram(resilience_efa1, digits = 2, simple = TRUE)
```

Factor Analysis



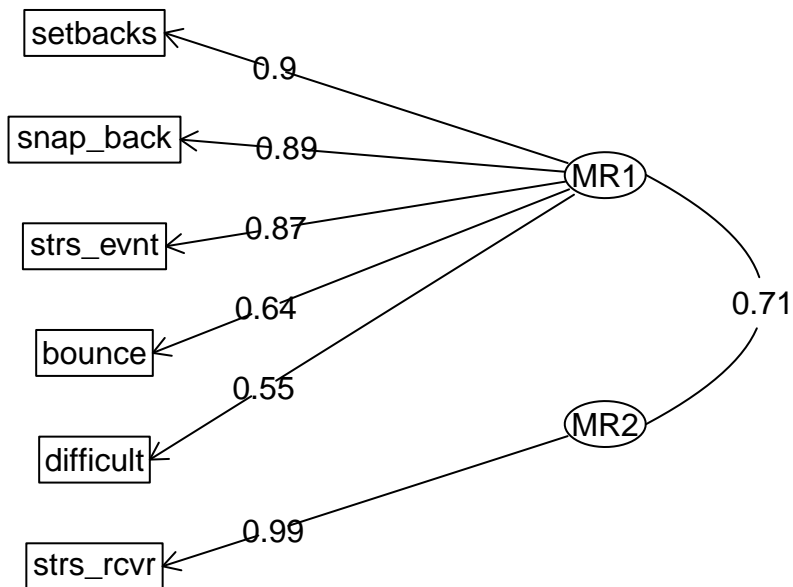
```
summary(resilience_efa1)
```

```
##
## Factor analysis with Call: fa(r = resilience_matrix, nfactors = 1, cor = "poly")
##
## Test of the hypothesis that 1 factor is sufficient.
## The degrees of freedom for the model is 9 and the objective function was 0.1
## The number of observations was 363 with Chi Square = 35.64 with prob < 4.6e-05
##
## The root mean square of the residuals (RMSA) is 0.03
## The df corrected root mean square of the residuals is 0.04
##
## Tucker Lewis Index of factoring reliability = 0.969
## RMSEA index = 0.09 and the 10 % confidence intervals are 0.06 0.123
## BIC = -17.41
```

Now, we can try a 2-factor EFA model:

```
resilience_efa2 <- fa(r = resilience_matrix, nfactors = 2, cor = "poly")
fa.diagram(resilience_efa2, digits = 2, simple = TRUE)
```

Factor Analysis



```
resilience_efa2
```

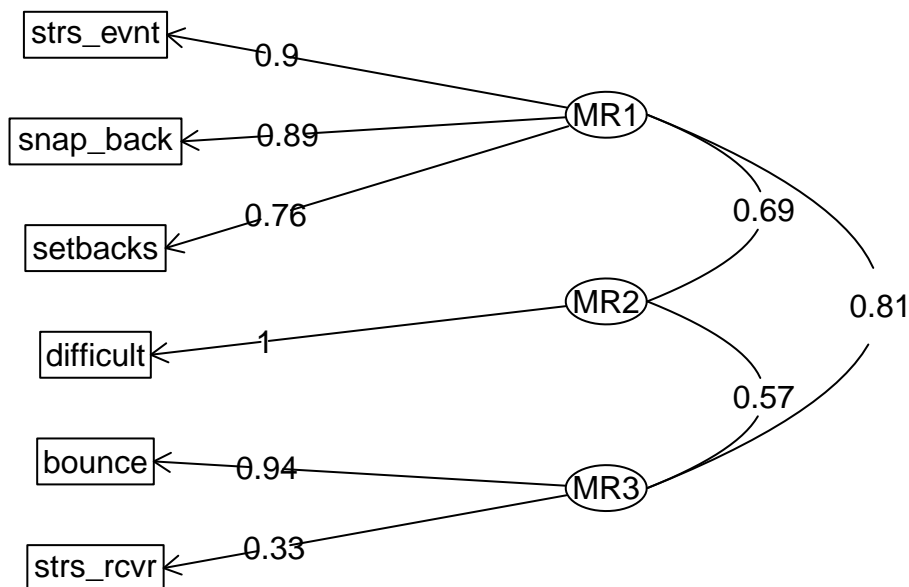
```
## Factor Analysis using method = minres
## Call: fa(r = resilience_matrix, nfactors = 2, cor = "poly")
## Standardized loadings (pattern matrix) based upon correlation matrix
##           MR1   MR2   h2   u2 com
## bounce    0.64  0.18 0.60 0.4044 1.2
## strs_evnt 0.87 -0.04 0.71 0.2918 1.0
## strs_rcvr 0.01  0.99 1.00 0.0034 1.0
## snap_back 0.89 -0.02 0.76 0.2373 1.0
## difficult 0.55  0.20 0.50 0.5004 1.3
## setbacks  0.90 -0.02 0.79 0.2059 1.0
##
##
##           MR1   MR2
## SS loadings      3.19 1.17
## Proportion Var    0.53 0.19
## Cumulative Var    0.53 0.73
## Proportion Explained 0.73 0.27
## Cumulative Proportion 0.73 1.00
##
## With factor correlations of
##           MR1   MR2
## MR1 1.00 0.71
## MR2 0.71 1.00
##
## Mean item complexity = 1.1
```

```
## Test of the hypothesis that 2 factors are sufficient.
##
## The degrees of freedom for the null model are 15 and the objective function was 3.98 with Chi Squ
## The degrees of freedom for the model are 4 and the objective function was 0.02
##
## The root mean square of the residuals (RMSR) is 0.01
## The df corrected root mean square of the residuals is 0.02
##
## The harmonic number of observations is 322 with the empirical chi square 1.5 with prob < 0.83
## The total number of observations was 363 with Likelihood Chi Square = 8.56 with prob < 0.073
##
## Tucker Lewis Index of factoring reliability = 0.988
## RMSEA index = 0.056 and the 90 % confidence intervals are 0 0.109
## BIC = -15.02
## Fit based upon off diagonal values = 1
## Measures of factor score adequacy
##
## Correlation of (regression) scores with factors    MR1  MR2
## Multiple R square of scores with factors          0.96 1.00
## Minimum correlation of possible factor scores      0.85 0.99
```

Finally, we can try a 3-factor EFA model:

```
resilience_efa3 <- fa(r = resilience_matrix, nfactors = 3, cor = "poly")
fa.diagram(resilience_efa3, digits = 2, simple = TRUE)
```

Factor Analysis




```
summary(resilience_efa3)
```

```
##
## Factor analysis with Call: fa(r = resilience_matrix, nfactors = 3, cor = "poly")
##
## Test of the hypothesis that 3 factors are sufficient.
## The degrees of freedom for the model is 0 and the objective function was 0
## The number of observations was 363 with Chi Square = 0.18 with prob < NA
##
## The root mean square of the residuals (RMSA) is 0
## The df corrected root mean square of the residuals is NA
##
## Tucker Lewis Index of factoring reliability = -Inf
## With factor correlations of
##      MR1 MR2 MR3
## MR1 1.00 0.69 0.81
## MR2 0.69 1.00 0.57
## MR3 0.81 0.57 1.00
```

```
names <- c("1", "2")
rmsea <- c(0.09, 0.056)
bic <- c(-17.41, -15.02)
chi_sq <- c("4.6e-05", "0.073")
```

```
athletic_efa1 %>% summary()
```

```
##
## Factor analysis with Call: fa(r = athletic_identity_matrix, nfactors = 1, cor = "poly")
##
## Test of the hypothesis that 1 factor is sufficient.
## The degrees of freedom for the model is 14 and the objective function was 0.79
## The number of observations was 363 with Chi Square = 284.24 with prob < 2.3e-52
##
## The root mean square of the residuals (RMSA) is 0.12
## The df corrected root mean square of the residuals is 0.15
##
## Tucker Lewis Index of factoring reliability = 0.548
## RMSEA index = 0.231 and the 10 % confidence intervals are 0.208 0.255
## BIC = 201.72
```

```
athletic_efa2 %>% summary()
```

```
##
## Factor analysis with Call: fa(r = athletic_identity_matrix, nfactors = 2, cor = "poly")
##
## Test of the hypothesis that 2 factors are sufficient.
## The degrees of freedom for the model is 8 and the objective function was 0.47
## The number of observations was 363 with Chi Square = 166.46 with prob < 7.1e-32
##
## The root mean square of the residuals (RMSA) is 0.07
## The df corrected root mean square of the residuals is 0.12
##
## Tucker Lewis Index of factoring reliability = 0.535
## RMSEA index = 0.234 and the 10 % confidence intervals are 0.204 0.266
## BIC = 119.31
```

```
## With factor correlations of
##      MR1 MR2
## MR1 1.00 0.45
## MR2 0.45 1.00

athletic_efa3 %>% summary()

##
## Factor analysis with Call: fa(r = athletic_identity_matrix, nfactors = 3, cor = "poly")
##
## Test of the hypothesis that 3 factors are sufficient.
## The degrees of freedom for the model is 3 and the objective function was 0.03
## The number of observations was 363 with Chi Square = 9.33 with prob < 0.025
##
## The root mean square of the residuals (RMSA) is 0.01
## The df corrected root mean square of the residuals is 0.04
##
## Tucker Lewis Index of factoring reliability = 0.95
## RMSEA index = 0.076 and the 10 % confidence intervals are 0.024 0.134
## BIC = -8.36
## With factor correlations of
##      MR1 MR3 MR2
## MR1 1.00 0.56 0.33
## MR3 0.56 1.00 0.43
## MR2 0.33 0.43 1.00

tibble(
  factor = names,
  rmsea = rmsea,
  bic = bic,
  chi_sq = chi_sq
) %>% knitr::kable(col.names = c("Number of Factors", "RMSEA", "BIC", "$\\chi^2$ p-value"))
```

Number of Factors	RMSEA	BIC	χ^2 p-value
1	0.090	-17.41	4.6e-05
2	0.056	-15.02	0.073

Reliability

```
psych::alpha(resilience_matrix)

##
## Reliability analysis
## Call: psych::alpha(x = resilience_matrix)
##
## raw_alpha std.alpha G6(smc) average_r S/N ase mean sd median_r
##      0.89      0.89      0.87      0.57 7.8 0.0092 3.6 0.79      0.55
##
## lower alpha upper      95% confidence boundaries
## 0.87 0.89 0.9
##
## Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## bounce      0.87      0.87      0.85      0.57 6.7 0.0109 0.0054 0.54
```

```
## strs_evnt      0.86      0.86      0.84      0.56 6.3      0.0115 0.0043 0.55
## strs_rcvr      0.87      0.87      0.85      0.58 6.9      0.0104 0.0066 0.58
## snap_back      0.86      0.86      0.84      0.55 6.1      0.0117 0.0036 0.55
## difficult      0.88      0.88      0.86      0.59 7.3      0.0099 0.0038 0.58
## setbacks      0.85      0.85      0.83      0.54 5.9      0.0121 0.0036 0.53
##
## Item statistics
##           n raw.r std.r r.cor r.drop mean  sd
## bounce    322  0.78  0.79  0.73  0.69  4.0 0.90
## strs_evnt  322  0.83  0.82  0.78  0.73  3.4 1.08
## strs_rcvr  322  0.77  0.77  0.70  0.66  3.6 0.99
## snap_back  322  0.83  0.83  0.79  0.74  3.5 1.01
## difficult  322  0.74  0.74  0.66  0.62  3.4 0.99
## setbacks   322  0.85  0.85  0.83  0.78  3.6 0.99
##
## Non missing response frequency for each item
##           1      2      3      4      5 miss
## bounce    0.02 0.06 0.15 0.49 0.28 0.11
## strs_evnt 0.05 0.18 0.29 0.34 0.14 0.11
## strs_rcvr 0.02 0.14 0.25 0.42 0.16 0.11
## snap_back 0.02 0.18 0.19 0.48 0.13 0.11
## difficult 0.02 0.19 0.28 0.39 0.11 0.11
## setbacks  0.03 0.13 0.23 0.47 0.15 0.11
```

Chronbach's alpha is 0.89 (0.88, 0.91). No items can be dropped to improve this measure, so we will keep all of them in this latent variable.

CFA

```
resilience_model <-
' resilience =~ bounce + strs_evnt + strs_rcvr + snap_back + difficult + setbacks
'

resilience_cfa = cfa(resilience_model, data = resilience_matrix,
                      ordered = names(resilience_matrix),
                      std.lv = TRUE)
summary(resilience_cfa, fit.measures = TRUE, rsquare = TRUE)

## lavaan 0.6-10 ended normally after 17 iterations
##
##      Estimator                      ML
##      Optimization method          NLMINB
##      Number of model parameters          12
##
##                               Used      Total
##      Number of observations          322      363
##
## Model Test User Model:
##
##      Test statistic          20.216
##      Degrees of freedom           9
##      P-value (Chi-square)        0.017
##
## Model Test Baseline Model:
##
```

```

##      Test statistic                971.399
##      Degrees of freedom              15
##      P-value                        0.000
##
## User Model versus Baseline Model:
##
##      Comparative Fit Index (CFI)      0.988
##      Tucker-Lewis Index (TLI)        0.980
##
## Loglikelihood and Information Criteria:
##
##      Loglikelihood user model (H0)    -2247.133
##      Loglikelihood unrestricted model (H1) -2237.025
##
##      Akaike (AIC)                    4518.266
##      Bayesian (BIC)                   4563.561
##      Sample-size adjusted Bayesian (BIC) 4525.499
##
## Root Mean Square Error of Approximation:
##
##      RMSEA                          0.062
##      90 Percent confidence interval - lower 0.025
##      90 Percent confidence interval - upper 0.099
##      P-value RMSEA <= 0.05            0.253
##
## Standardized Root Mean Square Residual:
##
##      SRMR                          0.026
##
## Parameter Estimates:
##
##      Standard errors                Standard
##      Information                    Expected
##      Information saturated (h1) model Structured
##
## Latent Variables:
##      Estimate Std.Err z-value P(>|z|)
##      resilience =~
##      bounce      0.662   0.045  14.732   0.000
##      strs_evnt    0.852   0.052  16.419   0.000
##      strs_rcvr    0.679   0.051  13.415   0.000
##      snap_back    0.814   0.048  17.031   0.000
##      difficult    0.644   0.051  12.559   0.000
##      setbacks     0.828   0.046  17.954   0.000
##
## Variances:
##      Estimate Std.Err z-value P(>|z|)
##      .bounce     0.376   0.034  10.974   0.000
##      .strs_evnt   0.433   0.042  10.201   0.000
##      .strs_rcvr   0.524   0.046  11.396   0.000
##      .snap_back   0.345   0.035   9.824   0.000
##      .difficult   0.565   0.049  11.614   0.000
##      .setbacks    0.286   0.031   9.119   0.000
##      resilience   1.000

```

```
##
## R-Square:
##           Estimate
##    bounce      0.538
##    strs_evnt    0.626
##    strs_rcvr    0.468
##    snap_back    0.658
##    difficult    0.423
##    setbacks     0.706
```

Final CFA

```
final_model <-
'external_identity =~ sprt_goals + cnsdr_ath + frnds_ath
  internal_value =~ sprt_impt + think_sprt
  negative_events =~ dprs_sprt + bad_sprt

  athlete_identity =~ external_identity + internal_value + negative_events

  resilience =~ bounce + strs_evnt + strs_rcvr + snap_back + difficult + setbacks
'
fin_df <- athletes %>% map_df(., as.numeric)

final_cfa = cfa(final_model,
  data = fin_df,
  std.lv = TRUE)
summary(final_cfa, fit.measures = TRUE, rsquare=TRUE)
```

```
## lavaan 0.6-10 ended normally after 42 iterations
##
##      Estimator                      ML
##      Optimization method          NLMINB
##      Number of model parameters      30
##
##                                     Used      Total
##      Number of observations          322        363
##
## Model Test User Model:
##
##      Test statistic                  106.384
##      Degrees of freedom                61
##      P-value (Chi-square)              0.000
##
## Model Test Baseline Model:
##
##      Test statistic                  1645.418
##      Degrees of freedom                78
##      P-value                          0.000
##
## User Model versus Baseline Model:
##
##      Comparative Fit Index (CFI)      0.971
##      Tucker-Lewis Index (TLI)        0.963
```

```

##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)            -5730.730
##   Loglikelihood unrestricted model (H1)      -5677.538
##
##   Akaike (AIC)                            11521.460
##   Bayesian (BIC)                          11634.696
##   Sample-size adjusted Bayesian (BIC)      11539.540
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                    0.048
##   90 Percent confidence interval - lower    0.032
##   90 Percent confidence interval - upper    0.063
##   P-value RMSEA <= 0.05                    0.564
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                    0.060
##
## Parameter Estimates:
##
##   Standard errors                        Standard
##   Information                            Expected
##   Information saturated (h1) model      Structured
##
## Latent Variables:
##
##           Estimate  Std.Err  z-value  P(>|z|)
##   external_identity =~
##     sprt_goals      0.623    0.064    9.726    0.000
##     cnsdr_ath       0.605    0.062    9.806    0.000
##     frnds_ath       0.407    0.067    6.101    0.000
##   internal_value =~
##     sprt_impt       0.574    0.123    4.666    0.000
##     think_sprt      0.767    0.183    4.187    0.000
##   negative_events =~
##     dprs_sprt       0.634    0.082    7.694    0.000
##     bad_sprt        0.805    0.108    7.445    0.000
##   athlete_identity =~
##     external_dntty   0.866    0.156    5.539    0.000
##     internal_value   1.540    0.478    3.223    0.001
##     negative_evnts   0.777    0.150    5.178    0.000
##   resilience =~
##     bounce          0.661    0.045   14.692    0.000
##     strs_evnt       0.853    0.052   16.460    0.000
##     strs_rcvr       0.678    0.051   13.378    0.000
##     snap_back       0.814    0.048   17.025    0.000
##     difficult       0.644    0.051   12.557    0.000
##     setbacks        0.829    0.046   17.995    0.000
##
## Covariances:
##
##           Estimate  Std.Err  z-value  P(>|z|)
##   athlete_identity ~~

```

```
##      resilience      -0.142    0.069   -2.066    0.039
##
## Variances:
##           Estimate Std.Err  z-value  P(>|z|)
## .sprt_goals      0.229   0.062   3.708   0.000
## .cnsdr_ath       0.618   0.075   8.264   0.000
## .frnds_ath       1.575   0.130  12.135   0.000
## .sprt_impt       1.173   0.137   8.573   0.000
## .think_sprt      0.288   0.181   1.588   0.112
## .dprs_sprt       0.959   0.129   7.421   0.000
## .bad_sprt        1.017   0.187   5.435   0.000
## .bounce          0.378   0.034  10.995   0.000
## .strs_evnt       0.431   0.042  10.187   0.000
## .strs_rcvr       0.526   0.046  11.411   0.000
## .snap_back       0.345   0.035   9.839   0.000
## .difficult       0.565   0.049  11.619   0.000
## .setbacks        0.284   0.031   9.098   0.000
## .external_dntty  1.000
## .internal_value  1.000
## .negative_evnts  1.000
## athlete_idntty   1.000
## resilience        1.000
##
## R-Square:
##           Estimate
## sprt_goals      0.748
## cnsdr_ath       0.509
## frnds_ath       0.156
## sprt_impt       0.487
## think_sprt      0.873
## dprs_sprt       0.402
## bad_sprt        0.506
## bounce          0.536
## strs_evnt       0.628
## strs_rcvr       0.466
## snap_back       0.658
## difficult       0.423
## setbacks        0.707
## external_dntty  0.429
## internal_value  0.703
## negative_evnts  0.376
```

Modification Indices

```
modindices(final_cfa, power = TRUE, sort = TRUE, minimum.value = 10)
```

```
##           lhs op           rhs      mi      epc sepc.all delta   ncp
## 169 external_identity ~~      resilience 10.801 0.263    0.263  0.1 1.562
## 170   internal_value  ~~ negative_events 10.801 -2.559   -2.559  0.1 0.016
## 168 external_identity ~~ athlete_identity 10.801 1.853    1.853  0.1 0.031
##      power decision
## 169 0.239  **(m)**
## 170 0.052  **(m)**
## 168 0.054  **(m)**
```

Structural Equation Modeling

Let's first start with a basic SEM, relating athletic identity to MHC-SF.

```
basic_athlete_sem <- '
  # measurement model
  external_identity =~ sprt_goals + cnsdr_ath
  internal_value =~ sprt_impt + think_sprt
  negative_events =~ dprs_sprt + bad_sprt

  athlete_identity =~ external_identity + internal_value + negative_events

  # structural model - direct effects
  mhc_sf ~ a*athlete_identity
'
```

```
basic_athlete_sem_fit <- sem(basic_athlete_sem,
                             data = athletes,
                             sample.cov = TRUE,
                             missing = "ML")

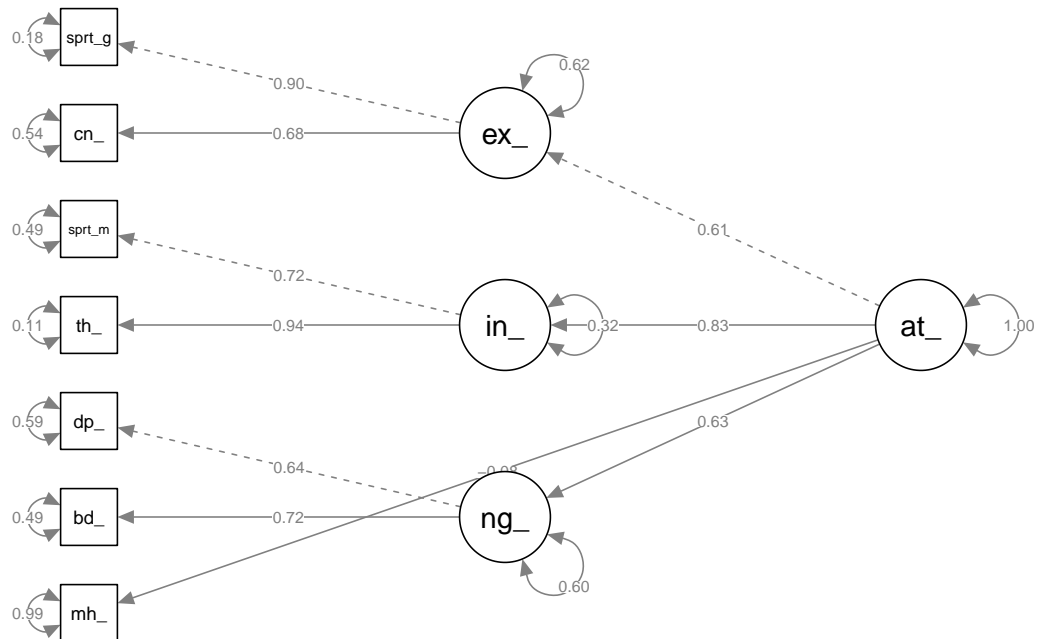
summary(basic_athlete_sem_fit, standardized=TRUE)
```

```
## lavaan 0.6-10 ended normally after 68 iterations
##
##      Estimator                      ML
##      Optimization method          NLMINB
##      Number of model parameters      24
##
##                               Used      Total
##      Number of observations          356      363
##      Number of missing patterns        2
##
## Model Test User Model:
##
##      Test statistic              32.741
##      Degrees of freedom             11
##      P-value (Chi-square)           0.001
##
## Parameter Estimates:
##
##      Standard errors              Standard
##      Information                  Observed
##      Observed information based on   Hessian
##
## Latent Variables:
##      Estimate  Std.Err  z-value  P(>|z|)  Std.lv  Std.all
##      external_identity =~
##      sprt_goals      1.000
##      cnsdr_ath       0.861    0.109    7.896    0.000    0.751    0.676
##      internal_value =~
##      sprt_impt       1.000
##      think_sprt      1.337    0.135    9.912    0.000    1.441    0.943
##      negative_events =~
##      dprs_sprt       1.000
##                               0.803    0.641
```



```
##      bad_sprt          1.286    0.203    6.322    0.000    1.032    0.718
## athlete_identity =~
##      external_dntty          1.000                                0.613    0.613
##      internal_value          1.667    0.326    5.120    0.000    0.827    0.827
##      negative_evnts          0.951    0.171    5.555    0.000    0.633    0.633
##
## Regressions:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## mhc_sf ~
##   athlt_dntt (a)  -1.982    1.657   -1.196    0.232   -1.060   -0.083
##
## Intercepts:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##   .sprt_goals          5.067    0.051   99.250    0.000    5.067    5.260
##   .cnsdr_ath           5.876    0.059   99.896    0.000    5.876    5.294
##   .sprt_impt           5.110    0.080   63.963    0.000    5.110    3.390
##   .think_sprt          4.904    0.081   60.577    0.000    4.904    3.211
##   .dprs_sprt           5.666    0.066   85.293    0.000    5.666    4.521
##   .bad_sprt            5.506    0.076   72.198    0.000    5.506    3.826
##   .mhc_sf              32.125    0.703   45.668    0.000   32.125    2.502
##   .external_dntty       0.000                                0.000    0.000
##   .internal_value       0.000                                0.000    0.000
##   .negative_evnts       0.000                                0.000    0.000
##   athlete_idntty       0.000                                0.000    0.000
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##   .sprt_goals          0.168    0.087    1.932    0.053    0.168    0.181
##   .cnsdr_ath           0.668    0.081    8.240    0.000    0.668    0.543
##   .sprt_impt           1.110    0.130    8.511    0.000    1.110    0.489
##   .think_sprt          0.258    0.180    1.432    0.152    0.258    0.111
##   .dprs_sprt           0.926    0.118    7.819    0.000    0.926    0.589
##   .bad_sprt            1.004    0.176    5.720    0.000    1.004    0.485
##   .mhc_sf              163.698   12.728   12.861    0.000   163.698    0.993
##   .external_dntty       0.474    0.099    4.773    0.000    0.624    0.624
##   .internal_value       0.367    0.143    2.567    0.010    0.316    0.316
##   .negative_evnts       0.387    0.097    3.986    0.000    0.599    0.599
##   athlete_idntty       0.286    0.069    4.143    0.000    1.000    1.000
```

```
# graph looks cleaner
semPaths(basic_athlete_sem_fit,
  what = "paths",
  whatLabels = "std",
  reorder = FALSE,
  layout = "tree3",
  rotation = 4,
  intercepts = FALSE)
```



```
basic_athlete_sem <- '
# measurement model
external_identity =~ sprt_goals + cnsdr_ath
internal_value =~ sprt_impt + think_sprt
negative_events =~ dprs_sprt + bad_sprt

# structural model - direct effects
mhc_sf ~ a*external_identity + b*internal_value + c*negative_events
'

basic_athlete_sem_fit <- sem(basic_athlete_sem,
  data = athletes,
  sample.cov = TRUE,
  missing = "ML")

summary(basic_athlete_sem_fit, standardized=TRUE)
```

```
## lavaan 0.6-10 ended normally after 79 iterations
```

```
##
```

##	Estimator	ML	
##	Optimization method	NLMINB	
##	Number of model parameters	26	
##			
##		Used	Total
##	Number of observations	356	363
##	Number of missing patterns	2	

```

##
## Model Test User Model:
##
##   Test statistic                7.984
##   Degrees of freedom              9
##   P-value (Chi-square)           0.536
##
## Parameter Estimates:
##
##   Standard errors                Standard
##   Information                    Observed
##   Observed information based on   Hessian
##
## Latent Variables:
##           Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## external_identity =~
##   sprt_goals          1.000          0.864  0.897
##   cnsdr_ath           0.877    0.101   8.718   0.000  0.758  0.683
## internal_value =~
##   sprt_impt           1.000          1.089  0.723
##   think_sprt          1.309    0.130  10.057   0.000  1.426  0.933
## negative_events =~
##   dprs_sprt           1.000          0.795  0.634
##   bad_sprt            1.311    0.195   6.736   0.000  1.043  0.725
##
## Regressions:
##           Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## mhc_sf ~
##   extrnl_dnt (a)      4.594    1.245   3.691   0.000   3.968  0.309
##   internl_vl (b)     -1.227    0.992  -1.237   0.216  -1.336 -0.104
##   negtv_vnts (c)     -4.847    1.477  -3.281   0.001  -3.854 -0.300
##
## Covariances:
##           Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## external_identity ~~
##   internal_value       0.489    0.078   6.287   0.000   0.520  0.520
##   negative_evnts       0.273    0.059   4.600   0.000   0.397  0.397
## internal_value ~~
##   negative_evnts       0.445    0.085   5.252   0.000   0.514  0.514
##
## Intercepts:
##           Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##   .sprt_goals          5.067    0.051  99.250   0.000   5.067  5.260
##   .cnsdr_ath           5.876    0.059  99.896   0.000   5.876  5.294
##   .sprt_impt           5.110    0.080  63.963   0.000   5.110  3.390
##   .think_sprt          4.904    0.081  60.577   0.000   4.904  3.211
##   .dprs_sprt           5.666    0.066  85.293   0.000   5.666  4.521
##   .bad_sprt            5.506    0.076  72.198   0.000   5.506  3.826
##   .mhc_sf              32.128    0.703  45.726   0.000  32.128  2.500
##   external_dntty       0.000          0.000  0.000
##   internal_value       0.000          0.000  0.000
##   negative_evnts       0.000          0.000  0.000
##
## Variances:

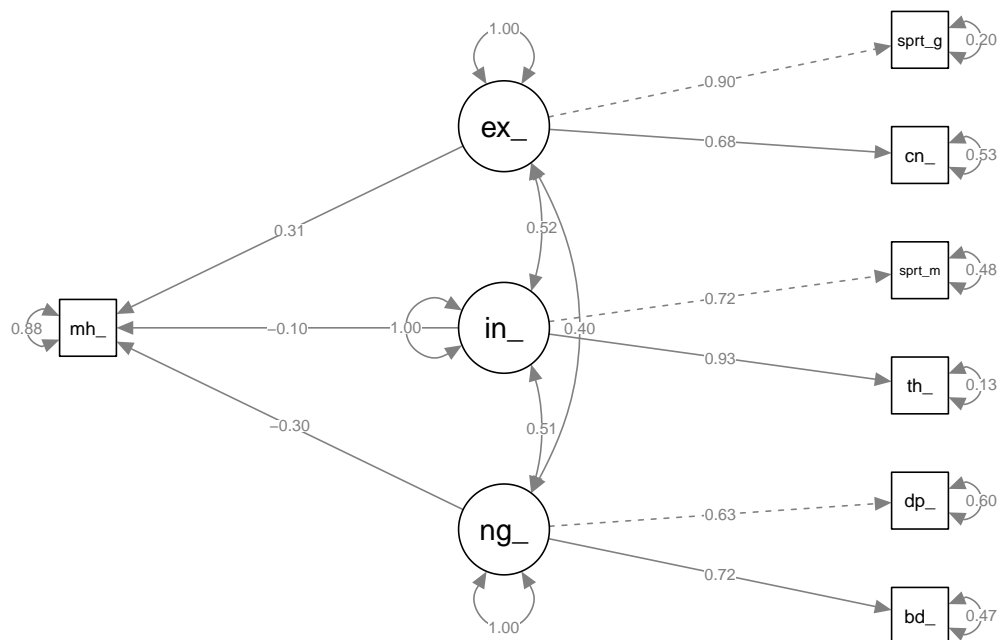
```

##		Estimate	Std.Err	z-value	P(> z)	Std.lv	Std.all
##	.sprt_goals	0.182	0.076	2.395	0.017	0.182	0.196
##	.cnsdr_ath	0.658	0.076	8.684	0.000	0.658	0.534
##	.sprt_impt	1.086	0.130	8.359	0.000	1.086	0.478
##	.think_sprt	0.301	0.175	1.723	0.085	0.301	0.129
##	.dprs_sprt	0.939	0.112	8.366	0.000	0.939	0.597
##	.bad_sprt	0.983	0.167	5.874	0.000	0.983	0.475
##	.mhc_sf	145.169	12.250	11.851	0.000	145.169	0.879
##	external_dntty	0.746	0.101	7.373	0.000	1.000	1.000
##	internal_value	1.186	0.181	6.568	0.000	1.000	1.000
##	negative_evnts	0.632	0.129	4.915	0.000	1.000	1.000

```

# graph looks cleaner
semPaths(basic_athlete_sem_fit,
  what = "paths",
  whatLabels = "std",
  reorder = FALSE,
  layout = "tree3",
  rotation = 4,
  intercepts = FALSE)

```



```

basic_athlete_sem <- '
# measurement model
external_identity =~ sprt_goals + cnsdr_ath
internal_value =~ sprt_impt + think_sprt
negative_events =~ dprs_sprt + bad_sprt

```

```

    resilience =~ bounce + strs_evnt + strs_rcvr + snap_back + difficult + setbacks

# structural model - direct effects
mhc_sf ~ a*external_identity + b*internal_value + c*negative_events
resilience ~ d*external_identity
resilience ~ e*internal_value
resilience ~ f*negative_events
,

basic_athlete_sem_fit <- sem(basic_athlete_sem,
    data = athletes,
    sample.cov = TRUE,
    missing = "ML")

summary(basic_athlete_sem_fit, standardized=TRUE)

```

```

## lavaan 0.6-10 ended normally after 103 iterations
##
##      Estimator                      ML
##      Optimization method          NLMINB
##      Number of model parameters    48
##
##                               Used      Total
##      Number of observations        356      363
##      Number of missing patterns      3
##
## Model Test User Model:
##
##      Test statistic                71.986
##      Degrees of freedom              56
##      P-value (Chi-square)           0.074
##
## Parameter Estimates:
##
##      Standard errors                Standard
##      Information                    Observed
##      Observed information based on    Hessian
##
## Latent Variables:
##      Estimate  Std.Err  z-value  P(>|z|)  Std.lv  Std.all
##      external_identity =~
##      sprt_goals      1.000
##      cnsdr_ath        0.878    0.100    8.815    0.000    0.758    0.683
##      internal_value =~
##      sprt_impt        1.000
##      think_sprt       1.323    0.132   10.044    0.000    1.433    0.938
##      negative_events =~
##      dprs_sprt        1.000
##      bad_sprt         1.283    0.186    6.914    0.000    1.031    0.717
##      resilience =~
##      bounce           1.000
##      strs_evnt        1.287    0.094   13.747    0.000    0.855    0.793
##      strs_rcvr        1.015    0.085   11.891    0.000    0.675    0.679
##      snap_back        1.224    0.087   14.113    0.000    0.814    0.809

```

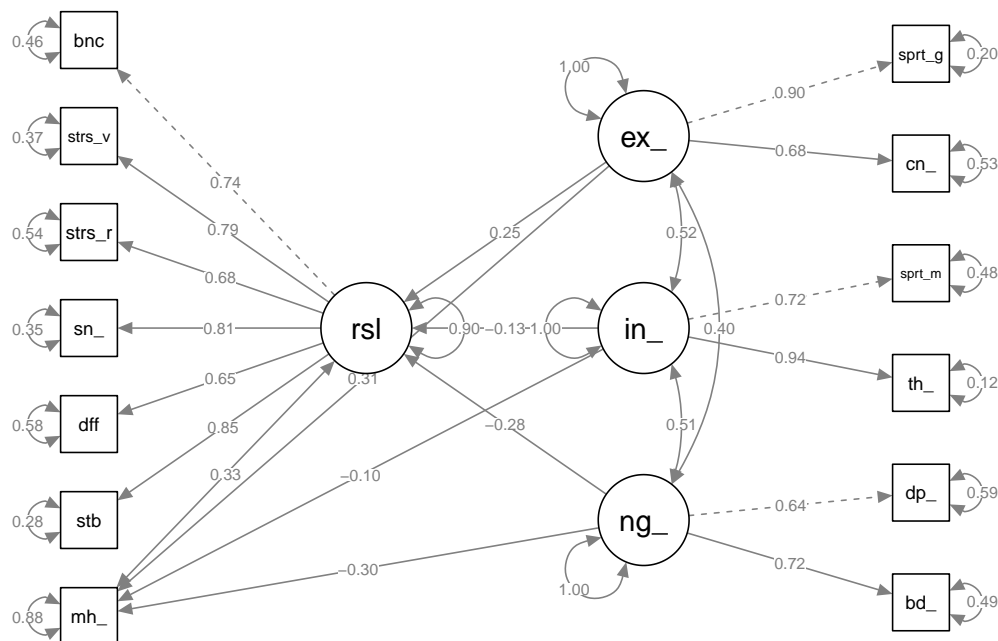
```

##      difficult      0.969    0.086   11.213    0.000    0.644    0.650
##      setbacks      1.256    0.085   14.742    0.000    0.835    0.846
##
## Regressions:
##              Estimate Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   mhc_sf ~
##     extrnl_dnt (a)    4.587    1.239    3.703    0.000    3.961    0.308
##     internal_vl (b)   -1.198    0.990   -1.210    0.226   -1.297   -0.101
##     negtv_vnts (c)   -4.821    1.472   -3.276    0.001   -3.875   -0.302
##   resilience ~
##     extrnl_dnt (d)    0.192    0.067    2.881    0.004    0.250    0.250
##     internal_vl (e)   -0.078    0.054   -1.450    0.147   -0.127   -0.127
##     negtv_vnts (f)   -0.231    0.080   -2.887    0.004   -0.279   -0.279
##
## Covariances:
##              Estimate Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   external_identity ~~
##     internal_value      0.484    0.078    6.235    0.000    0.518    0.518
##     negative_evnts      0.277    0.059    4.675    0.000    0.398    0.398
##   internal_value ~~
##     negative_evnts      0.448    0.084    5.323    0.000    0.514    0.514
##   .resilience ~~
##     .mhc_sf             2.474    0.532    4.653    0.000    3.933    0.326
##
## Intercepts:
##              Estimate Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   .sprt_goals          5.067    0.051   99.249    0.000    5.067    5.260
##   .cnsdr_ath           5.876    0.059   99.896    0.000    5.876    5.294
##   .sprt_impt           5.110    0.080   63.963    0.000    5.110    3.390
##   .think_sprt          4.904    0.081   60.577    0.000    4.904    3.211
##   .dprs_sprt           5.666    0.066   85.293    0.000    5.666    4.521
##   .bad_sprt            5.506    0.076   72.198    0.000    5.506    3.826
##   .bounce              3.953    0.050   78.695    0.000    3.953    4.374
##   .strs_evnt           3.350    0.060   55.917    0.000    3.350    3.106
##   .strs_rcvr           3.565    0.055   64.528    0.000    3.565    3.588
##   .snap_back           3.521    0.056   63.056    0.000    3.521    3.502
##   .difficult           3.372    0.055   61.215    0.000    3.372    3.404
##   .setbacks            3.577    0.055   65.263    0.000    3.577    3.624
##   .mhc_sf             32.127    0.703   45.725    0.000   32.127    2.500
##   external_dntty       0.000          0.000    0.000    0.000    0.000    0.000
##   internal_value       0.000          0.000    0.000    0.000    0.000    0.000
##   negative_evnts       0.000          0.000    0.000    0.000    0.000    0.000
##   .resilience         0.000          0.000    0.000    0.000    0.000    0.000
##
## Variances:
##              Estimate Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   .sprt_goals          0.183    0.075    2.439    0.015    0.183    0.197
##   .cnsdr_ath           0.657    0.075    8.749    0.000    0.657    0.534
##   .sprt_impt           1.099    0.129    8.483    0.000    1.099    0.484
##   .think_sprt          0.279    0.176    1.582    0.114    0.279    0.120
##   .dprs_sprt           0.925    0.111    8.326    0.000    0.925    0.589
##   .bad_sprt            1.006    0.162    6.227    0.000    1.006    0.486
##   .bounce              0.375    0.034   10.984    0.000    0.375    0.459
##   .strs_evnt           0.432    0.042   10.246    0.000    0.432    0.371

```

```
## .strs_rcvr      0.532    0.047   11.425    0.000    0.532    0.539
## .snap_back     0.349    0.035    9.952    0.000    0.349    0.345
## .difficult     0.567    0.049   11.632    0.000    0.567    0.578
## .setbacks      0.278    0.031    9.049    0.000    0.278    0.285
## .mhc_sf        145.189   12.260   11.842    0.000   145.189    0.879
## external_dntty 0.745    0.100    7.428    0.000    1.000    1.000
## internal_value 1.173    0.179    6.538    0.000    1.000    1.000
## negative_evnts 0.646    0.129    5.016    0.000    1.000    1.000
## .resilience    0.396    0.055    7.132    0.000    0.895    0.895
```

```
# graph looks cleaner
semPaths(basic_athlete_sem_fit,
  what = "paths",
  whatLabels = "std",
  reorder = FALSE,
  layout = "tree3",
  rotation = 4,
  intercepts = FALSE)
```



```
athlete_sem <- '
# measurement model
external_identity =~ sprt_goals + cnsdr_ath
internal_value =~ sprt_impt + think_sprt
negative_events =~ dprs_sprt + bad_sprt

athlete_identity =~ external_identity + internal_value + negative_events
```

```

    resilience =~ bounce + strs_evnt + strs_rcvr + snap_back + difficult + setbacks

# structural model - direct effects
mhc_sf ~ a*athlete_identity + c*resilience + e*age_grp
resilience ~ d*athlete_identity
age_grp ~ g*athlete_identity

# indirect
indirect_athlete_identity := d*c + g*e

# total
total_athlete_identity:= d*c + a
,

athletes <- athletes %>% map_df(., as.numeric())

athlete_sem_fit <- sem(athlete_sem,
                      data = athletes,
                      sample.cov = TRUE,
                      missing = "ML")

# standardized
summary(athlete_sem_fit, standardized = TRUE)

```

```

## lavaan 0.6-10 ended normally after 109 iterations
##
##      Estimator                      ML
##      Optimization method          NLMINB
##      Number of model parameters    48
##
##      Number of observations        363
##      Number of missing patterns    4
##
## Model Test User Model:
##
##      Test statistic                142.309
##      Degrees of freedom            71
##      P-value (Chi-square)          0.000
##
## Parameter Estimates:
##
##      Standard errors              Standard
##      Information                  Observed
##      Observed information based on Hessian
##
## Latent Variables:
##
##      Estimate  Std.Err  z-value  P(>|z|)  Std.lv  Std.all
##      external_identity =~
##      sprt_goals      1.000
##      cnsdr_ath        0.880    0.114    7.730    0.000    0.759    0.684
##      internal_value =~
##      sprt_impt        1.000
##      think_sprt       1.340    0.142    9.461    0.000    1.076    0.714
##      negative_events =~
##      dprs_sprt        1.000
##

```



```

##      bad_sprt          1.370    0.201    6.804    0.000    1.065    0.741
## athlete_identity =~
##      external_dntty      1.000                0.619    0.619
##      internal_value      1.473    0.243    6.057    0.000    0.730    0.730
##      negative_evnts      1.072    0.211    5.081    0.000    0.735    0.735
## resilience =~
##      bounce              1.000                0.664    0.735
##      strs_evnt           1.284    0.093   13.747    0.000    0.853    0.792
##      strs_rcvr           1.016    0.085   11.916    0.000    0.675    0.679
##      snap_back           1.224    0.087   14.137    0.000    0.813    0.810
##      difficult           0.968    0.086   11.222    0.000    0.643    0.650
##      setbacks            1.252    0.085   14.735    0.000    0.832    0.844
##
## Regressions:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## mhc_sf ~
##   athlt_dntt (a)    0.195    1.679    0.116    0.908    0.104    0.008
##   resilience (c)    7.525    1.133    6.644    0.000    4.997    0.390
##   age_grp (e)      1.257    0.557    2.256    0.024    1.257    0.123
## resilience ~
##   athlt_dntt (d)   -0.193    0.098   -1.975    0.048   -0.155   -0.155
## age_grp ~
##   athlt_dntt (g)   -0.730    0.197   -3.711    0.000   -0.390   -0.311
##
## Intercepts:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .sprt_goals        5.067    0.051   99.278    0.000    5.067    5.260
## .cnsdr_ath          5.876    0.059   99.909    0.000    5.876    5.294
## .sprt_impt          5.108    0.080   63.974    0.000    5.108    3.390
## .think_sprt         4.903    0.081   60.599    0.000    4.903    3.210
## .dprs_sprt          5.665    0.066   85.306    0.000    5.665    4.520
## .bad_sprt           5.504    0.076   72.213    0.000    5.504    3.826
## .bounce             3.954    0.050   78.719    0.000    3.954    4.379
## .strs_evnt          3.352    0.060   55.944    0.000    3.352    3.111
## .strs_rcvr          3.566    0.055   64.551    0.000    3.566    3.592
## .snap_back          3.523    0.056   63.083    0.000    3.523    3.508
## .difficult          3.373    0.055   61.238    0.000    3.373    3.408
## .setbacks           3.579    0.055   65.291    0.000    3.579    3.630
## .mhc_sf             28.739    1.656   17.356    0.000   28.739    2.242
## .age_grp            2.689    0.066   40.958    0.000    2.689    2.150
## .external_dntty      0.000                0.000    0.000
## .internal_value      0.000                0.000    0.000
## .negative_evnts      0.000                0.000    0.000
## athlete_idntty      0.000                0.000    0.000
## .resilience         0.000                0.000    0.000
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .sprt_goals        0.185    0.088    2.099    0.036    0.185    0.199
## .cnsdr_ath          0.656    0.083    7.874    0.000    0.656    0.533
## .sprt_impt          1.113    0.135    8.221    0.000    1.113    0.490
## .think_sprt         0.254    0.192    1.319    0.187    0.254    0.109
## .dprs_sprt          0.965    0.110    8.808    0.000    0.965    0.615
## .bad_sprt           0.935    0.170    5.511    0.000    0.935    0.452

```

```
##      .bounce          0.374    0.034   10.971    0.000    0.374    0.459
##      .strs_evnt       0.433    0.042   10.248    0.000    0.433    0.373
##      .strs_rcvr       0.531    0.046   11.414    0.000    0.531    0.538
##      .snap_back      0.347    0.035    9.928    0.000    0.347    0.344
##      .difficult      0.566    0.049   11.626    0.000    0.566    0.578
##      .setbacks       0.280    0.031    9.093    0.000    0.280    0.288
##      .mhc_sf         136.344   10.886   12.525    0.000   136.344    0.830
##      .age_grp        1.413    0.116   12.222    0.000    1.413    0.903
##      .external_dntty  0.459    0.099    4.614    0.000    0.617    0.617
##      .internal_value  0.542    0.122    4.439    0.000    0.468    0.468
##      .negative_evnts  0.278    0.090    3.085    0.002    0.460    0.460
##      athlete_idntty  0.284    0.067    4.256    0.000    1.000    1.000
##      .resilience     0.430    0.059    7.317    0.000    0.976    0.976
```

```
## Defined Parameters:
```

```
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      indrct_thlt_dn -2.373    0.932  -2.545    0.011  -1.265  -0.099
##      ttl_thlt_dntty -1.260    1.821  -0.692    0.489  -0.672  -0.052
```

```
# unstandardized
```

```
summary(athlete_sem_fit)
```

```
## lavaan 0.6-10 ended normally after 109 iterations
```

```
##
##      Estimator                      ML
##      Optimization method          NLMINB
##      Number of model parameters    48
##
##      Number of observations        363
##      Number of missing patterns    4
```

```
## Model Test User Model:
```

```
##
##      Test statistic                142.309
##      Degrees of freedom             71
##      P-value (Chi-square)           0.000
```

```
## Parameter Estimates:
```

```
##
##      Standard errors              Standard
##      Information                  Observed
##      Observed information based on Hessian
```

```
## Latent Variables:
```

```
##      Estimate Std.Err z-value P(>|z|)
##      external_identity =~
##      sprt_goals          1.000
##      cnsdr_ath           0.880    0.114    7.730    0.000
##      internal_value =~
##      sprt_impt           1.000
##      think_sprt          1.340    0.142    9.461    0.000
##      negative_events =~
##      dprs_sprt           1.000
##      bad_sprt            1.370    0.201    6.804    0.000
##      athlete_identity =~
```

```

##      external_dntty          1.000
##      internal_value          1.473      0.243      6.057      0.000
##      negative_evnts          1.072      0.211      5.081      0.000
##      resilience =~
##      bounce                  1.000
##      strs_evnt               1.284      0.093     13.747      0.000
##      strs_rcvr               1.016      0.085     11.916      0.000
##      snap_back               1.224      0.087     14.137      0.000
##      difficult               0.968      0.086     11.222      0.000
##      setbacks                1.252      0.085     14.735      0.000
##
## Regressions:
##              Estimate   Std.Err   z-value   P(>|z|)
##      mhc_sf ~
##      athlt_dntt (a)      0.195     1.679     0.116     0.908
##      resilience (c)      7.525     1.133     6.644     0.000
##      age_grp (e)        1.257     0.557     2.256     0.024
##      resilience ~
##      athlt_dntt (d)     -0.193     0.098    -1.975     0.048
##      age_grp ~
##      athlt_dntt (g)     -0.730     0.197    -3.711     0.000
##
## Intercepts:
##              Estimate   Std.Err   z-value   P(>|z|)
##      .sprt_goals         5.067     0.051    99.278     0.000
##      .cnsdr_ath          5.876     0.059    99.909     0.000
##      .sprt_impt          5.108     0.080    63.974     0.000
##      .think_sprt         4.903     0.081    60.599     0.000
##      .dprs_sprt          5.665     0.066    85.306     0.000
##      .bad_sprt           5.504     0.076    72.213     0.000
##      .bounce             3.954     0.050    78.719     0.000
##      .strs_evnt          3.352     0.060    55.944     0.000
##      .strs_rcvr          3.566     0.055    64.551     0.000
##      .snap_back          3.523     0.056    63.083     0.000
##      .difficult          3.373     0.055    61.238     0.000
##      .setbacks           3.579     0.055    65.291     0.000
##      .mhc_sf             28.739     1.656    17.356     0.000
##      .age_grp            2.689     0.066    40.958     0.000
##      .external_dntty     0.000
##      .internal_value     0.000
##      .negative_evnts     0.000
##      athlete_idntty      0.000
##      .resilience         0.000
##
## Variances:
##              Estimate   Std.Err   z-value   P(>|z|)
##      .sprt_goals         0.185     0.088     2.099     0.036
##      .cnsdr_ath          0.656     0.083     7.874     0.000
##      .sprt_impt          1.113     0.135     8.221     0.000
##      .think_sprt         0.254     0.192     1.319     0.187
##      .dprs_sprt          0.965     0.110     8.808     0.000
##      .bad_sprt           0.935     0.170     5.511     0.000
##      .bounce             0.374     0.034    10.971     0.000
##      .strs_evnt          0.433     0.042    10.248     0.000

```

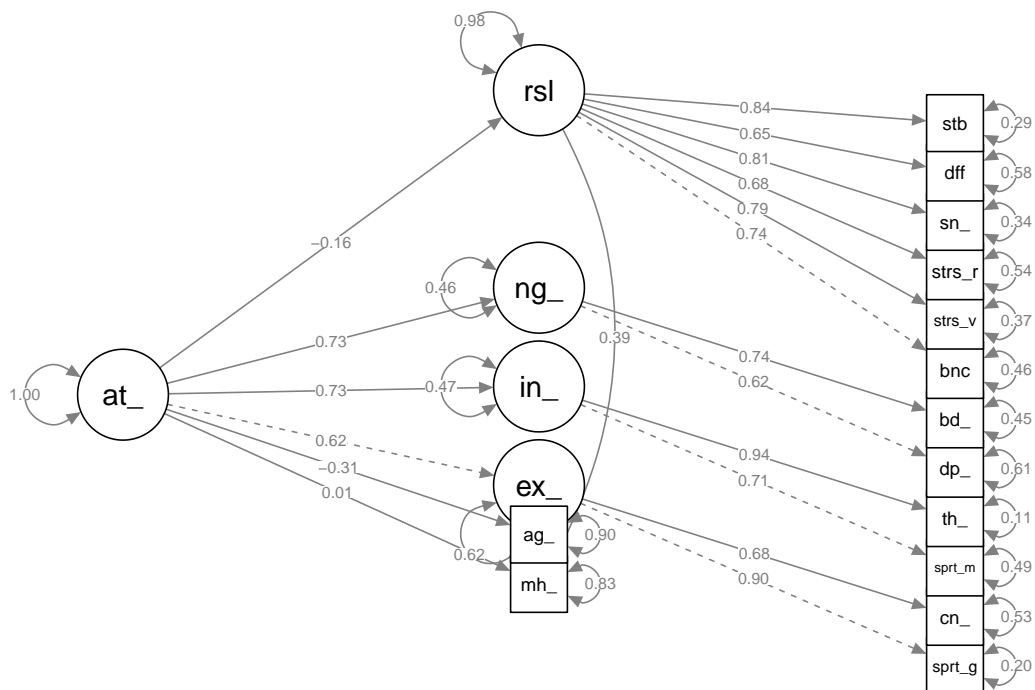
```
## .strs_rcvr      0.531    0.046   11.414    0.000
## .snap_back     0.347    0.035    9.928    0.000
## .difficult     0.566    0.049   11.626    0.000
## .setbacks      0.280    0.031    9.093    0.000
## .mhc_sf       136.344   10.886   12.525    0.000
## .age_grp       1.413    0.116   12.222    0.000
## .external_dntty 0.459    0.099    4.614    0.000
## .internal_value 0.542    0.122    4.439    0.000
## .negative_evnts 0.278    0.090    3.085    0.002
## athlete_idntty 0.284    0.067    4.256    0.000
## .resilience    0.430    0.059    7.317    0.000
```

```
##
```

```
## Defined Parameters:
```

```
##           Estimate Std.Err z-value P(>|z|)
## indrc_tthlt_dn -2.373   0.932  -2.545   0.011
## ttl_tthlt_dntty -1.260   1.821  -0.692   0.489
```

```
# graph looks cleaner
semPaths(athlete_sem_fit,
  what = "paths",
  whatLabels = "std",
  reorder = FALSE,
  layout = "tree2",
  rotation = 2,
  intercepts = FALSE)
```



```

athletes$age_grp %>% as.numeric()

##      [1] 3 1 1 3 4 4 3 3 1 4 2 3 5 1 5 2 2 2 2 2 5 1 1 1 4 2 2 2 3 4 1 3 1 4 5 1
##     [38] 2 2 3 1 1 1 3 2 3 2 4 1 2 1 1 3 2 1 1 3 2 1 3 1 1 1 3 4 5 5 4 3 4 2 3 3 1
##     [75] 5 1 1 4 1 2 3 1 4 1 6 2 1 3 2 2 3 2 4 1 2 5 1 2 4 2 4 3 6 1 5 4 3 2 3 2 5
##    [112] 3 2 3 3 4 2 4 4 2 2 3 4 4 3 3 4 4 3 3 2 2 2 4 2 5 2 4 5 3 3 1 2 3 4 5 4 4
##    [149] 2 3 2 2 2 5 4 4 4 5 3 5 4 4 6 1 4 2 2 1 3 4 2 5 6 2 1 1 2 2 2 2 3 3 4 5 2
##    [186] 3 2 1 4 2 3 2 2 2 3 2 4 1 2 2 2 3 2 2 2 2 2 2 2 2 4 1 3 2 2 3 3 4 3 3 4 1 2
##    [223] 1 3 3 7 4 2 4 3 4 4 4 4 5 4 4 2 3 3 4 2 2 3 2 4 4 3 2 2 3 4 2 4 2 2 3 3 2
##    [260] 3 3 3 2 3 3 2 2 2 2 3 3 2 2 2 2 2 3 2 1 3 5 2 2 3 4 4 3 3 4 3 1 2 4 2 2 2
##    [297] 3 2 3 2 2 3 5 3 3 3 1 2 1 1 2 1 1 1 1 1 1 2 1 6 1 3 2 2 3 3 4 2 2 2 2 2 2
##    [334] 3 2 2 2 7 3 1 4 2 6 2 2 6 3 2 4 1 2 1 1 3 3 2 2 3 2 2 2 2 2 2 2 2 2 2 2

non_athlete_sem <- '
# measurement model
external_identity =~ sprt_goals + cnsdr_ath
internal_value =~ sprt_impt + think_sprt
negative_events =~ dprs_sprt + bad_sprt

athlete_identity =~ external_identity + internal_value + negative_events

resilience =~ bounce + strsr_evnt + strsr_rcvr + snap_back + difficult + setbacks

# structural model - direct effects
mhc_sf ~ a*athlete_identity + c*resilience
resilience ~ d*athlete_identity

# indirect
indirect_athlete_identity := d*c

# total
total_athlete_identity:= d*c + a
'

non_athlete_sem_fit <- sem(non_athlete_sem,
  data = non_athletes,
  sample.cov = TRUE,
  missing = "ML")

# unstandardized
summary(non_athlete_sem_fit)

## lavaan 0.6-10 ended normally after 89 iterations
##
##      Estimator                      ML
##      Optimization method          NLMINB
##      Number of model parameters          44
##
##                               Used      Total
##      Number of observations          373      390
##      Number of missing patterns           5
##
## Model Test User Model:
##

```

```

##      Test statistic                      78.029
##      Degrees of freedom                      60
##      P-value (Chi-square)                   0.059
##
## Parameter Estimates:
##
##      Standard errors                      Standard
##      Information                          Observed
##      Observed information based on        Hessian
##
## Latent Variables:
##      Estimate Std.Err z-value P(>|z|)
##      external_identity =~
##      sprt_goals          1.000
##      cnsdr_ath           0.987    0.099    9.942    0.000
##      internal_value =~
##      sprt_impt           1.000
##      think_sprt          0.931    0.067   13.848    0.000
##      negative_events =~
##      dprs_sprt           1.000
##      bad_sprt            0.972    0.094   10.288    0.000
##      athlete_identity =~
##      external_dntty      1.000
##      internal_value      1.041    0.107    9.714    0.000
##      negative_evnts      1.013    0.120    8.462    0.000
##      resilience =~
##      bounce              1.000
##      strs_evnt           1.000    0.071   14.050    0.000
##      strs_rcvr           1.001    0.071   14.096    0.000
##      snap_back           1.143    0.069   16.448    0.000
##      difficult           0.975    0.066   14.664    0.000
##      setbacks            1.111    0.068   16.247    0.000
##
## Regressions:
##      Estimate Std.Err z-value P(>|z|)
##      mhc_sf ~
##      athlt_dntt (a)     -1.657    0.780   -2.124    0.034
##      resilience (c)     10.787    1.052   10.251    0.000
##      resilience ~
##      athlt_dntt (d)      0.077    0.049    1.579    0.114
##
## Intercepts:
##      Estimate Std.Err z-value P(>|z|)
##      .sprt_goals        4.288    0.139   30.913    0.000
##      .cnsdr_ath          3.412    0.150   22.819    0.000
##      .sprt_impt          3.805    0.141   27.057    0.000
##      .think_sprt         3.345    0.141   23.734    0.000
##      .dprs_sprt          4.275    0.158   27.071    0.000
##      .bad_sprt           4.042    0.153   26.373    0.000
##      .bounce             3.766    0.052   72.147    0.000
##      .strs_evnt          3.262    0.056   58.262    0.000
##      .strs_rcvr          3.401    0.057   59.928    0.000
##      .snap_back          3.339    0.056   59.522    0.000
##      .difficult          3.280    0.053   61.469    0.000

```

```

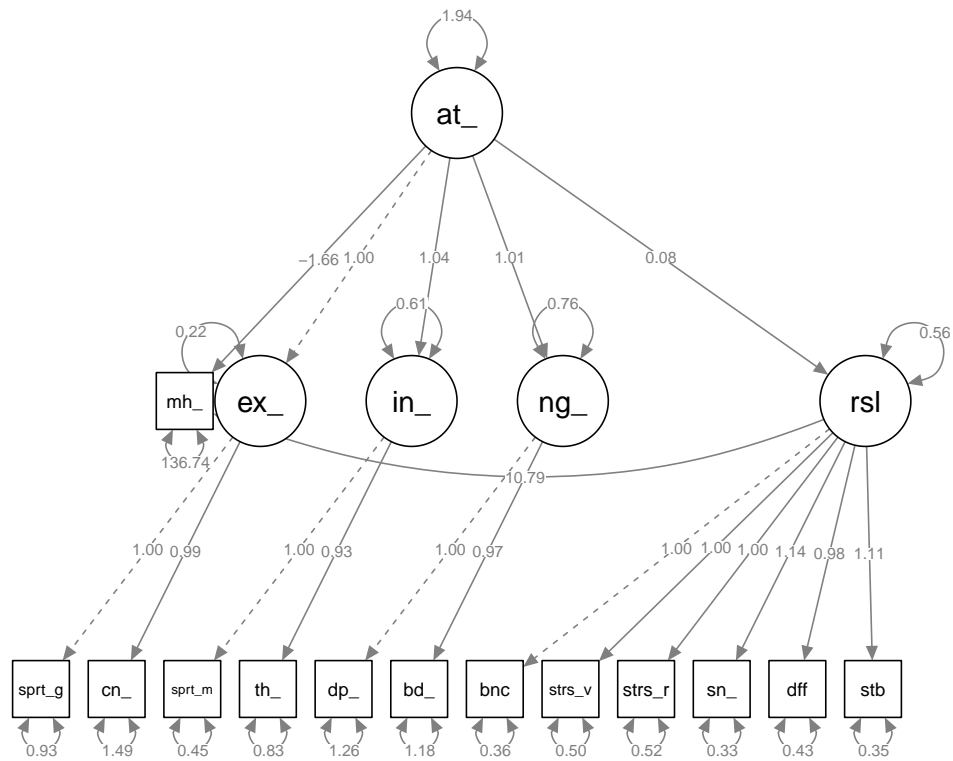
##      .setbacks      3.427    0.056   61.507    0.000
##      .mhc_sf        35.009    0.757   46.223    0.000
##      .external_dntty 0.000
##      .internal_value 0.000
##      .negative_evnts 0.000
##      athlete_idntty 0.000
##      .resilience    0.000
##
## Variances:
##      Estimate Std.Err z-value P(>|z|)
##      .sprt_goals      0.927    0.184    5.040    0.000
##      .cnsdr_ath       1.489    0.222    6.698    0.000
##      .sprt_impt       0.453    0.142    3.202    0.001
##      .think_sprt     0.832    0.147    5.644    0.000
##      .dprs_sprt      1.259    0.241    5.220    0.000
##      .bad_sprt       1.177    0.227    5.184    0.000
##      .bounce         0.357    0.033   10.804    0.000
##      .strs_evnt      0.495    0.043   11.449    0.000
##      .strs_rcvr      0.523    0.045   11.528    0.000
##      .snap_back      0.326    0.033    9.884    0.000
##      .difficult      0.426    0.038   11.275    0.000
##      .setbacks       0.352    0.034   10.319    0.000
##      .mhc_sf        136.741   11.592   11.796    0.000
##      .external_dntty 0.219    0.181    1.210    0.226
##      .internal_value 0.614    0.196    3.134    0.002
##      .negative_evnts 0.759    0.231    3.286    0.001
##      athlete_idntty 1.943    0.351    5.536    0.000
##      .resilience    0.564    0.068    8.254    0.000
##
## Defined Parameters:
##      Estimate Std.Err z-value P(>|z|)
##      indrct_thlt_dn  0.833    0.545    1.527    0.127
##      ttl_thlt_dntty -0.824    0.866   -0.951    0.341

```

```

# graph looks cleaner
semPaths(non_athlete_sem_fit,
  what = "paths",
  whatLabels = "est",
  reorder = FALSE,
  layout = "tree2",
  rotation = 1,
  intercepts = FALSE)

```



Interpretation

From our SEM, we observe that athlete identity *negatively* affects emotional well being, as defined by the MHC-SF scale. Resilience is associated with a positive effect on MHC-SF.