1. OVERVIEW

This Electronic Supplementary Material provides a more detailed description of the statistical approach used in the manuscript entitled “Multivariable modeling of factors associated with spinal pain in young adolescence.”

In interpreting results, note that the different reported measures of variable or group importance are geared towards different statistical aspects of these variables or groups. The variable selection process (through bi-level selection), and the calculation of pseudo-$R^2$ measures and average group ranks is geared towards the model’s predictive ability. In contrast, the calculation of $p$ values aims to reveal if the data carry sufficient evidence for the considered predictors to be risk-increasing or risk-reducing, regardless of predictive ability. Finally, the calculation of bootstrap-based variable importance scores (VISs) assesses the stability of the selected factors under sample variation.

Because of this, these measures will sometimes not agree, and their agreement may be viewed as reassuring and strengthening the conclusions.

2. LOGISTIC REGRESSION MODEL FITTED USING BI-LEVEL SELECTION METHODS

For each of the considered outcomes, a logistic regression model was fitted using regularization methods [1] on all of the variables collected in the 5 domains of interest. These methods are specifically designed for predicting an outcome measure in the presence of a large number of correlated factors or predictor variables. In particular, they attempt to fit a logistic regression model involving all factors, but `regularize’ the coefficients in that model in the sense that excessive coefficients are not tolerated according to some regularization criterion. Such regularization is needed to prevent overfitting, which typically manifests itself through regression models with sizeable coefficients. Regularization thus has the effect of shrinking coefficients down to zero, and even eliminating some factors or predictors from the model by setting their coefficients exactly to zero. The resulting models may very well include non-significant factors, but are generally better suited for prediction [2,3].
As regularization method, we used a so-called bi-level selection method [1] on all of the variables collected in the 5 domains of interest to take advantage of the grouping structure in the domains. Bi-level selection methods perform variable selection both within and between domains. In particular, relative to the more popular group lasso, bi-level selection methods do not include or exclude an entire domain from the model, but allow to additionally eliminate variables within each domain. This is done in such a way that a variable with a moderately sized coefficient is more likely removed from the model if the other variables in the same group are not associated with the outcome, and is more likely retained if some of the other variables in the same group are predictive of the outcome. Bi-level selection was achieved using a so-called composite minimax concave penalty. The advantage of using such penalty is that smaller variable domains are not overwhelmed by larger variable domains; it thus prevents that larger variable domains are more likely included in the model. Generalized cross-validation was used to select an optimal penalty parameter. The thus selected model was refitted using logistic regression with Firth correction to account for the high dimensionality of the model, and the resulting odds ratios and associated 95% confidence intervals were reported. Level of significance was set at $\alpha < 0.05$.

3. VARIABLE IMPORTANCE SCORES – AVERAGE GROUP RANKS

The relative importance of each variable was evaluated using variable importance scores (VISs), obtained by refitting the model in each of 1000 bootstrap samples and counting the percentage of times the considered variable was retained in the model. Important variables have higher importance scores. For each domain, the average VIS was calculated as was the average group ranking. To obtain the latter, each group was ranked from 1 to 5 in each of the bootstrap analyses; 5 was assigned to the group that was first removed from the model as regularization became more stringent; 4 was assigned to the next group that was removed, etc. Low values on the average group ranking thus point towards relatively more important risk domains.

REFERENCE LIST

