Modelling Obesity as a function of weekly physical activity profiles measured by Actigraph accelerometers

Nicole H Augustin[1], Calum Mattocks[2], Chris Riddoch[2], Andy Ness[3] and Julian Faraway[1]
[1] Department of Mathematical Sciences, University of Bath, Bath, UK; [2]School for Health, University of Bath; [3] Department of Oral and Dental Science, Bristol Dental Hospital.

INTRODUCTION

We develop a new statistical model investigating the relationship between fat mass and physical activity measured by actigraph. The key feature of the model is that it utilises the full profile of measured physical activity, rather than simple summary measures.

METHODS

Our data are from the the Avon longitudinal study of parents and children (ALSPAC). Fat mass, the outcome, was derived using a Lunar Prodigy DEXA scanner. Physical activity, the predictor, is a time series of 10080 minute by minute accelerometer measurements of counts per minute over 7 days available at three ages (12, 14 and 16). We first transform the profiles to activity level histograms, thereby making profiles comparable between individuals, reducing the dimension of data, but maintaining interpretability (Figure 1 left). We then fit a generalised version of a regression model with fat mass as the outcome and the profile histogram as one of the predictors. The response y_{ik} is total fat mass for individual i at age k, the vector x_{ik} is the accelerometer profile, with 10080 entries and $z_{ik}(x)$ is the corresponding histogram with some given number of mid-points x_j. Our new model approach is a generalised regression of scalars on functions:

$$log(y_{ik}) = \alpha + \sum_j f(x_j) z_{ik}(x_j) + \sum_l \gamma_l \texttt{confounder}_{lik} + \epsilon_{ik}$$

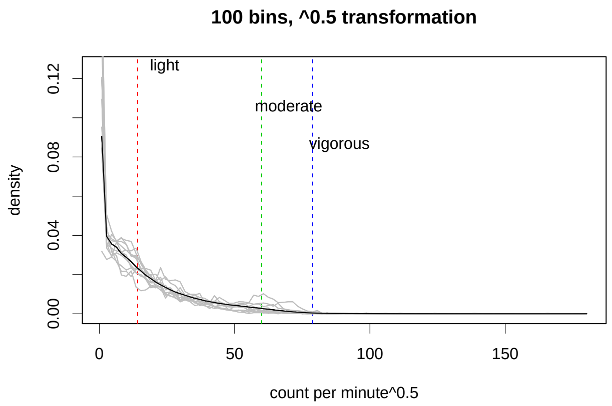
where the error ϵ_{ik} follows a normal distribution with zero mean and variance σ^2 and the confounders are `sex`, `height`, `height`^{2}. The $f(x)$ is an unknown smooth 'coefficient' function to be estimated, which we represent with an adaptive P-spline smoother. The $f(x_j)$ can be interpreted as regression coefficients relating to each of the histogram mid-points x_j.

RESULTS and CONCLUSIONS

Our new approach shows that the histogram is useful for exploring the whole range of physical activity when modelling fat mass. Preliminary model results are shown in Figure 1 (right), where the estimated coefficient function $f(x_j)$ is shown versus the square root of counts per minute. The graph supports the cut-point used for moderate to vigorous physical activity (MVPA) at around 3600 counts per minute set by a calibration study [1] and confirm that moderate and vigorous activity has a negative effect on fat mass. In addition, we find that light physical activity around 500 counts per minute has a significant positive effect on fat mass.

REFERENCES

[1] Mattocks C, Ness A, Leary SD, Tilling K, Blair S, Shield J, Deere, K, Saunders J, Kirkby J, Smith GD, Wells J, Wareham N, Reilly J, and Riddoch C (2008). Use of accelerometers in a large field based study of children: Protocols, design issues, and effects on precision. Journal or Physical Activity and Health, 5:S94–S107.



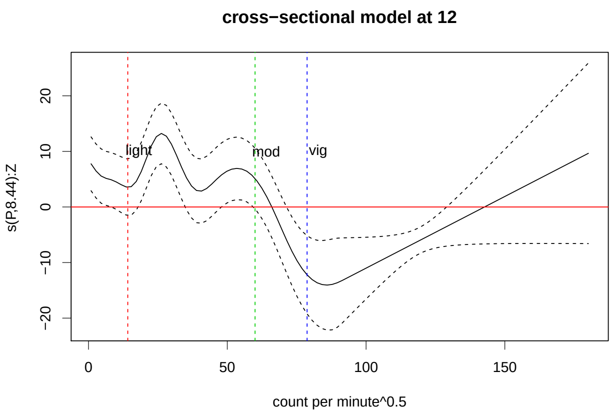


Figure 1: Left: Black solid line is the mean histogram of the square root actigraph measurements, with some sample profiles (grey lines), both at age 12. Right: Estimated coefficient function $f(x_j)$ with 95% confidence bands for accelerometer histogram at age 12. Red, green and blue lines correspond to light, moderate and vigorous physical activity at 200, 3600 and 6200 counts per minute from [1].