Association between Change in Microscopic White Matter Pathways and Cardiorespiratory Fitness in Response to a Behavioral Weight Loss Intervention

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http://psy.cmu.edu/~coaxlab/posters/porter_CNS19.pdf

Background

Poorer physical health, such as reduced cardiorespiratory fitness and higher adiposity, associates with individual differences in the microstructural integrity of white matter pathways (for review Porter et al, 2018). How improvements in physical health, through diet and exercise, impact white matter pathways remains unclear.

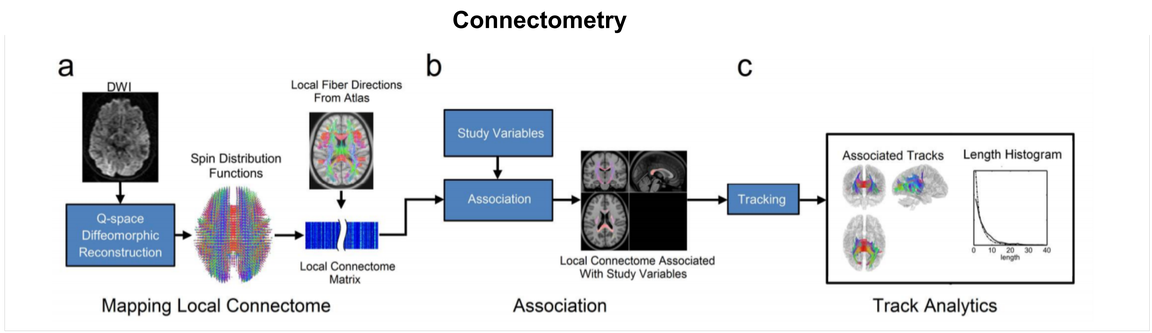
Hypothesis: Specific improvements in physical health factors, from a 12-month diet and exercise intervention, will associate with changes in white matter pathways.

Methods

Participants: N=91 (74 female; mean age of 44 years), with body types ranging from overweight to obese, participated in a 12-month behavioral weight loss intervention and energy-restricted diet alone or in combination with physical activity that progressed from 150-250 minutes/week.

Health measures: Participants were evaluated on changes in several health measures (post-pre); body mass index (BMI), weight measured in kg (wtkg), waist to hip ratio at the iliac crest (waistIliac), absolute value of liters of O2 per minute (VO2Lmin), graded exercise test (GxT seconds), and body fat composition using dual-energy x-ray absorptiometry percent fat when total body weight does not include bone weight (DXA Tissue) and percent fat when total body weight does include bone weight (DXA Region). A dimensionality reduction analysis (principal component analysis) was used to identify the lower dimensional components of shared variance across these health measures. These factors were used for the primary analysis with white matter.

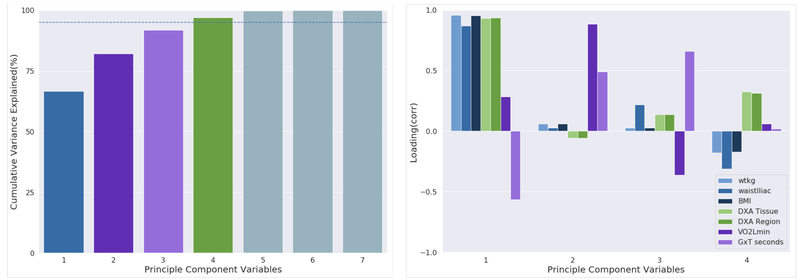
Diffusion Imaging: A diffusion tensor imaging sequence (DTI; 64 directions, b=2000 s/mm^2, 2.4mm^3 voxels) was collected on each subject, before and after the intervention, on a Siemens Verio 3T MRI system on the CMU campus. The DTI data were reconstructed using QSDR (Yeh et al 2011) and aggregated into MNI-space. Health-white matter associations were measured using a connectometry analysis (Yeh et al., 2016), that tracked associations with each principal component along white matter fascicles, controlling for age, sex, and post-pre changes in framewise displacement. Significant track segments were determined using an FDR threshold of less than 0.05 based on 2000 randomized permutations to the group.



(Yeh, et al 2016)

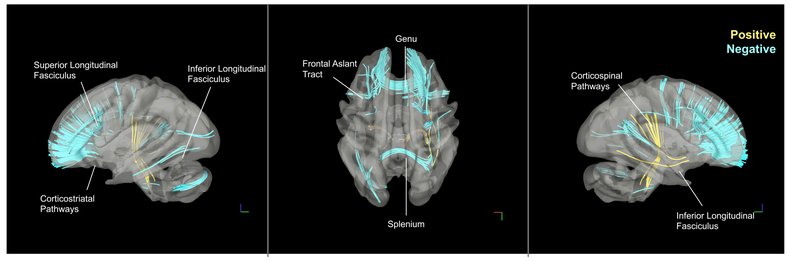
Results

Principle Component Analysis



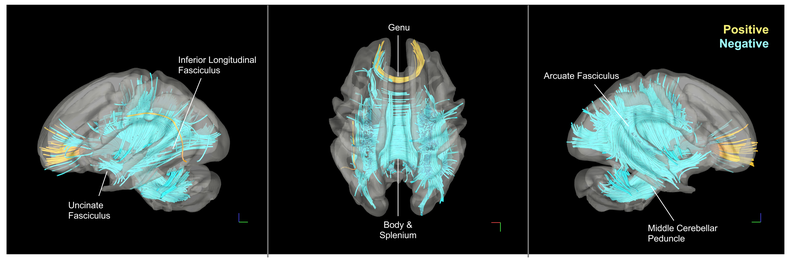
- Four principal components explained 95% of the variance in post-pre changes in the health related measures

Cardiorespiratory Fitness (PC2)



- Neither Adiposity (PC1) or Body Fat (PC4) associated with white matter.
- Cardiorespiratory fitness (PC2) negatively associated with changes in quantitative anisotropy (QA) in commissural, projection, and association pathways.
- Cardiorespiratory fitness positively associated with changes in QA values surrounding brainstem and association pathways.

Exercise Stress (PC3)



- Exercise stress (PC3) negatively associated with changes in QA values in large portions of commissural, projection and association pathways.
- Exercise stress positively associated with changes in QA values along predominantly commissural pathways.

Conclusion

- These results show that in the context of a behavioral weight loss program, changes in cardiorespiratory fitness but not adiposity track with change in the integrity of large scale white matter pathways in the human brain.
- Surprisingly, these associations were largely negative, such that greater improvements in fitness associated with lower anisotropy values along major white matter pathways.

References

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