Are Two Activities Better Than One? Effects of Music Training and Physical Activity on Cognitive Development

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Introduction

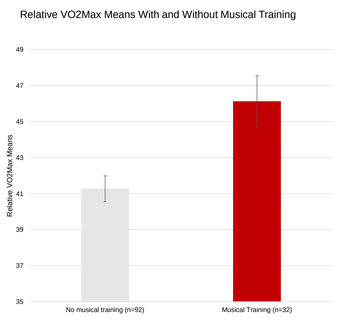
Background: Musical training during development has been shown to improve executive function and auditory processing (2), while physical activity (PA) intervention promotes executive ability and cognitive skills such as spelling in preadolescents (1). To evaluate effects of musical training and physical activity (PA) intervention, we studied possible auditory-motor transfer effects using data collected from the previous FITKids2 study (1).
Hypothesis: PA intervention and musical training both affect cognitive abilities and academic achievement in preadolescent children, but effects of these two forms of training will interact more for outcomes that tap into auditory-motor near transfer effects relative to outcomes that tap into far transfer. Preadolescent children have greater connectivity between the superior temporal gyrus (STG) and the precentral gyrus (PCG) based on musical training.

Methods

Subjects: 124 out of 221 original participants aged 7-9 were analyzed, consisting of a waitlist group (n=57, 18 musicians and 39 non-musicians) and a PA intervention group (n=67, 14 musicians and 53 non-musicians). Participants sustained either playing/not playing an instrument before and after a 9-month period PA intervention or waitlist.
VO_2max: VO_2max was obtained using a graded treadmill test where participants walked/ran on a treadmill with increasing speed until exhaustion. VO_2 averages were obtained every 20 seconds. VO_2max reflects plateaued oxygen consumption at higher treadmill speed and high plateaued heart rate, respiratory exchanged ratio, and exertion.
Academic and cognitive evaluation: Cognitive abilities were tested with the Woodcock-Johnson Psycho-Educational Battery, Third Edition (WJ III), working memory was measured with the Operation Span Task (OSPAN), and academic achievement was assessed with the Kaufman Test of Educational Achievement, Second Edition (KTEA II) before and after nine months. Age, sex, and socioeconomic status (SES) were used as covariates.
Diffusion Tensor Imaging (DTI): DTI data were acquired before the 9-month period in a Siemans Magnetom Trio Allegra 3 T scanner with at 3.44 mm^2 resolution with 4 mm slice thickness. 32 slices were obtained in the anterior-posterior commissure plane. 1 30-direction diffusion-weighted echo planar imaging scan at b = 1000 s/mm^2 and 4 T2-weighted b_0 images at b = 0 s/mm^2 were obtained for 97 participants (63 non-musicians, 34 musicians).

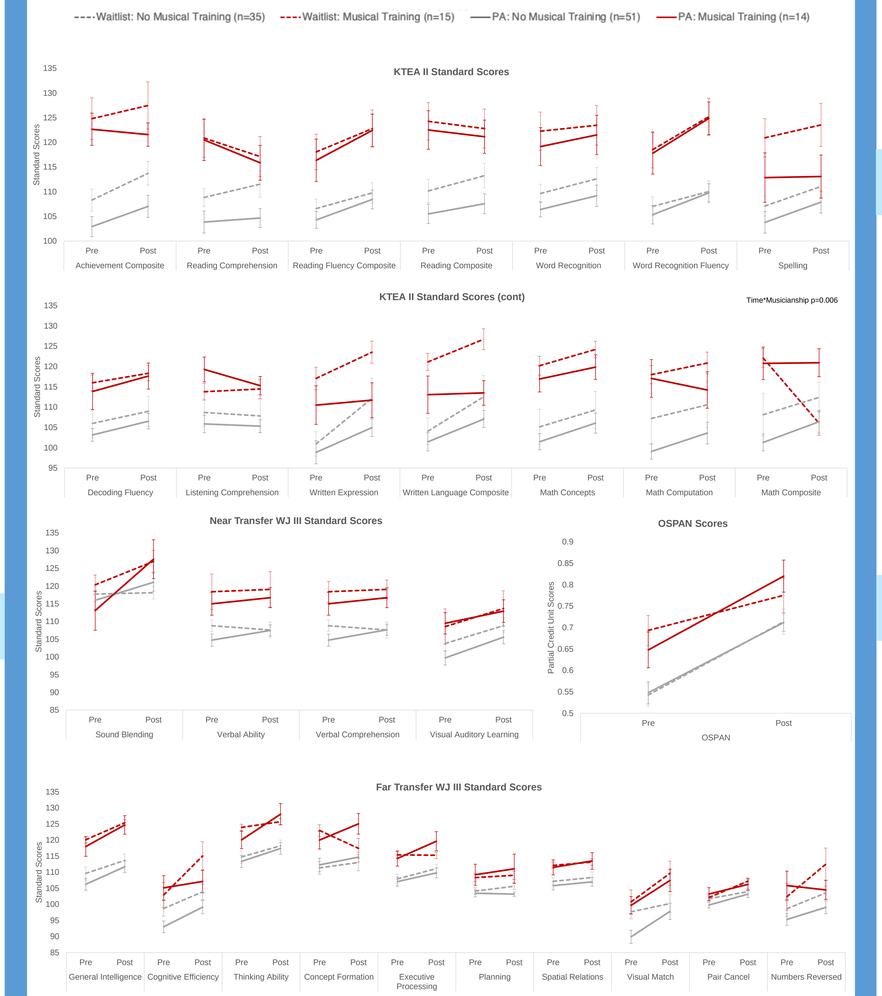
VO_2max Comparisons

Methods: An independent samples t-test was conducted to compare relative VO_2max in children with and without musical training before PA intervention. Age, sex, and SES were included as covariates.
Results: An independent samples t-test revealed a significant difference in relative VO_2max scores between children with n=32, M=46.122, SD=8.0860) and without (n=92, M=41.275, SD=6.8626) musical training; t(122)= -3.283, p=0.001.



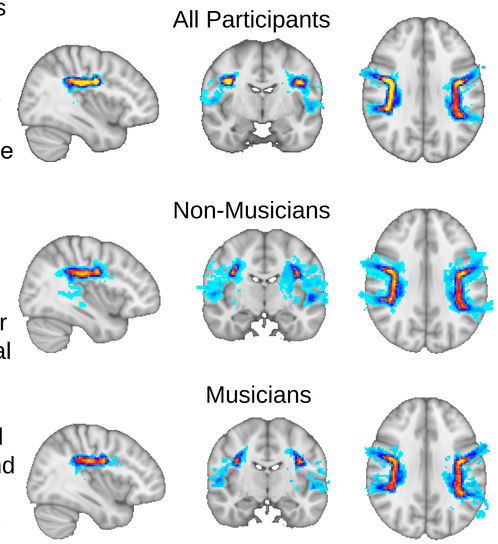
Behavioral Data

Methods: Age, sex, and socioeconomic status (SES) were used as covariates for all analyses. KTEA II reflected academic achievement while WJ III and OSPAN reflected cognitive ability.
Effect of musical training: A multivariate analysis of variance (MANOVA) using musical training as the independent variable was used to test if children with musical training (n=32) have higher academic achievement and cognitive ability scores compared to children without (n=125).
Results: A statistically significant difference was found in KTEA II scores based on preadolescent participation in music (F (14, 105) = 2.744, p = 0.002). Age (F(14, 105) = 1.834, p = 0.043) and SES (F(14, 105) = 2.368, p = 0.007) were also significant. Tests of between-subjects effects for KTEA II subtests showed musical training was a significant between-subjects factor across all subtests. A statistically significant difference was found in WJ III and OSPAN scores based on musical training (F (14, 90) = 3.300, p = 0.000). Age (F(14, 90) = 4.104, p = 0.000) was also significant. Tests of between-subjects effects revealed that for WJ III, musical training increased standard scores in all subtests except for Concept Formation, Thinking Ability, Sound Blending, and Pair Cancel.



TBSS and Probabilistic Tractography

Whole brain statistical analysis of the FA data was carried out using TBSS (Tract-Based Spatial Statistics), part of FSL. ROIs were hand-drawn and warped to each subject's native space T1 image after preprocessing.
Probabilistic tractography was performed after bedpostx in FSL to identify connections between the posterior Superior Temporal Gyrus and Precentral Gyrus to identify the arcuate fasciculus (3), which is previously shown to be related to musical training in adults and children (4, 5). Tracts were binarized and summed across subjects according to musical training.



Conclusion & Discussion

- Musically trained participants have higher relative VO_2max, or maximal oxygen consumption.
- Superior performance in working memory, cognitive, and academic achievement tests are present among children with musical training.
- RCT showed some effects of PA intervention on neuropsychological test (WJ III) and academic performance.
- While PA and musical training effects were mostly independent, there were synergistic interactions between physical activity and music training in math composite tests of the KTEA.
- Arcuate fasciculus shows higher FA in musically trained children, suggesting musical training gains are related to auditory-motor connectivity.

References & Acknowledgment

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