THE ASSOCIATION OF WHITE MATTER INTEGRITY AND AGE ON COGNITIVE PERFORMANCE IN U-2 PILOTS

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Introduction

Repeated occupational exposure to hypobaric conditions results in reduced white matter integrity as shown by increased white matter hyper-intensity (WMH) burden and decreased fractional anisotropy (FA) on MRI.

Background

WMH are a marker of cerebral integrity and associated with cognitive decline. Both U-2 pilots and aerospace physiological personnel display an increased incidence of WMH on MRI compared to healthy age-matched controls (non-pilots). U-2 pilots demonstrate an apparent acquired decrement in axonal integrity based on FA measurements. U-2 pilots demonstrate reduced neurocognitive performance associated with burden of WMH. Increase in WMH volume and decline in FA values are also observed in normal WM aging.

Methods

103 U-2 pilots (ages 28-58), 83 physiology/chamber technicians (ages 28-58), and 162 controls (ages 28-58). MRI included 3D FLAIR and diffusion tensor imaging sequences to acquire FA values/assess white matter integrity. U-2 pilots underwent MAB and microcognitive (MicroCog) assessment. Used generalized linear model (GLM) for effects of age, group, and interaction

Results

WMH Volume: Group Comparisons

Total FLAIR WMH Volume Over Time

MicroCog scores lower in U2P with higher WMH burden

Table 4 Current MicroCog comparison between U2Ps with high vs low WMH burden									
Level	MicroCog	Lower WMH (mean count/volume 0.6/0.003 mL)		Upper WMH (mean count/volume 14.4/0.213 mL)		p Value, t test (2-tailed)		p Value, Sidak (2-tailed)	
		Count (n = 33)	Volume (n = 30)	Count (n = 60)	Volume (n = 63)	Count	Volume	Count	Volume
1	Attention/mental control	104.8 ± 6.7	104.7 ± 7.2	104.2 ± 10.4	104.2 ± 10.1	0.808	0.806	1.000	1.000
1	Reasoning/calculation	104.1 ± 11.3	101.8 ± 11.7	96.8 ± 12.3	98.2 ± 12.6	0.009	0.197	0.044	0.666
1	Memory	110.2 ± 11.0	108.8 ± 12.5	102.9 ± 12.4	103.9 ± 12.1	0.006	0.075	0.030	0.323
1	Spatial processing	111.0 ± 8.3	110.9 ± 8.3	108.1 ± 9.8	108.3 ± 9.7	0.161	0.202	0.584	0.676
1	Reaction time	108.4 ± 6.1	109.5 ± 5.4	106.7 ± 6.9	106.2 ± 7.0	0.299	0.028	0.831	0.132
2	IPS	106.7 ± 11.5	104.7 ± 13.3	101.9 ± 12.5	103.0 ± 11.9	0.101	0.534	0.192	0.783
2	IPA	105.0 ± 7.9	105.2 ± 8.6	100.5 ± 10.2	100.7 ± 9.9	0.029	0.036	0.057	0.071
3	GCF	107.2 ± 8.9	106.1 ± 9.8	101.5 ± 9.8	102.3 ± 9.7	0.010	0.081	0.020	0.155
3	GCP	108.8 ± 8.6	107.6 ± 9.0	103.6 ± 9.3	104.4 ± 9.4	0.011	0.121	0.022	0.227

Effect of FA on MircoCog Scores

		Corpus Callosum Body	Fornix	Internal Capsule	Corona Radiata	External Capsule	Fronto-occipital	Superior Fronto-occipital
1	Attention	0.8555	0.3077	0.3923	0.7063	0.251	0.8146	0.7185
1	Reason	0.6974	0.4162	0.8526	0.8742	0.9397	0.3359	0.2474
1	Memory	0.6974	0.9523	0.3801	0.2496	0.7029	0.9499	0.9999
1	Spatial Processing*	*0.0058	0.2704	*0.0141	*0.0062	*0.0059	*0.0359	0.4049
1	Reaction Time	0.3823	0.1436	0.1493	0.2483	0.3257	*0.0335	0.283
2	Speed	0.9962	0.9834	0.1075	0.2437	0.5248	0.6299	0.6088
2	Accuracy	0.334	0.3044	0.6897	0.4949	0.1623	0.7929	0.4689
3	Function	0.5804	0.55	0.1256	0.1928	0.1698	0.824	0.9307
3	Proficiency	0.8985	0.6976	0.2462	0.3928	0.3653	0.967	0.6114

GLM with FA and Age as Independent Variables

Corpus Callosum Body			Fornix			Internal Capsule			Corona Radiata		
	Age			Age			Age			Age	
Attention	ns	ns	Attention	ns	0.031*	Attention	ns	0.045*	Attention	ns	ns
Reason	ns	ns	Reason	ns	ns	Reason	ns	ns	Reason	ns	ns
Memory	ns	ns	Memory	ns	ns	Memory	ns	ns	Memory	ns	ns
Spatial Processing	0.019*	ns	Spatial Processing	ns	ns	Spatial Processing	0.023*	ns	Spatial Processing	0.013*	ns
Reaction Time	ns	0.036*	Reaction Time	ns	0.022*	Reaction Time	ns	0.017*	Reaction Time	ns	0.017*
Speed	ns	ns	Speed	ns	ns	Speed	ns	ns	Speed	ns	ns
Accuracy	ns	ns	Accuracy	ns	ns	Accuracy	ns	ns	Accuracy	ns	ns
Function	ns	ns	Function	ns	ns	Function	ns	ns	Function	ns	ns
Proficiency	ns	ns	Proficiency	ns	ns	Proficiency	ns	ns	Proficiency	ns	ns

External Capsule			Fronto-occipital			Superior Fronto-occipital		
	Age			Age			Age	
Attention	ns	0.031*	Attention	ns	ns	Attention	ns	ns
Reason	ns	0.0496*	Reason	ns	ns	Reason	ns	ns
Memory	ns	ns	Memory	ns	ns	Memory	ns	ns
Spatial Processing	0.015*	ns	Spatial Processing	0.046*	0.044*	Spatial Processing	ns	0.04*
Reaction Time	ns	0.017*	Reaction Time	0.045*	0.015*	Reaction Time	ns	0.014*
Speed	ns	ns	Speed	ns	ns	Speed	ns	ns
Accuracy	ns	ns	Accuracy	ns	ns	Accuracy	ns	ns
Function	ns	ns	Function	ns	ns	Function	ns	ns
Proficiency	ns	ns	Proficiency	ns	ns	Proficiency	ns	ns

Discussion – Conclusions

In U2P, both age and FA values independently influence certain microcognitive tracts

Positive correlation to spatial processing when controlling for age
Increasing age correlates with improved reaction time independent of FA values for all tracts

Suggests role of repetitive memory with increased age (long-term potential)

Occupational exposure to hypobaria does not result in acceleration of cerebral aging

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Abbreviations: GCF = general cognitive functioning; GCP = general cognitive proficiency; IPA = information processing accuracy; IPS = information processing speed; MicroCog = MicroCog: Assessment of Cognitive Functioning; U2P = U-2 pilot; WMH = white matter hyperintensity. Data are mean ± SD. All scores standard scores.