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The authors made the following contributions. First Author: Conceptualization, Writing - Original Draft Preparation, Writing - Review & Editing; Ernst-August Doelle: Writing - Review & Editing, Supervision.

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## Abstract

15 One or two sentences providing a **basic introduction** to the field, comprehensible to a  
16 scientist in any discipline.

17 *Keywords:* keywords

18 Word count: X

The title

## Results

The aggregated data-set describes 316,835 observations of daily physical activity and sleep from 24,935 unique participants. Table ?? shows demographic information. A table of study characteristics can be found in supplementary materials.

### The effects of physical activity volume on sleep

We explored the effects of physical activity on sleep (RQ1) using mixed-effects models. We estimated the effect of physical activity volume on sleep by age, and the results are presented in Table 1 and Figure 1. There was no meaningful relationship between physical activity volume and sleep duration. However, a positive curvilinear relationship was observed between physical activity volume and sleep efficiency, onset, and regularity, which interacted with age. Sleep efficiency improved with greater physical activity volume, but improvements tapered off for older individuals. Physical activity volume and sleep onset had a positive association for younger individuals, but a negative association for older individuals, where sleep onset was reduced among those with the highest physical activity. There was a strong positive association between physical activity volume and sleep regularity, which was strongest among older participants. For participants aged 35 years and above, this link weakened among those with a physical activity volume greater than two standard deviations.

Table 1

*Sleep on physical activity volume controlling for SES, gender and BMI*

Term	$\beta$ [95% CI]	SE	t	p
Sleep duration				
(Intercept)	-0.37 [-0.94, 0.20]	0.29	-1.28	.291
Scale pa volume	0.03 [0.00, 0.07]	0.02	1.96	.050
Age	0.00 [-0.01, 0.00]	0.00	-0.29	.797
Scale pa volume <sup>2</sup>	0.00 [-0.01, 0.01]	0.00	0.11	.912
Scale pa volume:age	0.00 [0.00, 0.00]	0.00	0.92	.359
Age:scale pa volume <sup>2</sup>	0.00 [0.00, 0.00]	0.00	-0.94	.349
Sleep efficiency				
(Intercept)	-0.90 [-1.29, -0.50]	0.20	-4.46	.001
Scale pa volume	0.23 [0.20, 0.27]	0.02	12.97	< .001
Age	0.01 [0.01, 0.01]	0.00	9.99	.002
Scale pa volume <sup>2</sup>	-0.02 [-0.03, -0.01]	0.00	-4.77	< .001
Scale pa volume:age	0.00 [0.00, 0.00]	0.00	-5.16	< .001
Age:scale pa volume <sup>2</sup>	0.00 [0.00, 0.00]	0.00	-0.50	.617
Sleep onset				
(Intercept)	-0.98 [-1.50, -0.47]	0.26	-3.77	.060
Scale pa volume	0.11 [0.09, 0.14]	0.01	8.32	< .001
Age	0.02 [0.02, 0.02]	0.00	9.81	.007
Scale pa volume <sup>2</sup>	-0.01 [-0.02, -0.01]	0.00	-4.73	< .001
Scale pa volume:age	0.00 [0.00, 0.00]	0.00	-8.70	< .001
Age:scale pa volume <sup>2</sup>	0.00 [0.00, 0.00]	0.00	2.34	.034
Sleep regularity				
(Intercept)	-0.13 [-0.39, 0.13]	0.13	-0.96	.415
Scale pa volume	0.33 [0.29, 0.36]	0.02	19.10	< .001
Age	0.01 [0.00, 0.01]	0.00	5.07	.019
Scale pa volume <sup>2</sup>	-0.03 [-0.03, -0.02]	0.00	-5.74	< .001
Scale pa volume:age	0.00 [0.00, 0.00]	0.00	0.64	.540
Age:scale pa volume <sup>2</sup>	0.00 [0.00, 0.00]	0.00	-3.33	.006

*Note.* Adjusted for SES, BMI, and sex.

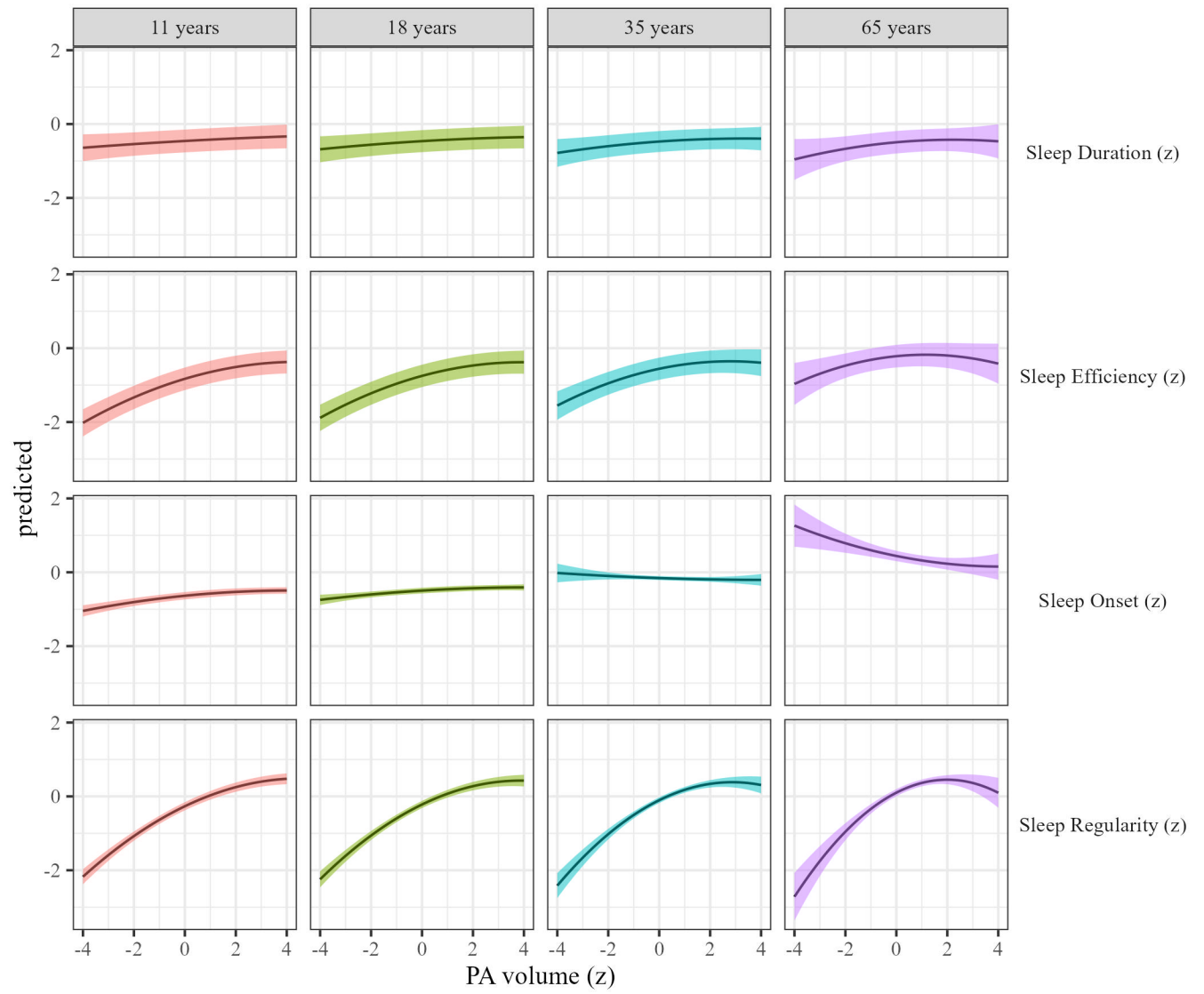


Figure 1. Sleep metrics on Physical activity volume