

## **Supplementary Material**

### **Impact of Age, Sex, Body Constitution, and the COVID-19 Pandemic on the Physical Fitness of 38,084 German Primary School Children.**

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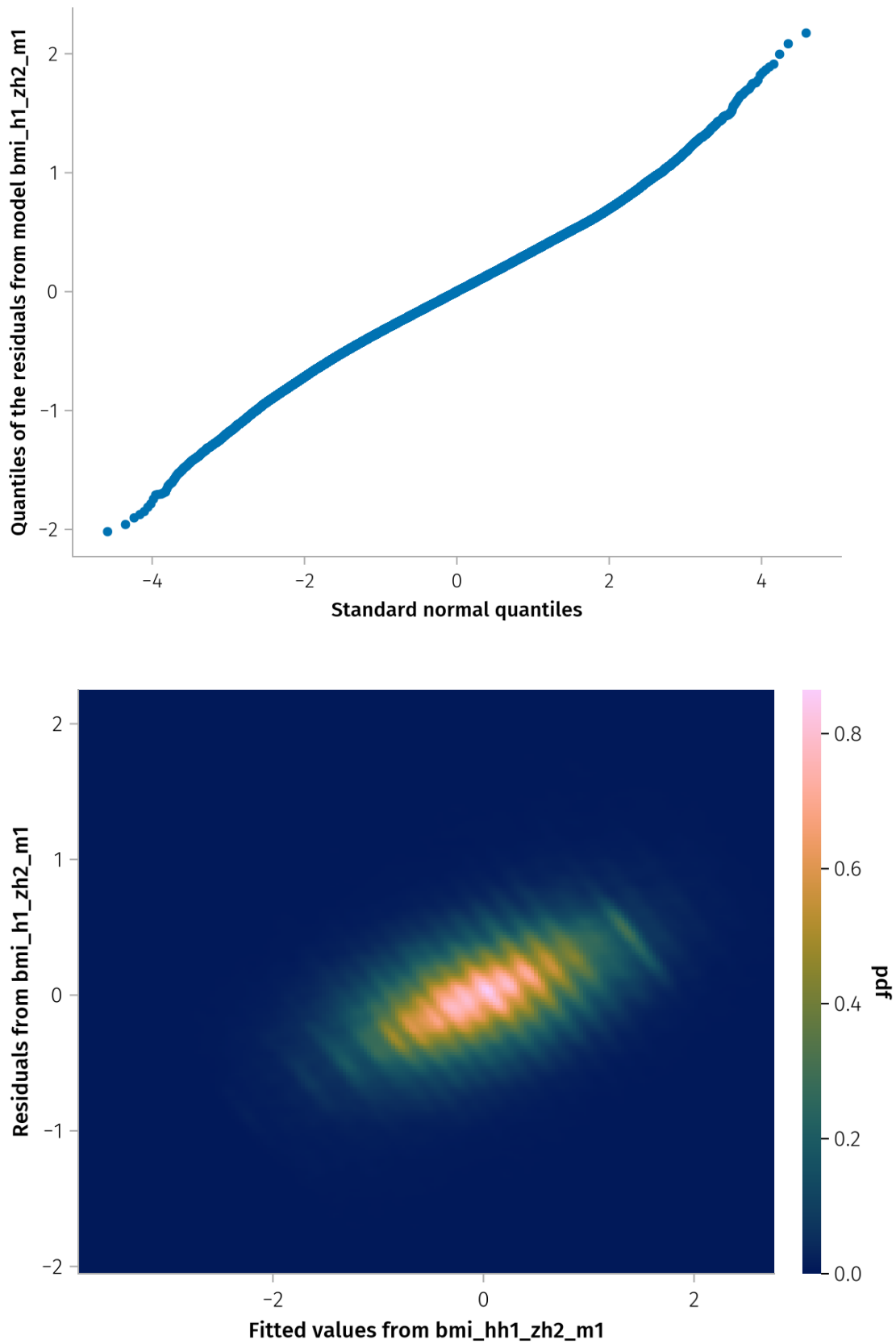
**Note:** Data, along with Julia and R scripts for reproducing figures and analyses, are available at the OSF repository (<https://osf.io/ztyfp/>).

*Supplementary Table 1. LMM fixed-effect estimates and test statistics*

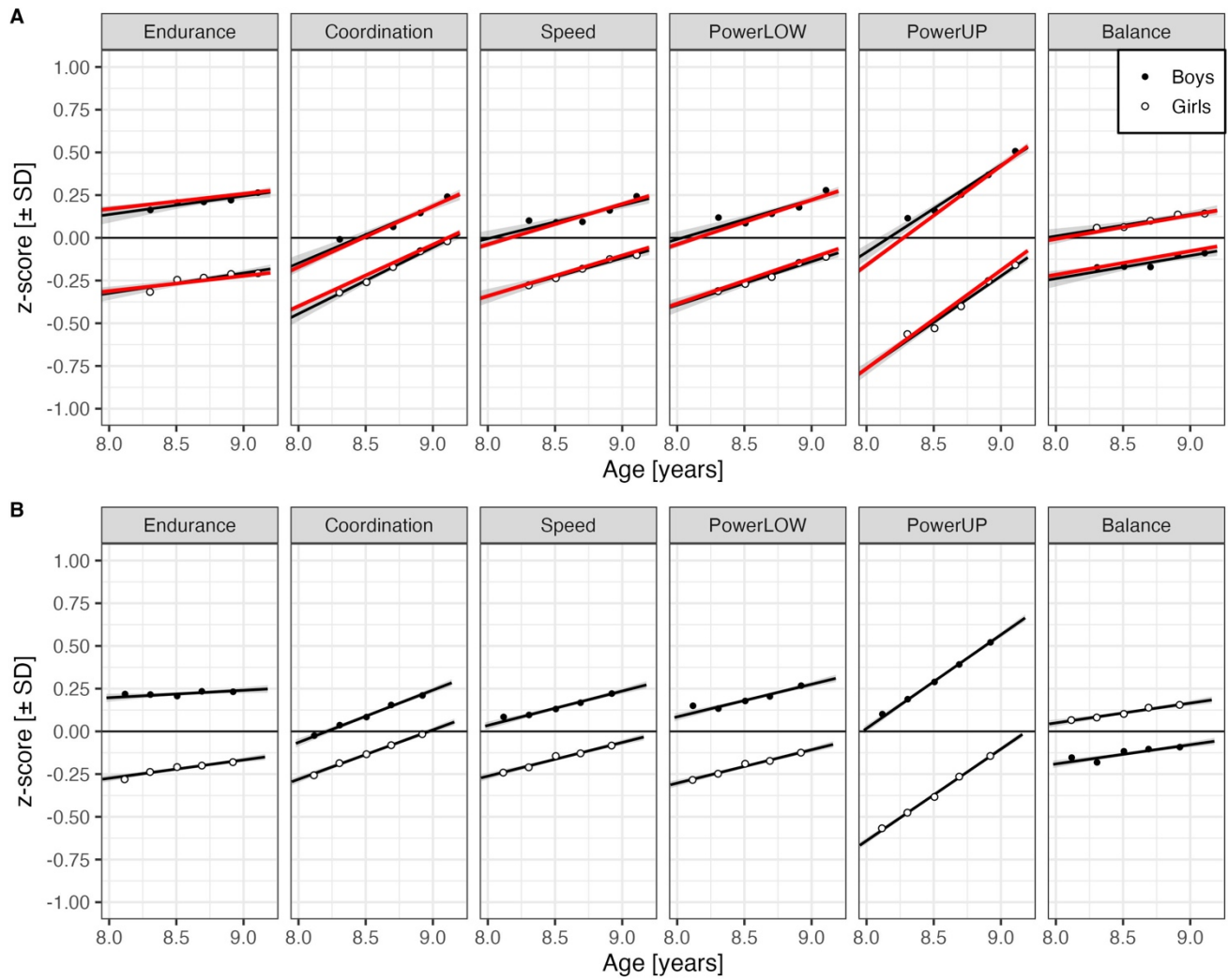
| Test         | Coef        | Est     | SE     | z        | p      |
|--------------|-------------|---------|--------|----------|--------|
| Endurance    | sex         | 0.4823  | 0.0161 | 29.9814  | 0.0000 |
|              | age         | 0.0925  | 0.0143 | 6.4889   | 0.0000 |
|              | zBMI        | -0.6058 | 0.0354 | -17.1050 | 0.0000 |
|              | zBMI2       | -0.1901 | 0.0046 | -41.3501 | 0.0000 |
|              | zBMI3       | -0.0395 | 0.0017 | -22.7818 | 0.0000 |
|              | sex x zBMI  | -0.0720 | 0.0082 | -8.7815  | 0.0000 |
|              | sex x zBMI2 | -0.0457 | 0.0053 | -8.5590  | 0.0000 |
|              | age x zBMI  | -0.0869 | 0.0123 | -7.0402  | 0.0000 |
|              | zHeight     | -0.2269 | 0.0242 | -9.3575  | 0.0000 |
|              | zHeight2    | 0.0008  | 0.0044 | 0.1910   | 0.8485 |
|              | zMass       | 0.4312  | 0.0484 | 8.9168   | 0.0000 |
|              | cvd         | -0.0640 | 0.0291 | -2.1950  | 0.0282 |
|              | pre CD      | -0.0695 | 0.0106 | -6.5372  | 0.0000 |
|              | post CD     | -0.0079 | 0.0103 | -0.7663  | 0.4435 |
|              | cvd x sex   | -0.0475 | 0.0190 | -2.5022  | 0.0123 |
|              | cvd x zBMI  | 0.0072  | 0.0085 | 0.8484   | 0.3962 |
| Coordination | sex         | 0.2251  | 0.0179 | 12.5752  | 0.0000 |
|              | age         | 0.3583  | 0.0158 | 22.7114  | 0.0000 |
|              | zBMI        | -0.2634 | 0.0397 | -6.6354  | 0.0000 |
|              | zBMI2       | -0.1106 | 0.0051 | -21.7393 | 0.0000 |
|              | zBMI3       | -0.0245 | 0.0019 | -12.8107 | 0.0000 |
|              | sex x zBMI  | -0.0414 | 0.0091 | -4.5544  | 0.0000 |
|              | sex x zBMI2 | -0.0299 | 0.0059 | -5.0834  | 0.0000 |
|              | age x zBMI  | -0.0771 | 0.0136 | -5.6547  | 0.0000 |
|              | zHeight     | -0.0314 | 0.0272 | -1.1544  | 0.2484 |
|              | zHeight2    | -0.0116 | 0.0049 | -2.3456  | 0.0190 |
|              | zMass       | 0.1760  | 0.0543 | 3.2428   | 0.0012 |
|              | cvd         | -0.1804 | 0.0295 | -6.1130  | 0.0000 |
|              | pre CD      | -0.0060 | 0.0118 | -0.5090  | 0.6108 |
|              | post CD     | 0.0263  | 0.0107 | 2.4597   | 0.0139 |
|              | cvd x sex   | 0.0320  | 0.0211 | 1.5205   | 0.1284 |
|              | cvd x zBMI  | 0.0010  | 0.0094 | 0.1023   | 0.9185 |

| Test     | Coef        | Est     | SE     | z        | p      |
|----------|-------------|---------|--------|----------|--------|
| Speed    | sex         | 0.2995  | 0.0171 | 17.5386  | 0.0000 |
|          | age         | 0.2364  | 0.0151 | 15.6559  | 0.0000 |
|          | zBMI        | -0.5535 | 0.0375 | -14.7701 | 0.0000 |
|          | zBMI2       | -0.1852 | 0.0049 | -38.1061 | 0.0000 |
|          | zBMI3       | -0.0418 | 0.0018 | -22.6841 | 0.0000 |
|          | sex x zBMI  | -0.0519 | 0.0087 | -5.9867  | 0.0000 |
|          | sex x zBMI2 | -0.0483 | 0.0057 | -8.5375  | 0.0000 |
|          | age x zBMI  | -0.0813 | 0.0130 | -6.2307  | 0.0000 |
|          | zHeight     | -0.1622 | 0.0256 | -6.3284  | 0.0000 |
|          | zHeight2    | -0.0050 | 0.0046 | -1.0859  | 0.2775 |
|          | zMass       | 0.4273  | 0.0512 | 8.3493   | 0.0000 |
|          | cvd         | -0.0303 | 0.0292 | -1.0374  | 0.2995 |
|          | pre CD      | -0.0358 | 0.0108 | -3.3061  | 0.0009 |
|          | post CD     | -0.0270 | 0.0105 | -2.5667  | 0.0103 |
|          | cvd x sex   | 0.0147  | 0.0201 | 0.7288   | 0.4661 |
|          | cvd x zBMI  | 0.0187  | 0.0090 | 2.0807   | 0.0375 |
| PowerLOW | sex         | 0.3428  | 0.0172 | 19.8884  | 0.0000 |
|          | age         | 0.2681  | 0.0152 | 17.5939  | 0.0000 |
|          | zBMI        | -0.6171 | 0.0384 | -16.0893 | 0.0000 |
|          | zBMI2       | -0.1918 | 0.0049 | -39.0197 | 0.0000 |
|          | zBMI3       | -0.0407 | 0.0019 | -21.8454 | 0.0000 |
|          | sex x zBMI  | -0.0435 | 0.0088 | -4.9612  | 0.0000 |
|          | sex x zBMI2 | -0.0312 | 0.0057 | -5.4429  | 0.0000 |
|          | age x zBMI  | -0.0989 | 0.0132 | -7.4946  | 0.0000 |
|          | zHeight     | -0.1688 | 0.0263 | -6.4244  | 0.0000 |
|          | zHeight2    | 0.0054  | 0.0048 | 1.1352   | 0.2563 |
|          | zMass       | 0.4986  | 0.0524 | 9.5133   | 0.0000 |
|          | cvd         | -0.0748 | 0.0281 | -2.6623  | 0.0078 |
|          | pre CD      | 0.0208  | 0.0097 | 2.1477   | 0.0317 |
|          | post CD     | -0.0021 | 0.0105 | -0.1988  | 0.8424 |
|          | cvd x sex   | 0.0258  | 0.0203 | 1.2711   | 0.2037 |
|          | cvd x zBMI  | -0.0067 | 0.0091 | -0.7374  | 0.4609 |

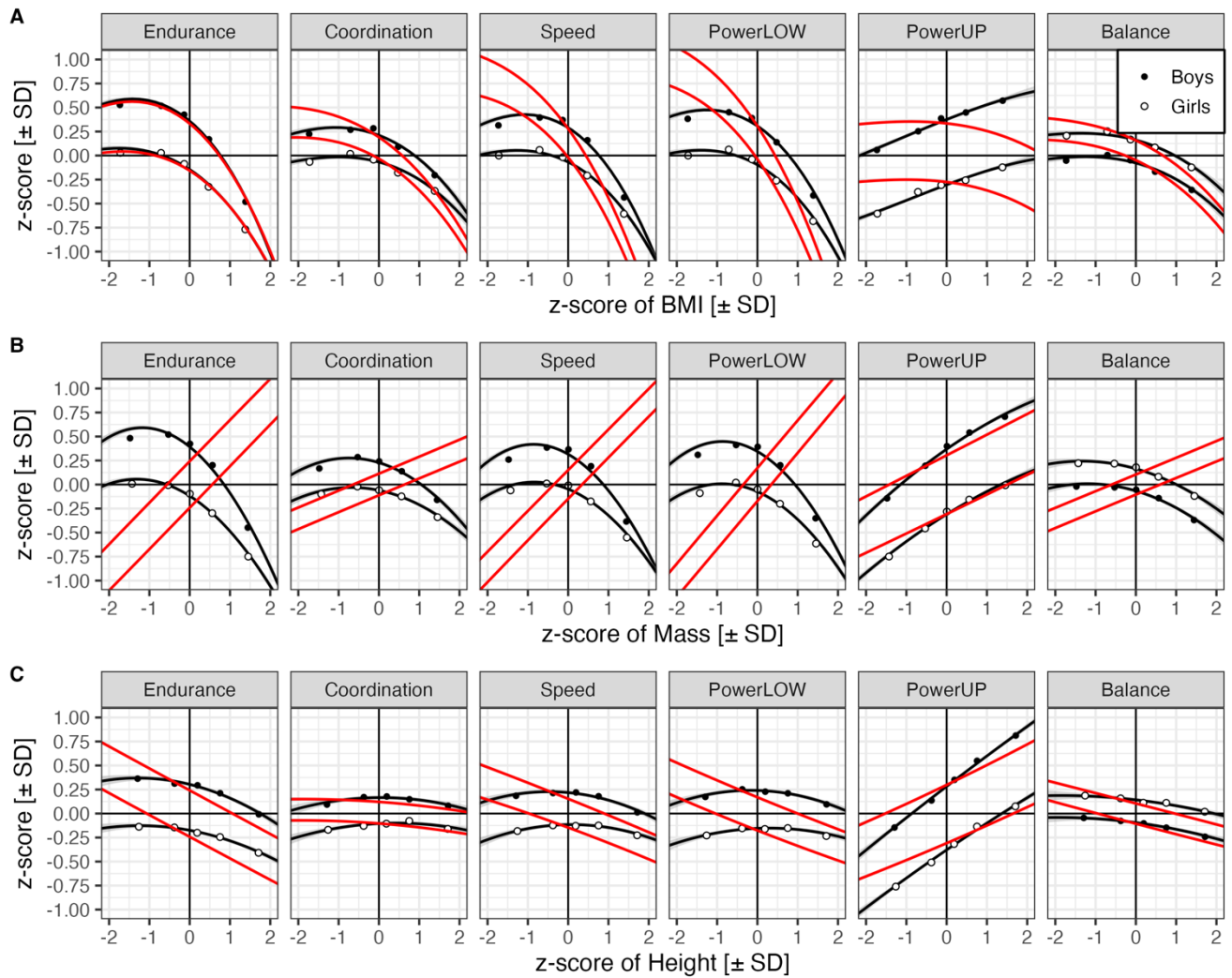
| Test    | Coef        | Est     | SE     | z        | p      |
|---------|-------------|---------|--------|----------|--------|
| PowerUP | sex         | 0.6117  | 0.0158 | 38.6680  | 0.0000 |
|         | age         | 0.5731  | 0.0140 | 40.8815  | 0.0000 |
|         | zBMI        | -0.0495 | 0.0348 | -1.4221  | 0.1550 |
|         | zBMI2       | -0.0433 | 0.0045 | -9.5947  | 0.0000 |
|         | zBMI3       | -0.0129 | 0.0017 | -7.5548  | 0.0000 |
|         | sex x zBMI  | 0.0076  | 0.0080 | 0.9398   | 0.3473 |
|         | sex x zBMI2 | -0.0096 | 0.0052 | -1.8279  | 0.0676 |
|         | age x zBMI  | -0.0126 | 0.0121 | -1.0400  | 0.2983 |
|         | zHeight     | 0.1913  | 0.0238 | 8.0472   | 0.0000 |
|         | zHeight2    | 0.0054  | 0.0043 | 1.2461   | 0.2127 |
|         | zMass       | 0.2087  | 0.0475 | 4.3964   | 0.0000 |
|         | cvd         | -0.1652 | 0.0270 | -6.1290  | 0.0000 |
|         | pre CD      | 0.0443  | 0.0096 | 4.5944   | 0.0000 |
|         | post CD     | 0.0515  | 0.0102 | 5.0377   | 0.0000 |
|         | cvd x sex   | 0.0589  | 0.0186 | 3.1607   | 0.0016 |
|         | cvd x zBMI  | -0.0022 | 0.0083 | -0.2659  | 0.7903 |
| Balance | sex         | -0.2097 | 0.0182 | -11.5085 | 0.0000 |
|         | age         | 0.1405  | 0.0161 | 8.7498   | 0.0000 |
|         | zBMI        | -0.1973 | 0.0399 | -4.9428  | 0.0000 |
|         | zBMI2       | -0.0775 | 0.0052 | -14.9240 | 0.0000 |
|         | zBMI3       | -0.0191 | 0.0020 | -9.7671  | 0.0000 |
|         | sex x zBMI  | -0.0004 | 0.0093 | -0.0479  | 0.9618 |
|         | sex x zBMI2 | -0.0074 | 0.0060 | -1.2280  | 0.2194 |
|         | age x zBMI  | -0.0602 | 0.0139 | -4.3312  | 0.0000 |
|         | zHeight     | -0.1095 | 0.0273 | -4.0087  | 0.0001 |
|         | zHeight2    | 0.0004  | 0.0049 | 0.0758   | 0.9396 |
|         | zMass       | 0.1737  | 0.0545 | 3.1857   | 0.0014 |
|         | cvd         | 0.0571  | 0.0296 | 1.9308   | 0.0535 |
|         | pre CD      | -0.0062 | 0.0110 | -0.5618  | 0.5742 |
|         | post CD     | -0.0111 | 0.0108 | -1.0285  | 0.3037 |
|         | cvd x sex   | -0.0498 | 0.0214 | -2.3250  | 0.0201 |
|         | cvd x zBMI  | -0.0362 | 0.0096 | -3.7685  | 0.0002 |



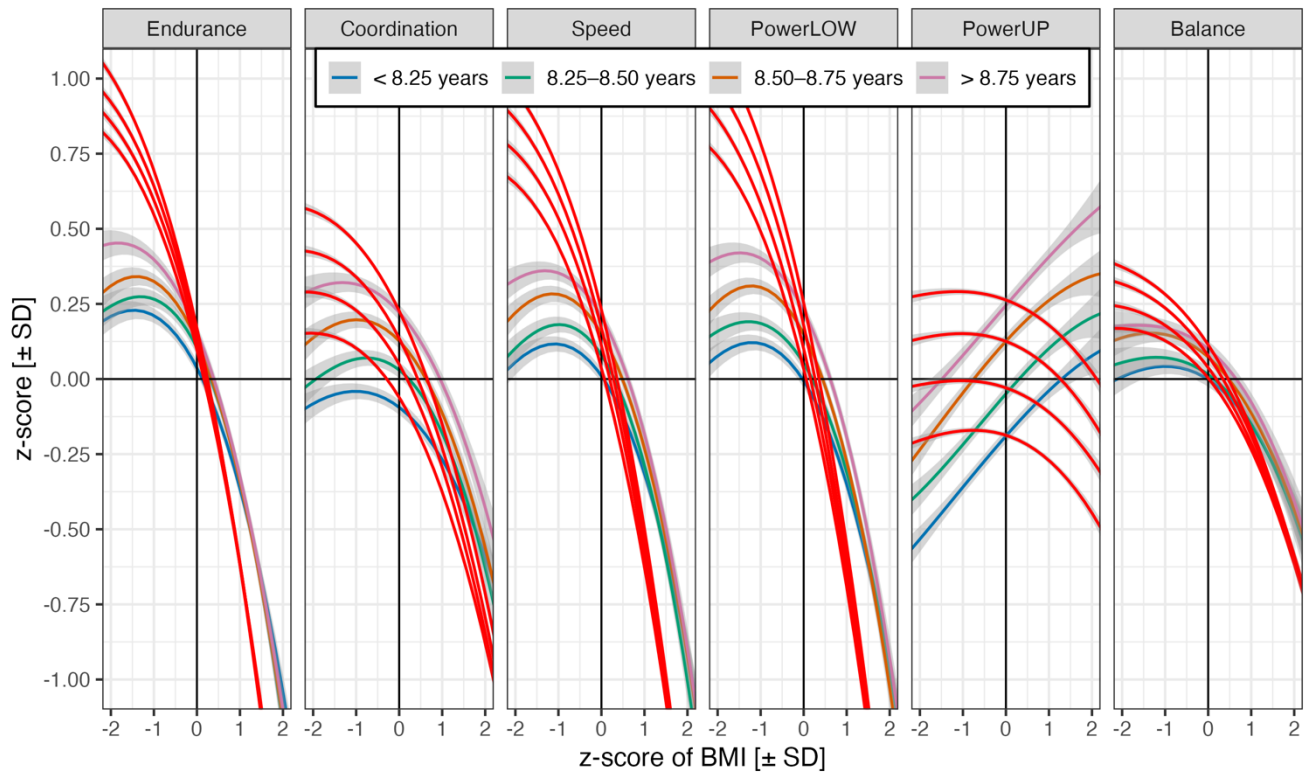
Supplementary Figure 1. (A) Quantile-quantile plot of the residuals for model *m1* versus a standard normal. (B) Heatmap of residuals versus fitted values for model



Supplementary Figure 2. Age and sex effects on six physical fitness components for third-grade elementary school children from (A) 2017-2023 cohorts in Thuringia ( $N=38,084$  children) and (B) 2016-2022 cohorts in Brandenburg ( $N=98,510$  children). Endurance = 6-minute run, Coordination = star run, Speed = 20-meter sprint, PowerLOW = standing long jump, PowerUP = ball-push test, and Balance = one-legged-stance. Points represent means for 0.20-year-wide bins; black smooths indicate linear fits to observations; red smooths represent fits to partial effects. Error bands for smooths show 95% confidence intervals.

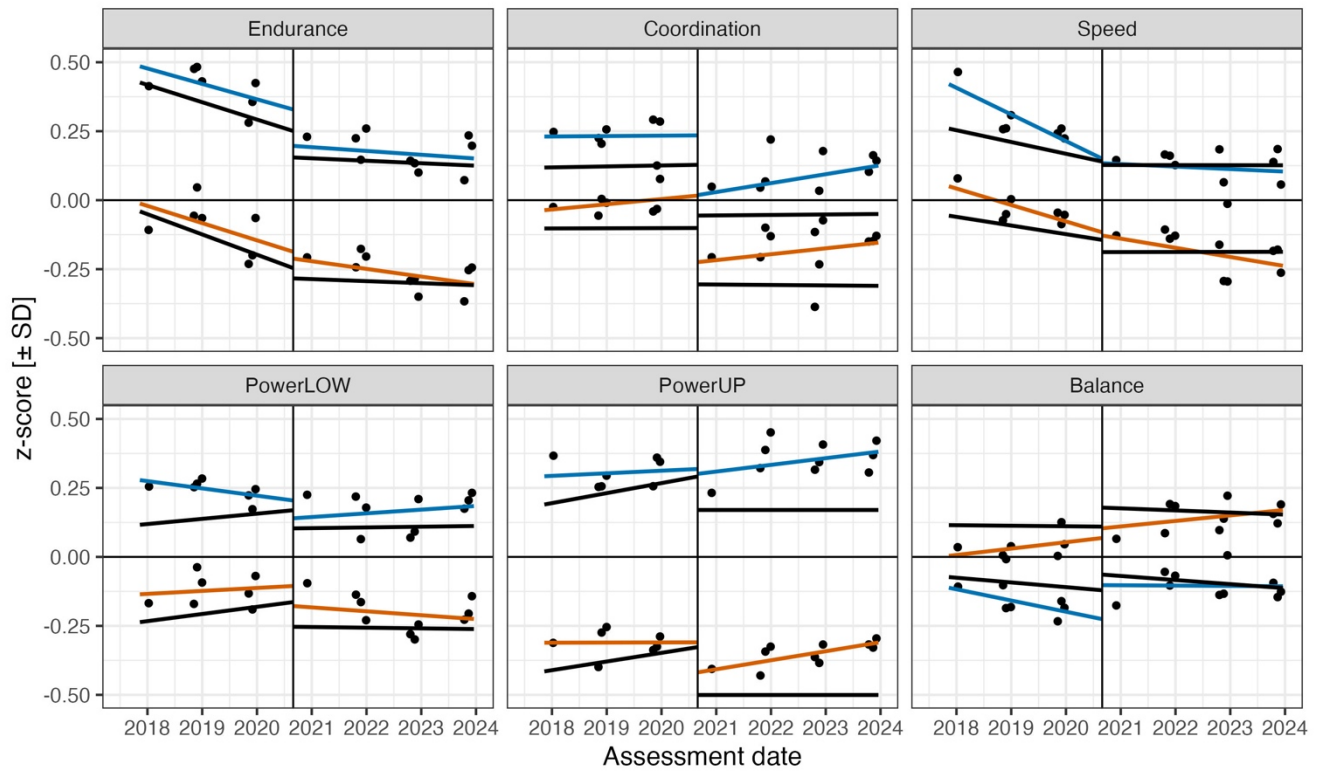


Supplementary Figure 3. Zero-order fixed effects illustrate the interaction of sex with (A) cubic-trend effects of  $zBMI$ , (B) quadratic  $zMass$ , and (C) quadratic  $zHeight$  fitted to observations; the shaded areas represent 95% confidence intervals (CIs). Endurance = 6-minute run, Coordination = star run, Speed = 20-meter sprint, PowerLOW = standing long jump, PowerUP = ball-push test, and Balance = one-legged-stance. The points indicate observed z-score means for bins containing approximately equal-sized numbers of children. The interaction with sex shows significance in both the linear and quadratic trends of  $zBMI$ .



Supplementary Figure 4. Zero-order fixed effects for the interaction between age and cubic-trend effects of zBMI are fitted to observations (color scale) and partial effects (red) for four age groups; shaded areas represent 95% confidence intervals (CIs). Children were grouped into four age categories for visualizing the interaction; in the linear mixed model (LMM), age was treated as a continuous linear covariate and significantly interacted with the linear trend of zBMI. Endurance = 6-minute run, Coordination = star run, Speed = 20-meter sprint, PowerLOW = standing long jump, PowerUP = ball-push test, and Balance = one-legged-stance.





Supplementary Figure 5. Zero-order relations for the regression of physical fitness on the assessment date (2017-11-20 to 2023-12-21) and the critical date for testing the COVID-19 effect on August 30, 2020 (i.e., the vertical line marks the first day of school in third grade for the 2020 cohort of boys, blue line, and girls, red line). The black dots represent the observed z-score means for bins of assessment dates with at least 1,000 children. The black lines indicate the partial effects of the COVID-19 and sex interaction. Endurance = 6-minute run, Coordination = star run, Speed = 20-meter sprint, PowerLOW = standing long jump, PowerUP = ball-push test, and Balance = one-legged-stance.