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How did the Sars-CoV-2 Pandemic affect the Physical Fitness of Primary School Children?

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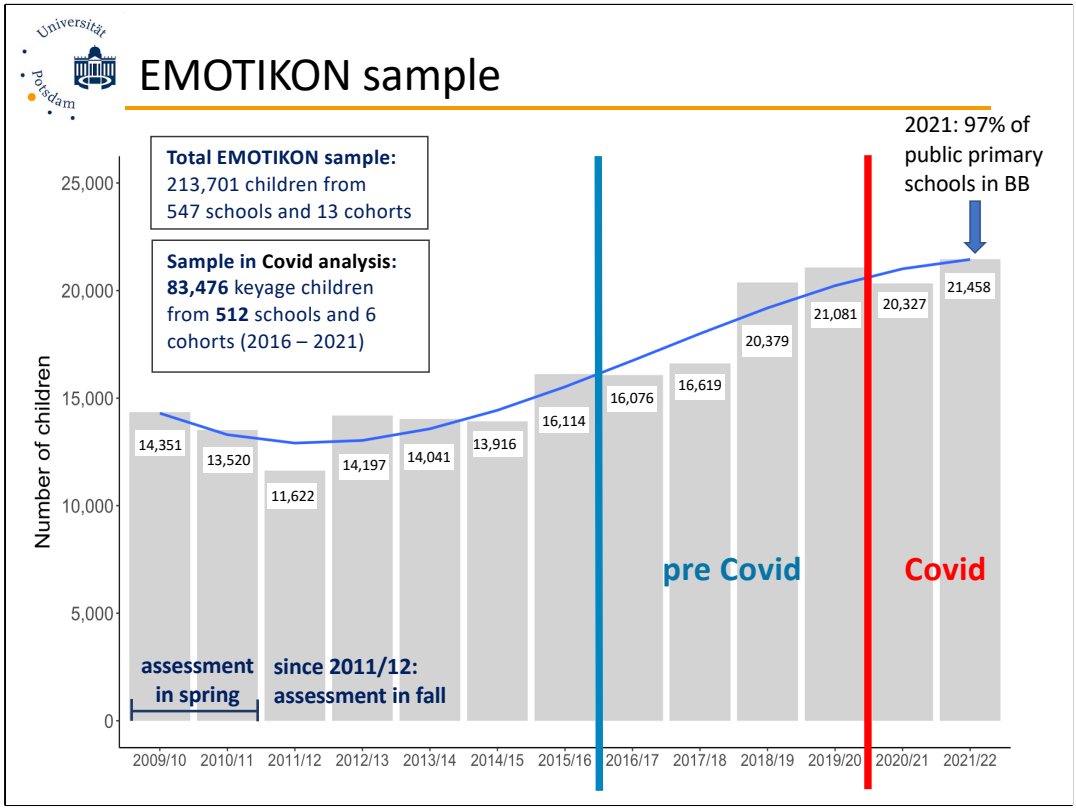
How did the Sars-CoV-2 Pandemic affect the Physical Fitness of Primary School Children?

Paula Teich, Thea Fühner, Kathleen Golle & Reinhold Kliegl

EMOTIKON project @ University of Potsdam

Ein Gehirn, viel Bewegung - Variabilität und Plastizität über die Lebensspanne
54. asp-Tagung, Münster, 2022-06-16 (revised 2022-09-09).



Each year, the EMOTIKON project assesses the physical fitness of all third-graders in the Federal State of Brandenburg, Germany. Participation for public primary schools is mandatory. The whole sample includes 213,701 children from 547 schools and from 13 different cohorts (2009 – 2021).

Our Covid analyses are based on 83,476 „keyage children“ from 512 schools and 6 cohorts (2016 – 2021). Keyage children are children who were enrolled in school according to the legal key date. They were 6 years old when they were enrolled in school and are between 8 and 9 years in third grade. We only included keyage children (and excluded younger- and older-than-keyage children) in our analyses, because the timing of school enrollment is associated with the physical fitness of children. For more information on the effect of timing of school enrollment on physical fitness, please see the presentation by Reinhold Kliegl:
Kliegl, R., Teich, P., Granacher, U., & Fühner, T. (2022). "Developmental Gains in Physical Fitness Components of Keyage and Older-than-Keyage Third-Graders". 54. Jahrestagung der Arbeitsgemeinschaft für Sportpsychologie (asp 2022) in Münster, 2022-06-16.

Effect of the Covid-Pandemic on PF

Covid effect = effect of the **two pandemic years** on physical fitness

Covid effect ≠ effect of Covid infection!

Just to be clear, by ”Covid effect” we do **not** mean the effect of a previous Covid infection, but the **effect of the two pandemic years on the physical fitness**.

EMOTIKON tests

Cardiorespiratory endurance: 6-min run **[m]**

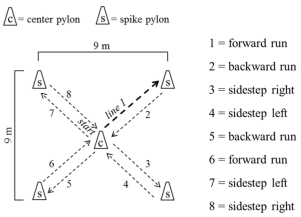
Coordination: star-run **[m/s]**

Speed: 20-m sprint **[m/s]**

PowerLOW: standing long jump **[cm]**

PowerUP: ball push test **[m]**

Static balance: one-legged stance with eyes closed **[s]**



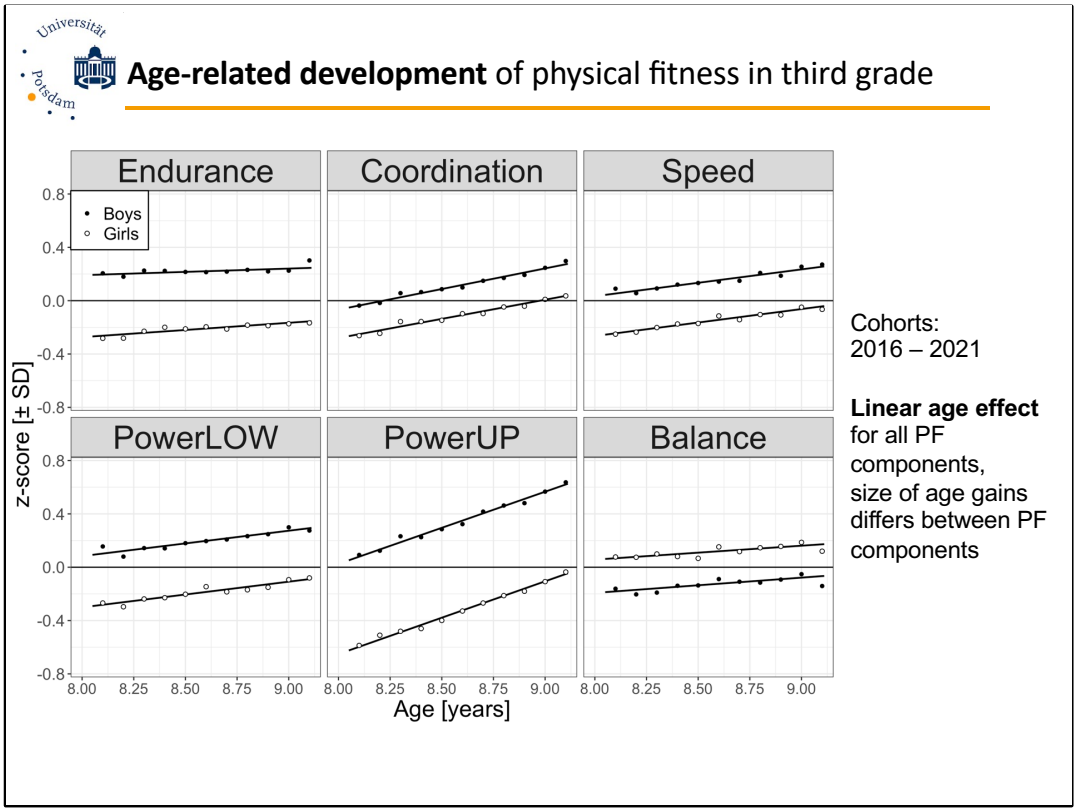
In 2016, the one-legged stance test replaced the stand-and-reach test (flexibility)

Analysis

Test scores were z-transformed

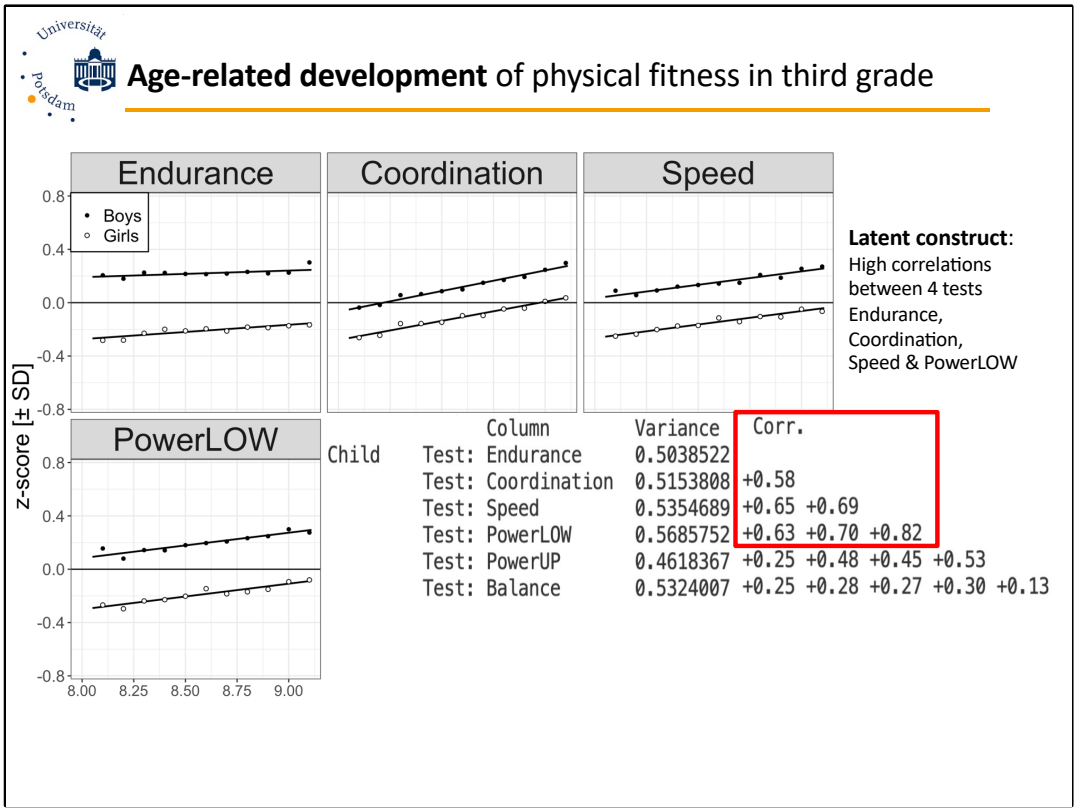
Linear mixed model

- Fixed effects
  - PF Component (Levels: Endurance, Coordination, Speed, PowerLOW, PowerUP, Balance)
  - Covid (0, 1)
  - Age (linear, centered at 8.5)
  - Sex
  - Cohort (cubic) → **secular trends**
  - + interactions among fixed effects
- Random effects
  - Child (N = **83,476**)
    - Test-related variance components & correlation parameters
  - School (N = **512**)
    - Test-, age-, sex- and covid-related variance components & correlation parameters



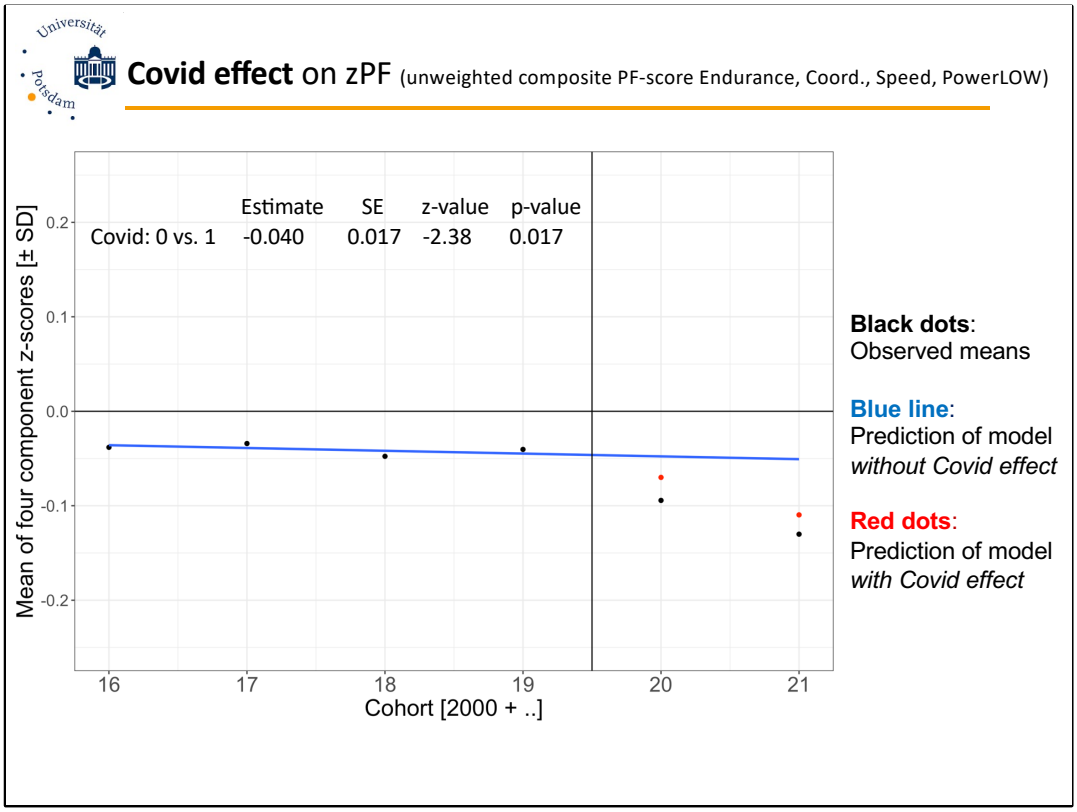
Before I get to the Covid effects, I want to show you another interesting finding from the model. Here we see the cross-sectional age-related development in the 6 physical fitness components, between the ages 8 and 9 years, separately for boys and girls. The rate of the development differs between the physical fitness components, but is completely linear for each component. Remarkably, for most physical fitness components, the development is completely parallel for boys and girls – except for Endurance (for Endurance, the slope of the boys is a little less steep than the slope for girls). We also see that boys outperform girls in every physical fitness test except for Balance, where girls are better than boys.

For more information about age and sex effects on physical fitness, please see the paper: Fühner, T., Granacher, U., Golle, K., & Kliegl, R. (2021). Age and sex effects in physical fitness components of 108,295 third graders including 515 primary schools and 9 cohorts. *Scientific Reports, 11*, 17566. https://doi.org/10.1038/s41598-021-97000-4

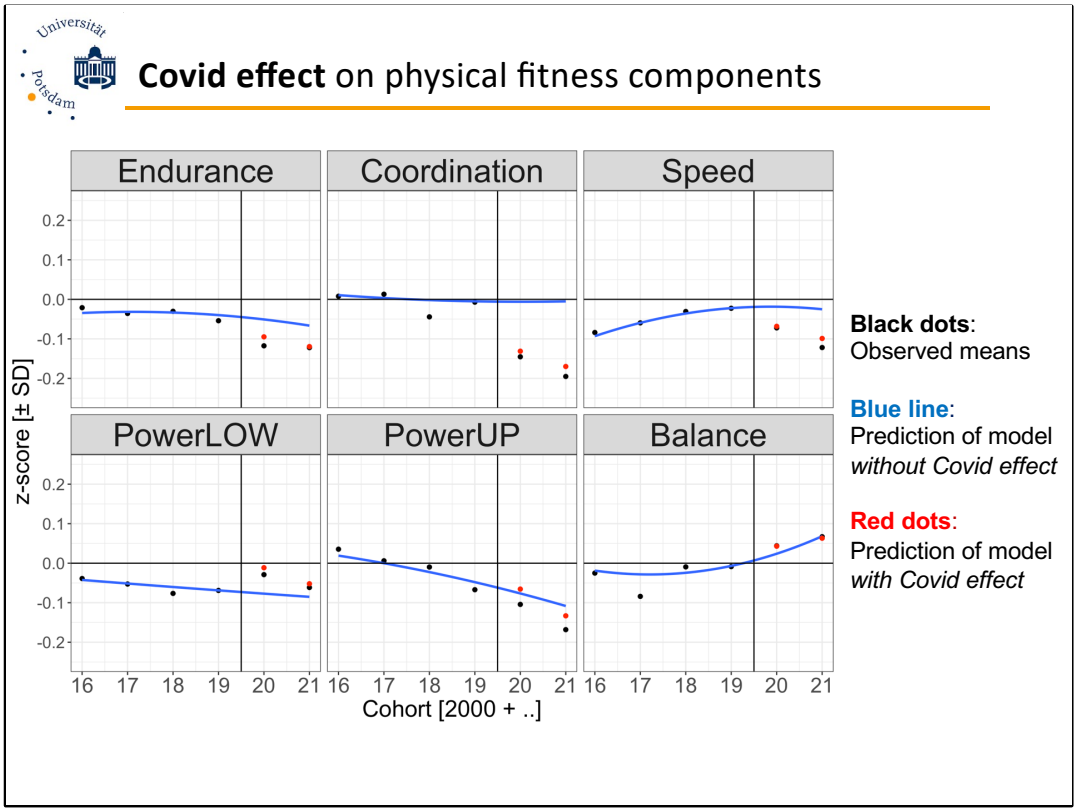


In our model, we saw that 4 tests (assessing Endurance, Coordination, Speed and PowerLOW) correlate highly with each other. This shows that they represent the latent construct “physical fitness”. The other two tests (assessing PowerUP and Balance) do not correlate so highly with the rest of the tests.

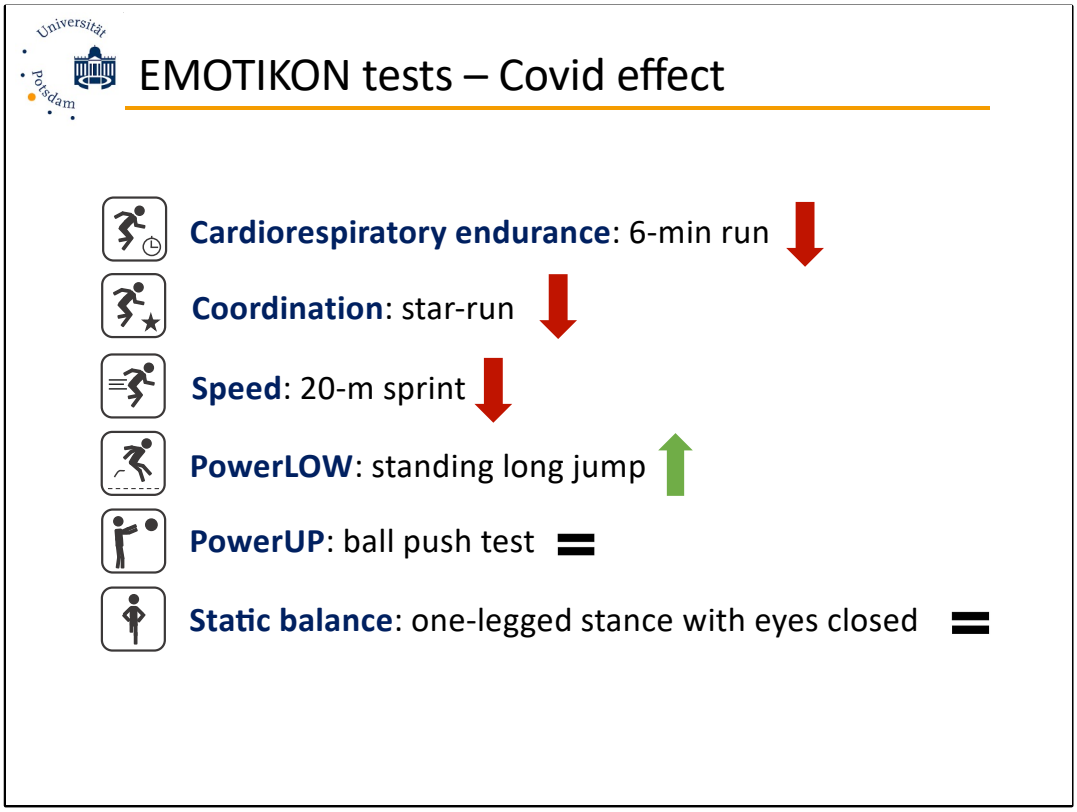
We thus computed a composite score of the 4 tests Endurance, Coordination, Speed, PowerLOW (zPF) and another composite score of the 3 running tests (zPF_runs). The composite scores are in z-score units. We tested the Covid effects on the composite physical fitness scores, and also on all physical fitness components separately.



The Covid effect (distance between red dots and blue line) on the composite physical fitness score (zPF) is negative. Let's have a look at the individual physical fitness components.



For all 3 running tests (Endurance, Coordination, Speed) there is a negative Covid effect (red dots are below the blue line). For PowerLOW we see a positive Covid effect (red dots are above the blue line) and for PowerUP and Balance we found no evidence for a Covid effect. In the panels, we also see that the secular trends (changes in physical fitness over time) differ between the 6 physical fitness components.



We found a negative Covid effect for the composite physical fitness scores, negative Covid effects for the 3 running tests, and a positive Covid effect for PowerLOW. How big and how meaningful are these effects? There are several approaches to assess the relevance of an effect.

How meaningful are the Covid effects?

	Endur-ance	Coordination	Speed	PowerLOW	*zPF_runs**	*zPF**
Covid effect/ year	- 8 m	- 0.041 m/s	- 0.021 m/s	+ 1 cm	- 0.07	- 0.04
2020+2021:	- 15 m	- 0.082 m/s	- 0.042 m/s	+ 2 cm	- 0.14	- 0.08

**zPF_runs*: composite score of three running tests (Endurance, Coordination, Speed)
**zPF*: composite score of four tests (Endurance, Coordination, Speed, PowerLOW)

In the table we see the Covid effects for the 4 physical fitness tests and for the composite scores in the original test metric, after one year of Covid (first row) and after two years of Covid (second row). After two years of Covid, children ran 15 m less in the 6-min run than before Covid. On average, children run about 1000 m in the 6-min run, so this is a small change. Children ran 8 cm/s less in the star-run test (Coordination) after two Covid years. For PowerLOW (standing long jump), children jumped 2 cm further after two Covid years. The composite scores zPF_runs and zPF are in z-score units.

How meaningful are the Covid effects?

	Endur-ance	Coordination	Speed	PowerLOW	*zPF_runs**	*zPF**
Covid effect/ year	- 8 m	- 0.041 m/s	- 0.021 m/s	+ 1 cm	- 0.07	- 0.04
2020+2021:	- 15 m	- 0.082 m/s	- 0.042 m/s	+ 2 cm	- 0.14	- 0.08
Cohen's *d* (Covid x 2)	0.05 (0.10)	0.15 (0.30)	0.06 (0.12)	0.05 (0.10)	0.07 (0.14)	0.04 (0.08)

**zPF_runs*: composite score of three running tests (Endurance, Coordination, Speed)
**zPF*: composite score of four tests (Endurance, Coordination, Speed, PowerLOW)

In the last row, we see the effect sizes (Cohen's *d*) for the change in performance after one and after two Covid years.

How meaningful are the Covid effects?

	Endur-ance	Coordination	Speed	PowerLOW	*zPF_runs**	*zPF**
Covid effect/ year	- 8 m	- 0.041 m/s	- 0.021 m/s	+ 1 cm	- 0.07	- 0.04
2020+2021:	- 15 m	- 0.082 m/s	- 0.042 m/s	+ 2 cm	- 0.14	- 0.08
Cohen's *d* (Covid x 2)	0.05 (0.10)	0.15 (0.30)	0.06 (0.12)	0.05 (0.10)	0.07 (0.14)	0.04 (0.08)
Smallest meaningful change	**- 31 m**	**- 0.058 m/s**	**- 0.084 m/s**	**3.9 cm**	**- 0.15**	**- 0.15**

Smallest meaningful change: 0.2 * *SD*

**zPF_runs*: composite score of three running tests (Endurance, Coordination, Speed)
**zPF*: composite score of four tests (Endurance, Coordination, Speed, PowerLOW)

In training and movement sciences, there is another approach to evaluate the meaning of a change. We can calculate a threshold that a change in performance has to exceed to be practically relevant. We calculated this threshold (smallest meaningful change) by 0.2 * *SD*.
For most physical components, the Covid-related change in performance does not exceed the threshold of a small meaningful change. In the case of Endurance for example, the threshold is 31 meters, but the performance change after two Covid years is only 15 m. The exception is Coordination, where the Covid effect after two years is larger than the threshold. According to this approach, we would conclude that most Covid-related changes of children's physical fitness might be significant, but are not practically relevant.

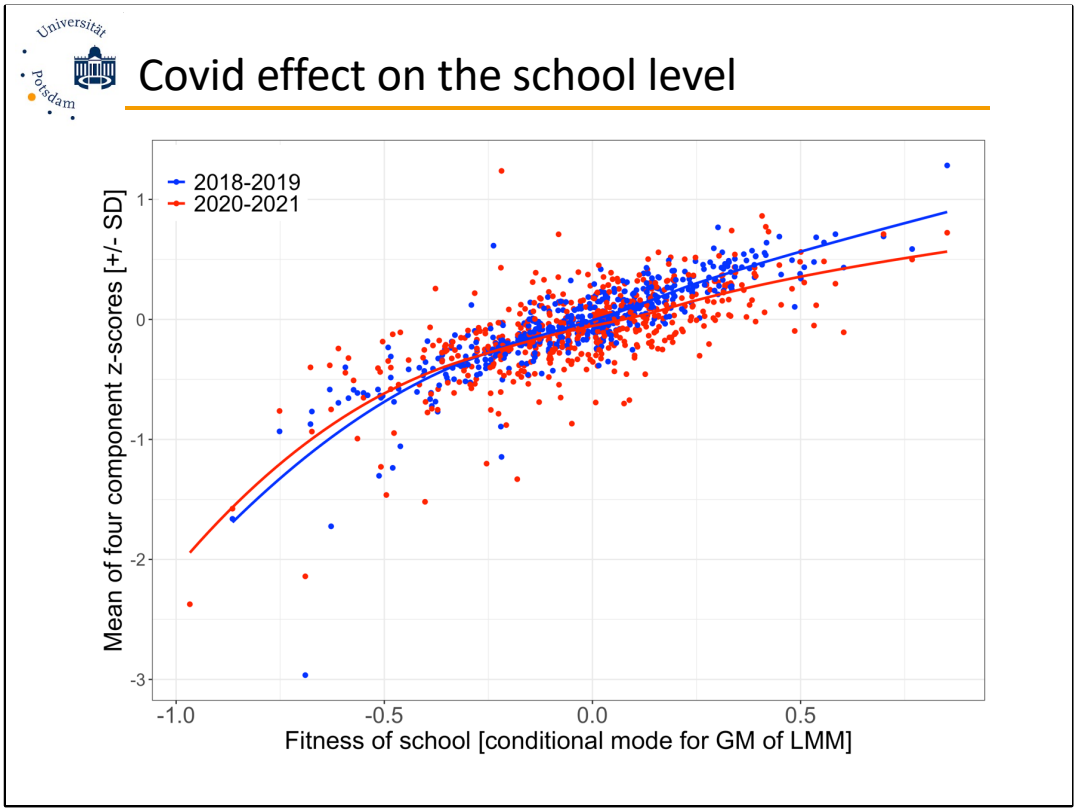
Another approach to assess the relevance of an effect comes from educational science: How many months are children behind or advanced in their development? To calculate the developmental costs or gains, we can look at how children would normally develop during one school year, and compare the Covid-related change to this age effect.

How meaningful are the Covid effects?

	Endur-ance	Coordination	Speed	PowerLOW	*zPF_runs*	*zPF*
Covid effect/ year	- 8 m	- 0.041 m/s	- 0.021 m/s	+ 1 cm	- 0.07	- 0.04
2020+2021:	- 15 m	- 0.082 m/s	- 0.042 m/s	+ 2 cm	- 0.14	- 0.08
Cohen's *d* (Covid x 2)	0.05 (0.10)	0.15 (0.30)	0.06 (0.12)	0.05 (0.10)	0.07 (0.14)	0.04 (0.08)
Developmental costs / gains relative to cross-sectional one-year development (estimates from Covid LMM)	**- 17 mth**	**- 12 mth**	**- 6 mth**	**+ 6 mth**	**- 9 mth**	**- 5 mth**
Developmental costs / gains relative to longitudinal one-year development	**- 7 mth**	**- 6 mth**	**- 4 mth**	**+ 3 mth**	**- 5 mth**	**- 3 mth**

We calculated the developmental costs / gains after two Covid years in two different ways. In the second to last row the developmental costs /gains are calculated as the Covid effect relative to a **cross-sectional one-year development** (the Covid and age effect estimates both come from our Covid LMM). In the last row, the developmental costs / gains are calculated as the Covid effect relative to the **longitudinal one-year development**. This longitudinal development was assessed in a sample of 1,013 keyage children who were tested in third grade and retested one year later in fourth grade.

Because we interpret the Covid effect relative to the age effect, the developmental costs get larger if the age effect gets smaller. Since the cross-sectional age effects are smaller than the longitudinal age effects, the developmental costs / gains due to Covid are larger if they are calculated with the cross-sectional age effect and smaller if they are calculated with the longitudinal age effect. We propose that a longitudinal assessment yields a more reliable estimate of the developmental (age-related) gain than a cross-sectional one. Therefore, we consider the smaller Covid related developmental costs / gains (last row) to be more credible.

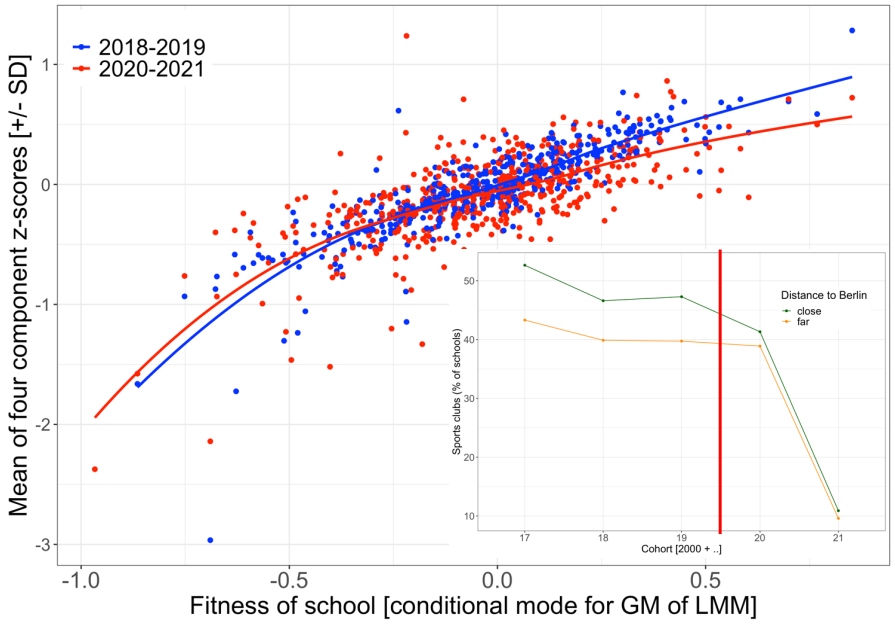


We can also look at the Covid effects on the School level. Which schools had larger negative Covid effects? The "fitter schools" with children who perform well in the physical fitness tests? Or schools with children with a lower physical fitness?

Interestingly, "fitter" schools had larger negative Covid effects. One could say that they had more to loose.
The x-axis of the figure shows the fitness score of each school (= conditional mode of the Grand Mean). This fitness score represents a school's "fitness" right before Covid. On the y-axis we have the composite fitness score (zPF, four fitness tests) on the school level. In blue we see the mean composite fitness score of the two years before Covid (2018 + 2019), and in red we see the fitness score during the two Covid years (2020 + 2021). For fitter schools, the difference between fitness during and before Covid (distance between the red and blue line) is larger than for schools with a lower fitness.

One factor related to the physical fitness of children is sports club participation. For children who do not participate in sports clubs, the lockdown did not make much of a difference in this aspect. We know that the access to sports clubs differs between children and between geographical regions (socio-economic status).

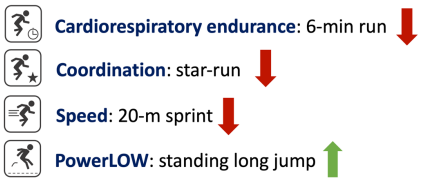
Covid effect on the school level



Children who live close to Berlin, in areas with a somewhat higher socio-economic status („Speckgürtel“, green in figure), are more likely to be in sports clubs than children who live far away from Berlin, at least in the years before Covid. However, during Covid, and especially in 2021, it did not matter in which area the children lived, because the lockdown temporarily prohibited sports club participation.

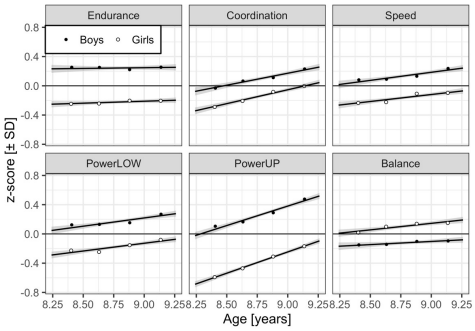
Covid effects on physical fitness of children

- **Negative Covid effect** for **comp. PF-score** and **comp. running score**
- **Negative Covid effect** for **running tests** (endurance, coordination, speed), **positive Covid effect** for **PowerLOW**

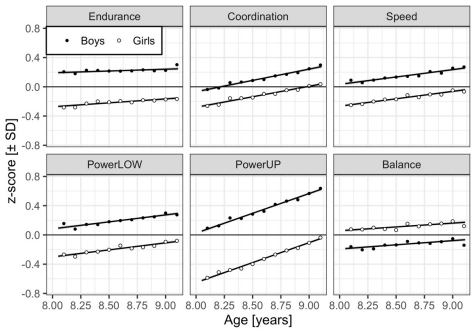


- **Meaningfulness** of these effects depends on perspective
  - training & movement science, educational science
- "Fitter" schools had larger negative covid effects
- **Outlook**: Next EMOTIKON assessment in fall 2022: Catch-up?

Thuringia replicates Brandenburg



Thuringia:
16,496 keyage third-graders from **292 schools** and **5 cohorts** (2017 to 2021; cross-sectional data)

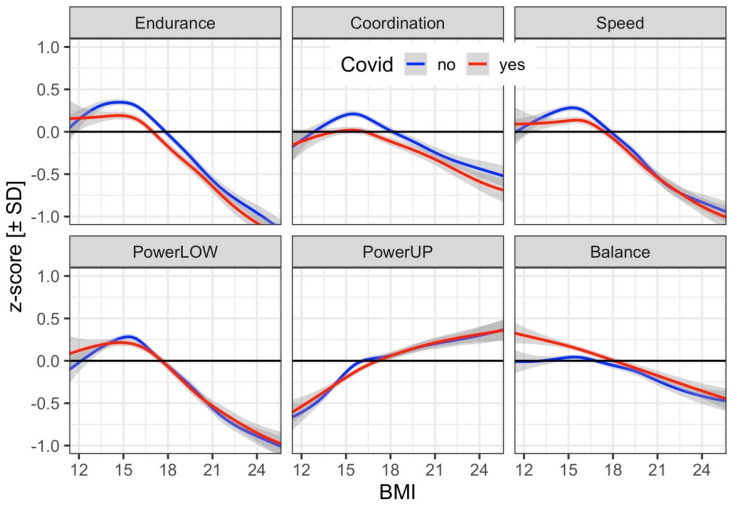


Brandenburg:
83,476 keyage third-graders from **512 schools** and **6 cohorts** (2016 to 2021; cross-sectional data)

Source: Bähr, F., Kliegl, R., & Puta, C. (2022). "Impact of Body Mass Index on Physical Fitness Components of Third-Graders". 54. Jahrestagung der Arbeitsgemeinschaft für Sportpsychologie (asp 2022) in Münster, 2022-06-16. *https://www.uni-potsdam.de/de/emotikon/publikationen*

Remarkably, our results were replicated by EMOTIKON's sister project "Bewegte Kinder = gesündere Kinder - BeKiGeKi" ("Active children = healthier children") in Thuringia. Both projects annually assess the physical fitness of third-graders and use the same 6 physical fitness tests. Just like in the EMOTIKON sample, in the Thuringian sample the cross-sectional age effects for all components are completely linear and boys outperform girls in all tests except for Balance. For Balance, the Thuringian girls' cross-sectional age-related development is a little larger than the Thuringian boys' development.

Thuringia replicates Brandenburg



Source: Bähr, F., Kliegl, R., & Puta, C. (2022). "Impact of Body Mass Index on Physical Fitness Components of Third-Graders". 54. Jahrestagung der Arbeitsgemeinschaft für Sportpsychologie (asp 2022) in Münster, 2022-06-16. *https://www.uni-potsdam.de/de/emotikon/publikationen*

The Covid effects were also replicated by Thuringia. In the Thuringian study sample, information on most of the children's BMIs is available. The BMI can thus be included as a covariate in the analyses, as it was when estimating the Covid effects. The Covid effect is significant and negative for the same physical fitness components as in EMOTIKON: Endurance, Coordination, and Speed (for all three running tests). The normal-weight third-graders, with a BMI around 15, show the highest drop in performance due to Covid.

For more information on the association between BMI and physical fitness, please see the presentation by Florian Bähr:

Bähr, F., Kliegl, R., & Puta, C. (2022). "Impact of Body Mass Index on Physical Fitness Components of Third-Graders". 54. Jahrestagung der Arbeitsgemeinschaft für Sportpsychologie (asp 2022) in Münster, 2022-06-16. *https://www.uni-potsdam.de/de/emotikon/publikationen*

Thank you!

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