

**UNIVERSITÄT ERFURT** | Freistaat Thüringen | Ministerium für Bildung, Jugend und Sport | **LSB** LANDESSPORTBUND THÜRINGEN | **FRIEDRICH-SCHILLER-UNIVERSITÄT JENA** | **EMOTIKON**

# Impact of Body Mass Index on Physical Fitness Components of Third-Graders

Florian Bähr, Reinhold Kliegl, & Christian Puta  
54. Jahrestagung der Arbeitsgemeinschaft für Sportpsychologie (asp 2022) Münster, 2022-06-16

**Bewegte Kinder = Gesundere Kinder**

since 2017  
22.231 Third-Graders  
292 Primary Schools

**Physical Inactivity  
Malnutrition  
Overweight**

**Children**

Ravens-Siebert, U., et al., Soziale Gesundheit und Gesundheitsverhalten von Kindern und Eltern während der COVID-19-Pandemie. Dtsch. Arztebl International, 2022. [Online First]; p. 1-1.  
Krause, L., et al., KIGGS Welle 1 – Landesmodul Thüringen, 2016, Robert Koch-Institut.  
Schmidt, et al., Zur Situation des körperlich-sportlichen Aktivitäts von Kindern und Jugendlichen während der COVID-19-Pandemie in Deutschland. Die Motorik-Modul Studie (MoMo), 2021.  
DAK-Gesundheit, Corona: Alarmierende Folgen für Kinder und Jugendliche, in DAK-Sonderanalyse untersucht Auswirkungen der Pandemie in der Krankheitsverbreitung 2020, 2021, Pressestelle DAK-Gesundheit Hamburg, p. 3-4.

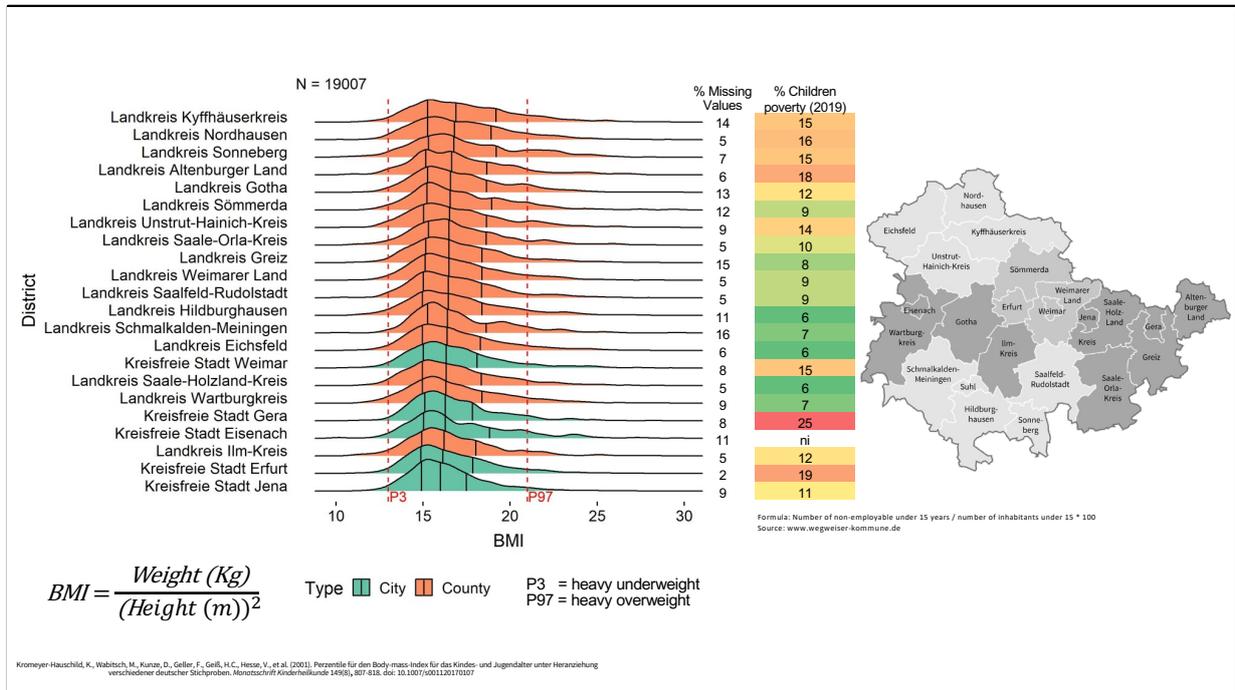
Let's talk about the impact of the body mass index on physical fitness components of third-graders.

The data come from the project “beki = geki” (“Bewegte Kinder = gesündere Kinder”, engl.: “Active children = healthier children”), which started in 2017 in Thuringia as a sister project to Brandenburg’s EMOTIKON project.

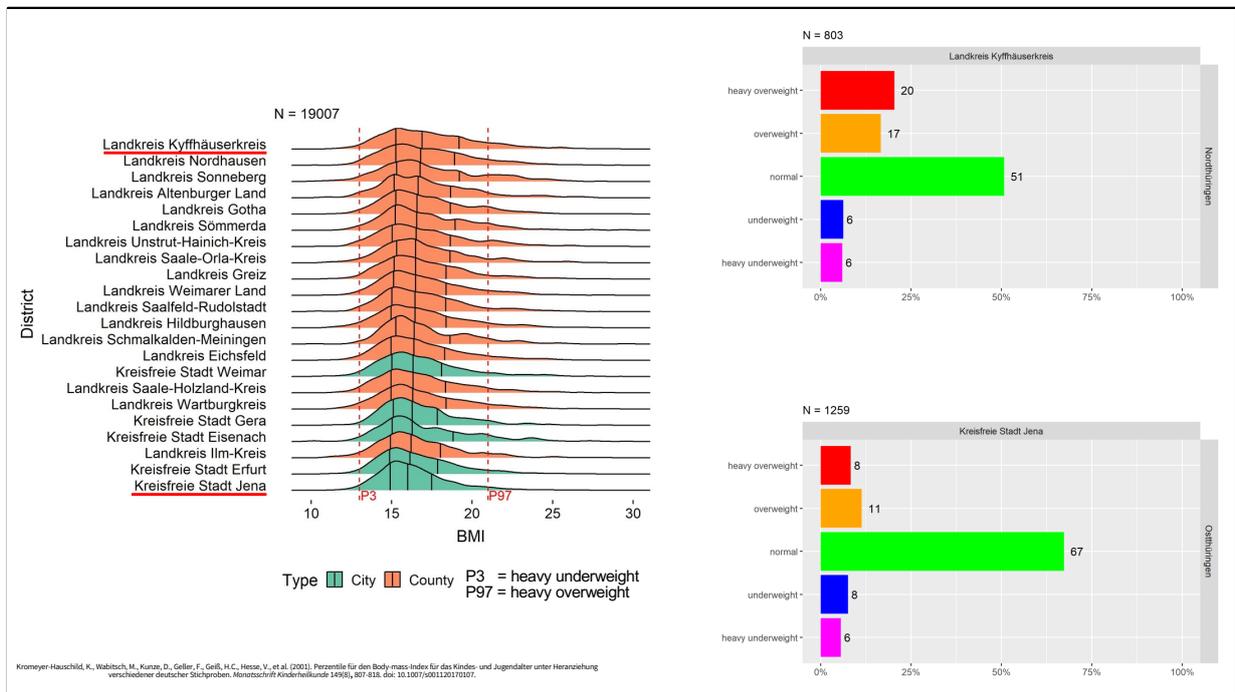
To date, the data encompasses over 20 thousand third-graders from 292 primary schools.

The analyses I present today are motivated by the fact that physical inactivity, malnutrition, and overweight of children is a growing problem in our society these days.

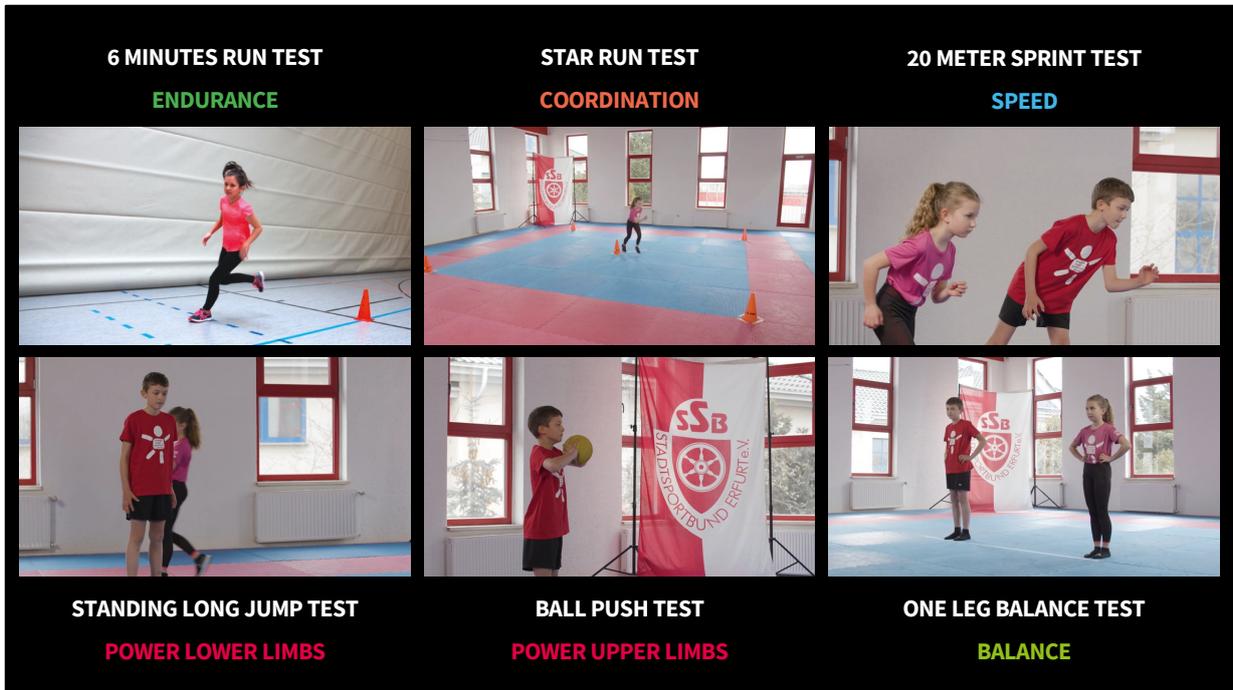
Unfortunately, the pandemic further reinforced this negative trend.



Let's have a look at the distribution of the BMI in the districts of Thuringia. Cities are shown in green and counties in orange. The chart is ordered by the median, which is the black line in the middle. As you can see, there is a larger proportion of overweight third-graders in counties than in the cities. The proportion of missing values is acceptable and suggests that the proportion may be even higher in counties. Taking into account children poverty, it is striking that cities at the bottom and counties at the top show a large proportion. However, the proportion of children poverty is higher in counties where we find more overweight third-graders.

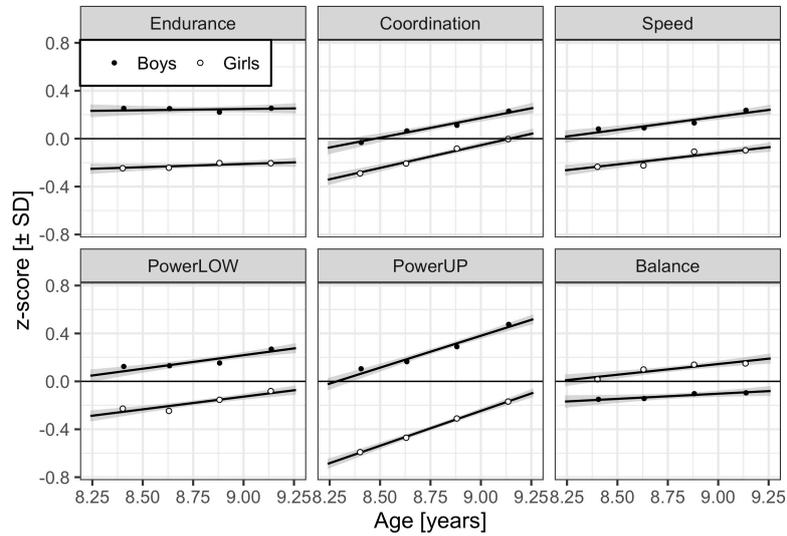


When comparing the lower and upper ends of the distribution, the differences in overweight are more obvious.  
 Note that a BMI higher than the 97<sup>th</sup> percentile or the category “heavy overweight” is of clinical relevance.  
 Now, I want to show you the physical fitness components.



As you can see, we use the same tests as EMOTIKON in Brandenburg to measure the components Endurance, Coordination, Speed, Power of Lower and Upper Limbs, and Balance.

## Age and Sex Effects



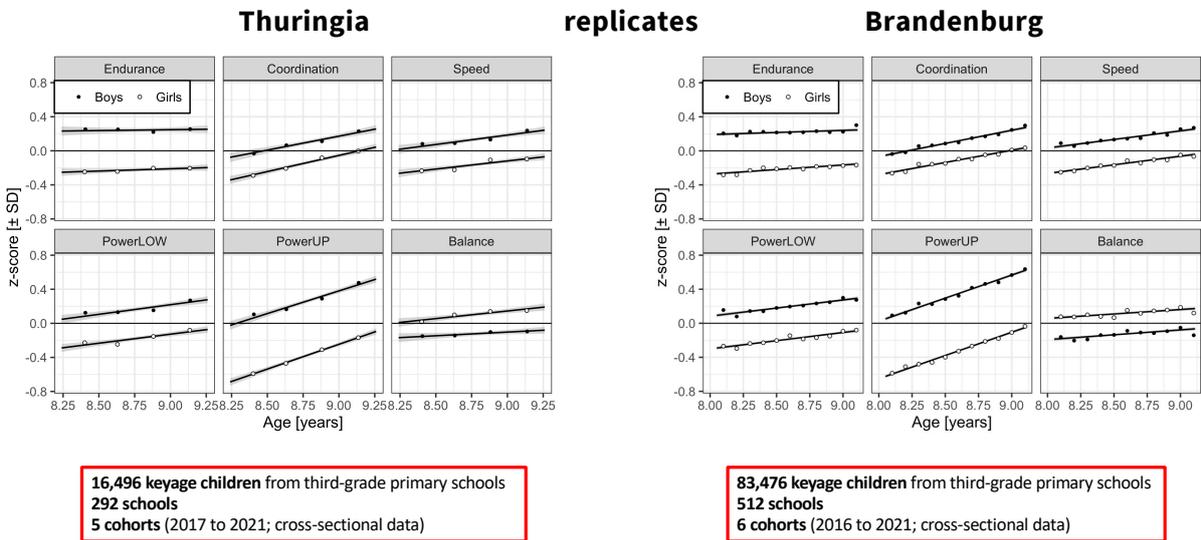
16,496 keyage children from third-grade primary schools  
292 schools  
5 cohorts (2017 to 2021; cross-sectional data)

I want to show you the overall results for boys and girls from Thuringia, which include data from 2017 to 2021.

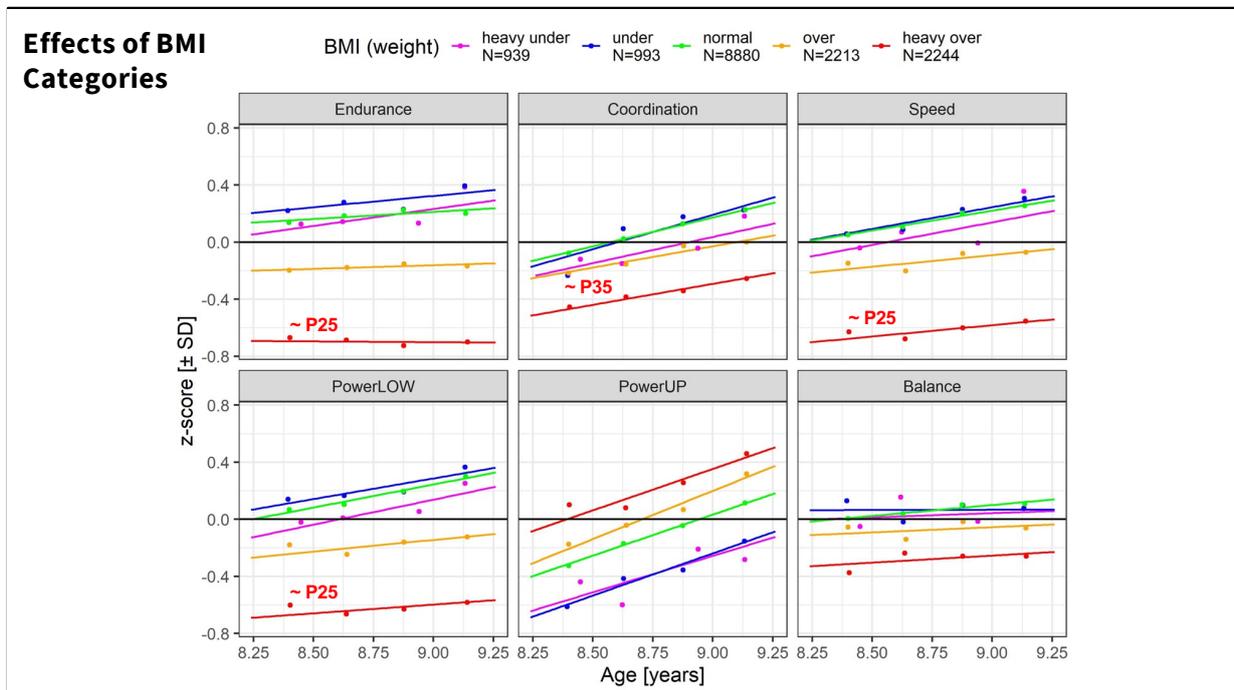
There are linear age effects for all components and boys scored higher than girls with the exception of Balance, where girls outperformed boys. For Balance, the girls' slope (age effect) is a little larger than the boys' slope.

Since we used the same tests as the EMOTIKON project, it was obvious to compare the results of the two states.

## Age and Sex Effects



And here we are, showing that the age effects (slopes) and sex effects of both states are statistically identical, with a minor exception for Endurance and Balance. Since replication in science is a problem nowadays, it is a remarkable result to us.



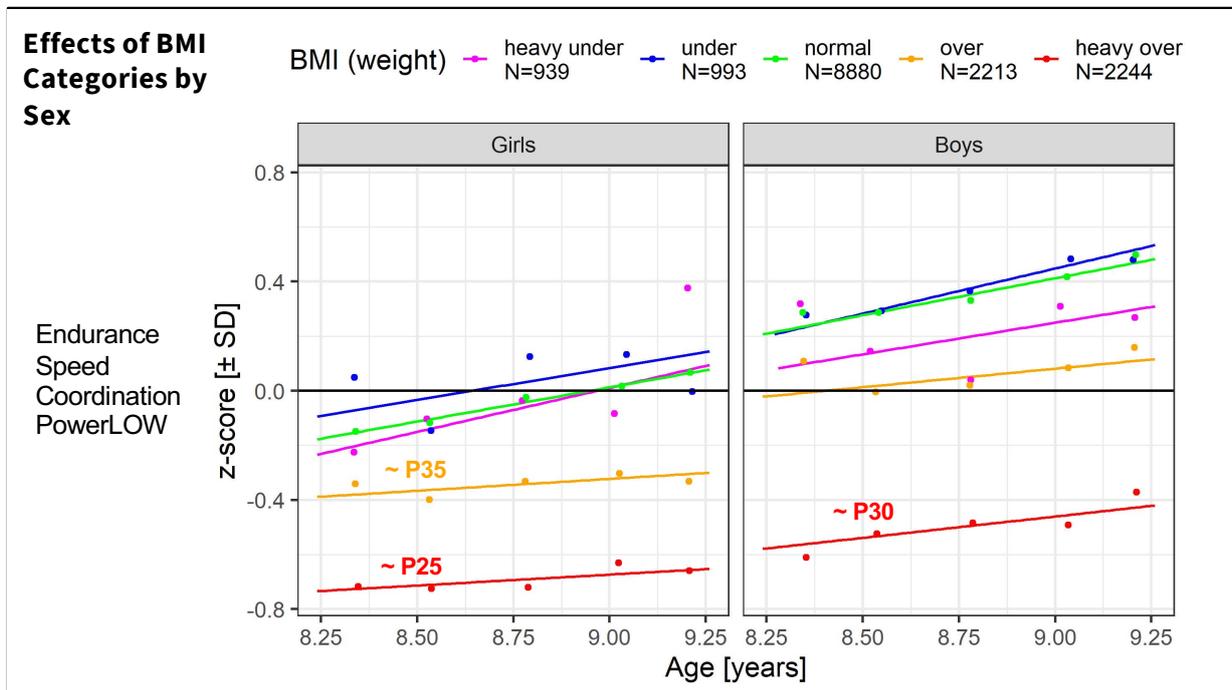
Let's have a look at the impact of the BMI on the components.

As you can see, in the four highly correlated components - Endurance, Coordination, Speed, and PowerLow, as Paula Teich presented earlier - the average performance score of heavy overweight third graders is 15 to 25 % lower compared to the overall sample mean.

Overweight third graders scored best in the ball push test, where mass is a leading factor.

However, overweight third graders also perform worse than their peers in the Balance Test.

Another important aspect is that the slope of the age effect of overweight third-graders is lower than the slope of their peers in Endurance, Speed, and PowerLow. This shows that overweight third-graders have less skill development over the year than their non-overweight peers.



For this chart, we calculated the mean score of the four highly correlated components on the left, which Paula Teich presented earlier.

As you can see, the performance of girls is more affected by obesity than the performance of boys.

Note that the age effect is much smaller than the BMI effect!

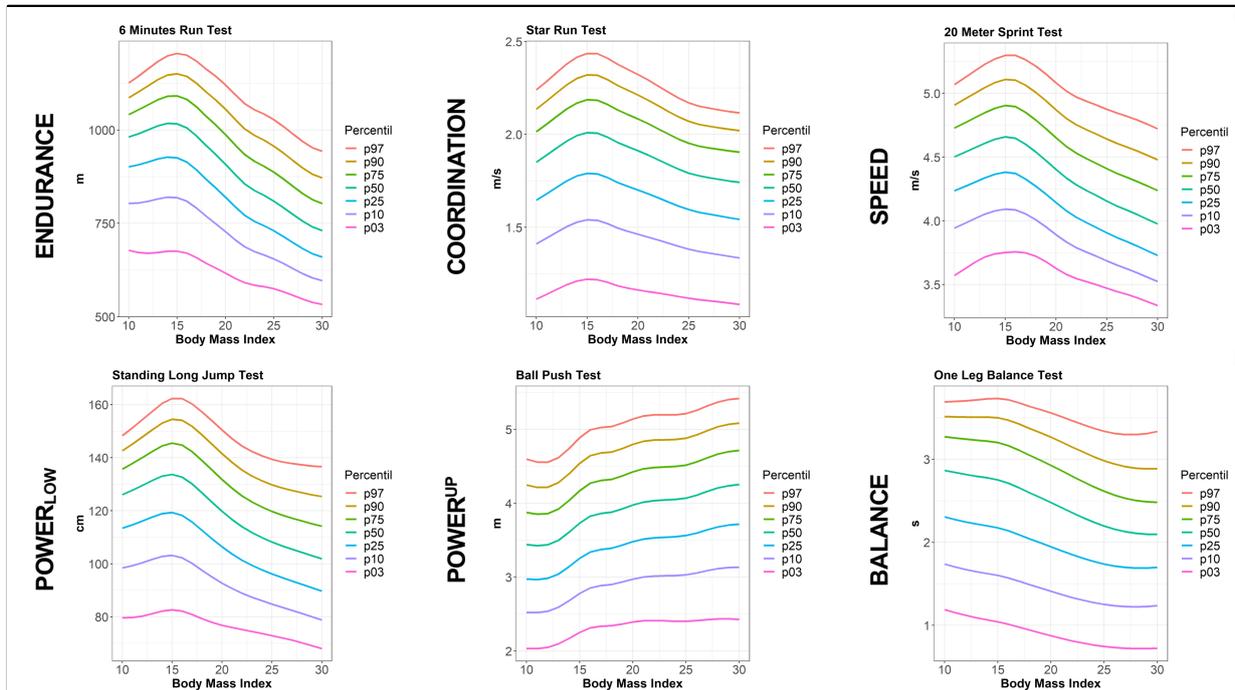
This is a problem in school sports, because the normative values of school performance tests consider age and gender, but not the BMI.

To illustrate as well as to solve the problem, we calculated percentiles of all tests adjusted by the BMI.

## BMI-adjusted Percentiles of Physical Fitness Components

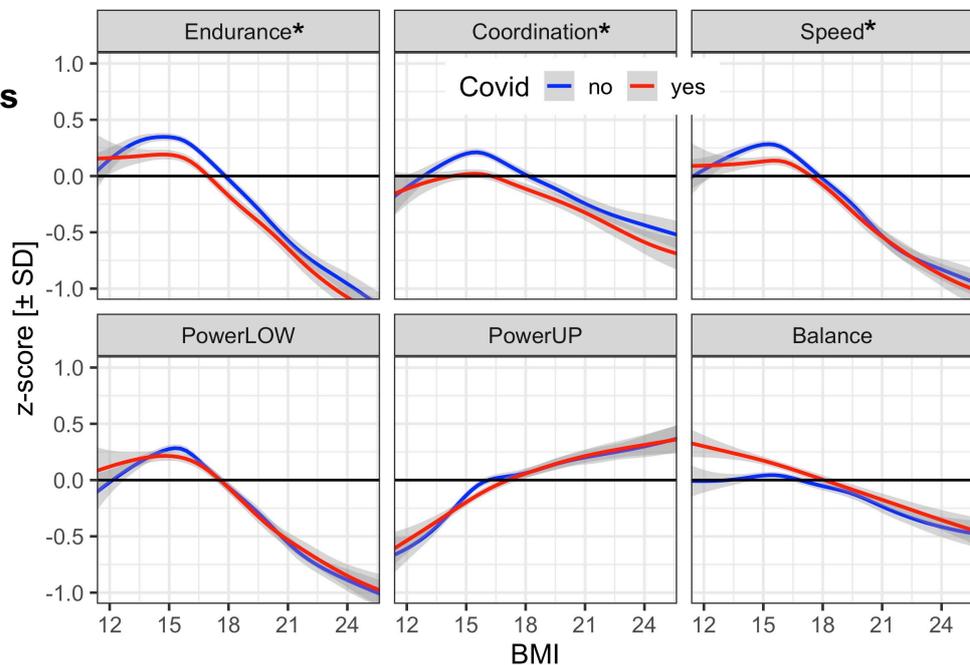
- Generalized additive models for location, scales, and shape (GAMLSS) integrated in R<sup>1</sup>.
  - Extension of the LMS method<sup>2</sup> for estimation of skewed data including adjustment of kurtosis
- Estimation of percentile curves by using the LMS method (BCCGo), Box-Cox power exponential (BCPE) distribution, and Box-Cox t (BCT) distribution
  - Response variable = Test Score
  - Explanatory variable = BMI
  - "Goodness of Fit" model comparison and selection via "Generalised Akaike Information Criterion (GAIC)<sup>3</sup>".
  - visual diagnostic via Worm-Plots<sup>4</sup>

<sup>1</sup>Rigby RA and Stasinopoulos DM. Generalized additive models for location, scale and shape (with discussion). Appl Stat 2005; 54: 507-544.  
<sup>2</sup>Cole TJ. The LMS method for constructing normalized growth standards. Eur J Clin Nutr 1990; 44: 45-60.  
<sup>3</sup>Cole TJ and Green PJ. Smoothing reference centile curves: the LMS method and penalized likelihood. Stat Med 1992; 11: 1305-1319. 4.  
<sup>4</sup>van Buuren S and Fredriks M. Worm plot: a simple diagnostic device for modelling growth reference curves. Stat Med 2001; 20: 1259-1277.



Let's have a look at the percentile curves for all components adjusted for the BMI. As you can see for Endurance, Coordination, Speed, PowerLow, and Balance, children with overweight aren't able to achieve the same results as their classmates. If, despite high effort, an overweight child always performs worse than most of their classmates (with the exception for PowerUp), it probably becomes more difficult for this child to develop motivation to do sports.

## What about Covid Effects and BMI?



As the last part of my presentation, I want to give you some insights to Covid effects depending on the BMI.

By **"Covid effect"** I mean the **effect of the two pandemic years** on the physical fitness, not the effect of a Covid infection!

As you can see, the Covid effect is significant for Endurance, Coordination, and Speed (for all three running tasks!).

It is striking that especially in these components the normal-weight third-graders, with a BMI around 15, show the highest drop in performance due to Covid.

This is in agreement with the results presented by Paula Teich.

Our effects are significant because we were able to control for BMI.



## KeyPoints

- A larger proportion of overweight third-graders live in counties than in cities of Thuringia.
- Average performance of heavy overweight third-graders in Endurance, Coordination, Speed, and PowerLow is lower by 15 % - 25 % compared to the overall sample mean.
- Overweight third-graders have less skill development over the year (lower slope of the age effect).
- Girls' performance is more affected by obesity than boys.
- In five of six tests, overweight third-graders aren't able to achieve the same results as their classmates.
- Normal-weight third-graders show the highest drop in run tasks performance during the pandemic.



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# Thank You!



## BLOG



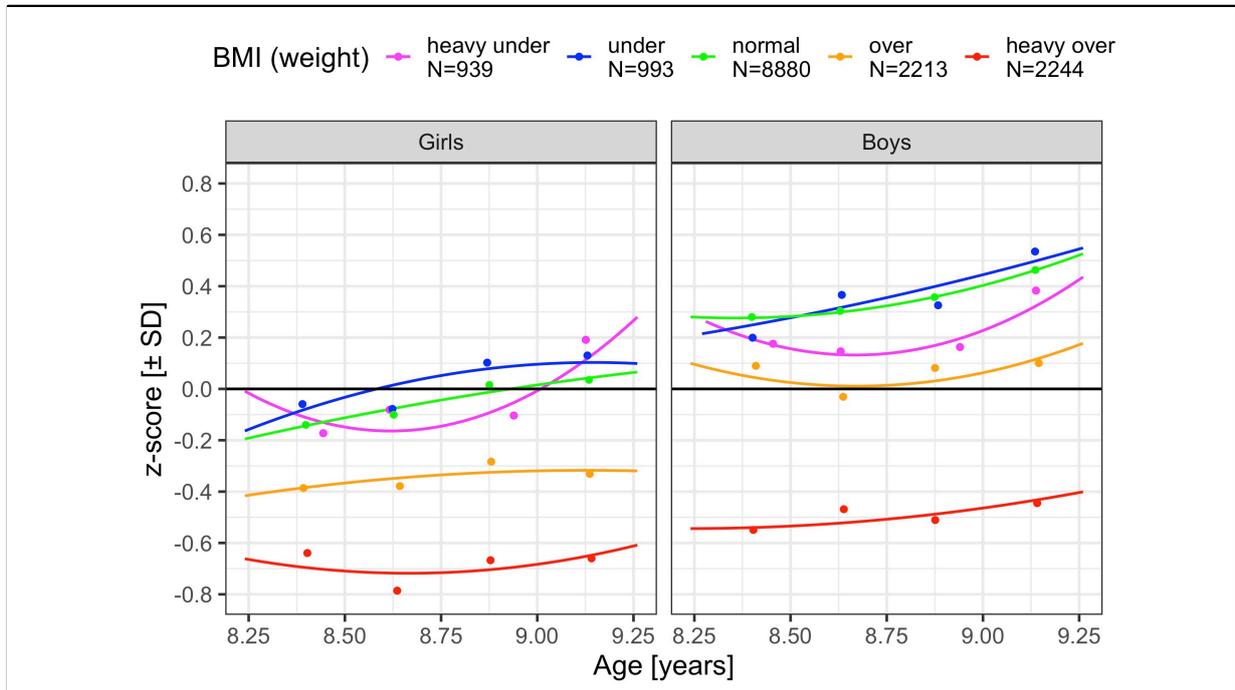
### bewegte Kinder = gesündere Kinder

Übungen für das Gleichgewicht mit Susanne Wulter und dem Mädchenchor...



Übungen für das Gleichgewicht mit Susanne Wulter und dem Mädchenchor...





Quadratic trend of heavy underweight third-graders.