

Body Composition and its correlates in children and adolescents living in Germany: An updated cross-sectional replication study based on the MoMo 2.0-Study

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Short Report

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Abstract

A population's body composition and its interplay with health-related correlates should be monitored continuously to inform public health strategies and track potential changes. We conducted a cross-sectional replication study using data from 2.930 children and adolescents aged 6–17 years participating in the nationwide [replication study blinded for peer review] (2022–2025) and compared the findings with 2.869 participants from [original study blinded for peer review] (2014–2017). Overall, 98 of 108 predefined hypotheses (90.7%) were replicated, including 39 hypotheses that were supported and 59 that were consistently not supported across both studies. Physical fitness again showed the strongest and most consistent associations with body composition parameters across age groups and sexes. Compared with the earlier cohort, participants in the [replication study blinded for peer review] exhibited generally lower fat-free mass index and phase angle. These findings demonstrate a high degree of reproducibility of the reported associations between body composition and its correlates while indicating potentially unfavorable between-wave differences in body composition among German youth.

1 Introduction

Previous research in childhood and adolescence has linked body composition to several health-related factors, including physical activity (PA) and physical fitness (PF) (Ballarin et al., 2022; Mateo-Orcajada et al., 2022). In contrast, a preregistered analysis of a large observational dataset found limited support for several theoretically expected associations (Source blinded for peer review).

In light of these findings and broader concerns regarding the reproducibility and generalizability of research findings (Vachon et al., 2021), it remains unclear to what extent reported associations and developmental patterns of body composition across childhood are robust, generalizable, or sample-specific. Direct replications using independent and more recent data are therefore essential to evaluate the stability of previous findings and to provide stakeholders and decision-makers with up-to-date evidence.

The present study provides a cross-sectional replication of prior analyses on body composition and its correlates in youth using an independent and more recent nationwide sample in Germany. By re-examining age- and sex-specific trajectories alongside the original hypotheses, we evaluate the reproducibility of both previously confirmed and non-confirmed findings and provide recent nationwide data on body composition in children and adolescents.

2 Materials and methods

Data were collected during the [replication study blinded for peer review] (2022–2025) and [original study blinded for peer review] (2014–2017) from a nationwide two-stage random sample. First, 185 (167 during [original study blinded for peer review]) municipalities across Germany were randomly selected with a probability proportional to the number of residents aged 4 to 17 years. Second, 140 individuals per municipality were randomly selected from local population registers and invited to participate by mail

(Woll et al., 2025). The study received ethical approval from the responsible institutional ethics committee.

Data processing and inclusion criteria followed previously published procedures (Source blinded for peer review). Assessments were conducted at decentralized study sites by trained examiners following standardized procedures described elsewhere (Woll et al., 2025).

During [original study blinded for peer review], PA was assessed using a hip-worn accelerometer (Actigraph GT3X+/wGT3X-BT). Detailed information about the procedure can be found elsewhere (Burchartz et al., 2020). During the [replication study blinded for peer review], assessment of PA was changed to thigh-worn accelerometers (ActivPAL4) and processed using the ActiPASS software (Fiedler et al., under review). We customized the default cadence thresholds for different intensities within ActiPASS to get age-specific results using the heuristic thresholds recommended by Tudor-Locke et al. (2018) for the walking intensities. Default PB categories by ActiPASS were used to define time spent in moderate to vigorous PA (MVPA). In both studies, accelerometers were worn over 24 hours on seven consecutive days. Each participant had to have at least two weekdays and one weekend day with at least 20 hours of recording to represent a valid week (Weber et al., 2024). PF was assessed using standardized motor performance tests, including standing long jump (SLJ) for lower-body explosive strength, physical working capacity at a heart rate of 170 bpm (PWC170) for cardiorespiratory fitness, and lateral jumping (side jump) as an indicator of coordination. Screen time (ST) was assessed via self-report, capturing daily duration of recreational digital media usage concerning watching TV, gaming on different devices (console, PC, smartphone, tablet), as well as using the internet for entertainment (streaming video-content, chatting, using social networks, general surfing) separately for weekdays and weekends (Schmidt et al., 2020). Total recreational ST was calculated as the sum of minutes across all activities when complete data were available. Socioeconomic status (SES) was determined based on parental education, occupation, and household income using a composite index adapted from the [blinded for peer review] framework, with higher scores indicating higher SES (range: 3–21). Body composition was assessed through bioelectrical impedance analysis (BIA) using a multi-frequency analyzer (NutriBox from Data Input with four channels, 50 kHz) by trained investigators according to the ESPEN guidelines for BIA in clinical practice (Kyle et al., 2004) in supine position. All participants were nonpregnant and healthy, defined as the absence of a clinical condition that could influence fluid balance, e.g., renal, endocrine, or myocardial disease, as ascertained by an interview. Fasting was not a precondition for study participation (Kyle et al., 2004). Resistance and reactance were used to derive fat mass index (FMI), fat-free mass index (FFMI), and phase angle (PhA) as of $57.297 \cdot \arctan(R/X_c)$. The BIA device has a technical error of $< 0.5\%$ (Dittmar, 2003) and high retest reliability ($r > 0.82$, $ICC > 0.96$) (Talma et al., 2013).

To replicate the hypotheses about the associations between PA, PF, ST, and SES with FMI, FFMI, and PhA, linear regression models stratified by sex and age group were used. A directional hypothesis was classified as supported when the corresponding regression coefficient was statistically significant ($p < .05$) in the preregistered direction and as unsupported otherwise. Additionally, independent-samples t

tests examined between-wave differences in FMI, FFMI, and PhA within each age-by-sex group. Statistical analyses were conducted using IBM SPSS Statistics (version 30.0; IBM Corp., Armonk, NY, USA) with statistical significance set at $p < .05$.

3 Results

Data from 2.930 children and adolescents (1.378 girls, 1.552 boys) participating in the [replication study blinded for peer review] and 2.869 children and adolescents (1.456 girls, 1.413 boys) participating in the [original study blinded for peer review] were included in the present analyses. Descriptive statistics and between-wave comparisons for body composition are presented in Table S1 (Online Resource 1).

3.1 Body composition

Figure 1 illustrates the age- and sex-specific distributions of FMI, FFMI, and PhA across both study waves. Exploratory between-wave comparisons showed significantly lower FFMI in all six groups (p values ranged from $< .001$ to $.048$) and significantly lower PhA in all six groups (all $p < .001$) in the [replication study blinded for peer review] compared with [original study blinded for peer review]. In contrast, FMI was significantly higher only in boys aged 6–10 years ($p < .001$) (Table S1, Online Resource 1). Despite these level differences, the age- and sex-specific patterns were broadly comparable across waves. FMI increased continuously with age among girls, whereas boys showed a temporary decline during early adolescence. Increases in FFMI and PhA during adolescence were more pronounced among boys.

Fig. 1 Age- and sex-specific distributions of (a) fat mass index (FMI), (b) fat-free mass index (FFMI), and (c) phase angle (PhA) in [original study blinded for peer review] and the [replication study blinded for peer review]. Lighter lines represent [original study blinded for peer review] and darker lines represent [replication study blinded for peer review]; red denotes girls and turquoise denotes boys. Vertical lines indicate the predefined age-group boundaries

3.2 Replication of preregistered hypotheses

Of the 108 directional hypotheses, 98 (90.7%) received the same support classification as in the original analyses: 39 were supported and 59 were unsupported in both samples (Table 1). Of the ten discordant findings, six involved MVPA: three for FMI, two for FFMI, and one for PhA. The remaining four concerned associations between PWC170 and PhA in girls aged 11–13 years, ST and FMI in boys aged 11–13 years and girls aged 14–17 years, and SES and PhA in boys aged 11–13 years. Complete regression coefficients and model statistics are provided in Tables S2 and S3 (Online Resource 2).

Table 1 Support for preregistered hypotheses in the original and replication analyses across age and sex groups

Hypotheses	Study	6-10 years		11-13 years		14-17 years	
		Boys	Girls	Boys	Girls	Boys	Girls
FMI							
MVPA (r ^{-a})	Replication	✗ ^b	✓ ^c	✗	✓	✓	✗
	Original	✓	✓	✓	✓	✗	✗
PWC170 (r-)	Replication	✗	✗	✗	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗
SLJ (r-)	Replication	✓	✓	✓	✓	✓	✓
	Original	✓	✓	✓	✓	✓	✓
SJ (r-)	Replication	✗	✗	✗	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗
ST (r ^{+d})	Replication	✓	✓	✓	✓	✓	✗
	Original	✓	✓	✗	✓	✓	✓
SES (r-)	Replication	✓	✓	✓	✓	✓	✓
	Original	✓	✓	✓	✓	✓	✓
FFMI							
MVPA (r+)	Replication	✓	✗	✗	✗	✓	✓
	Original	✗	✗	✗	✗	✓	✗
PWC170 (r+)	Replication	✓	✓	✓	✓	✓	✓
	Original	✓	✓	✓	✓	✓	✓
SLJ (r+)	Replication	✗	✗	✗	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗
SJ (r+)	Replication	✗	✗	✗	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗
ST (r-)	Replication	✗	✗	✗	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗
SES (r+)	Replication	✗	✗	✗	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗
PhA							
MVPA (r+)	Replication	✓	✗	✓	✗	✓	✓
	Original	✓	✓	✓	✗	✓	✓
PWC170 (r+)	Replication	✓	✗	✓	✓	✓	✓
	Original	✓	✗	✓	✗	✓	✓
SLJ (r+)	Replication	✓	✓	✓	✓	✓	✓
	Original	✓	✓	✓	✓	✓	✓
SJ (r+)	Replication	✗	✗	✗	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗
ST (r-)	Replication	✗	✗	✗	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗
SES (r+)	Replication	✗	✗	✓	✗	✗	✗
	Original	✗	✗	✗	✗	✗	✗

Abbreviations: FFMI, fat-free mass index; FMI, fat mass index; MVPA, moderate-to-vigorous physical activity; PhA, phase angle; PWC170, physical working capacity at a heart rate of 170 bpm; r, measure of association; SES, socioeconomic status; SJ, side jump; SLJ, standing long jump; ST, screen time

a negative directed hypothesis

b hypothesis rejected

c hypothesis confirmed

d positive directed hypothesis

Gray shading indicates divergent support classifications

4 Discussion

Across the two study waves, 98 of the 108 preregistered hypotheses received the same support classification, indicating a high degree of reproducibility and suggesting that the overall pattern of associations was largely robust across samples. PF, particularly SLJ and PWC170, again showed the strongest and most consistent associations with body composition across age groups and sexes. This concordance included both supported and unsupported hypotheses. Although concordant nonsignificant findings do not establish equivalence, they indicate that several theoretically expected associations were consistently not observed.

SLJ was repeatedly negatively associated with FMI and positively associated with PhA, whereas PWC170 was consistently positively associated with FFMI. At the same time, hypothesized negative associations between PWC170 and FMI and positive associations between SLJ and FFMI were consistently not observed. The replication of both supported and unsupported hypotheses strengthens confidence that these patterns are not attributable to sample-specific effects. These findings further support the idea that associations between PF and body composition depend strongly on how PF is operationalized. SLJ represents a weight-bearing task in which excess fat mass constitutes an additional mechanical load that may impair performance. In contrast, PWC170 was assessed using a cycling ergometer and therefore reflects a predominantly non-weight-bearing task. Performance in such assessments may benefit from larger absolute muscle mass and body size, potentially explaining the consistent positive association with FFMI as well as the absence of the hypothesized negative association with FMI. Similarly, FFMI reflects whole-body fat-free mass and does not necessarily translate into superior performance in a weight-bearing task such as the SLJ.

Lower SES and higher ST were associated with higher FMI in both samples, indicating that these factors may represent stable correlates of adiposity during childhood and adolescence. In contrast, six of the ten discrepant findings involved MVPA, which showed low explanatory value for body composition among both studies. Because PA was assessed using a different accelerometer system and processing approach in the [replication study blinded for peer review], methodological differences may have contributed to these inconsistencies.

Beyond the replication findings, the exploratory between-wave comparisons indicated a potentially unfavorable body composition pattern. PhA and FFMI were significantly lower in all age-by-sex groups. In contrast, evidence for higher FMI was limited to boys aged 6–10 years. These findings warrant continued monitoring of body composition among German youth. However, because two independent cross-

sectional samples were compared, the observed differences should be interpreted on a population level and not as evidence for individual changes.

Strengths of this study include the nationwide independent replication of a preregistered analysis in a large population-based sample using standardized assessment protocols. Nevertheless, several limitations should be acknowledged. Due to the cross-sectional design, causal inferences cannot be drawn. Pubertal maturation and nutritional status were not assessed, although both are known to influence growth and body composition (Cheuiche et al., 2021; Corkins et al., 2016). Findings are primarily generalizable to children and adolescents living in Germany. Finally, PA was assessed using different accelerometer systems and data processing approaches in [original study blinded for peer review] and the [replication study blinded for peer review].

5 Conclusion

This study demonstrated a high degree of concordance in associations between body composition and its correlates across two independent nationwide samples, with 98 of 108 preregistered hypotheses receiving the same support classification. PF, operationalized by SLJ and PWC170, showed the strongest and most consistent associations with body composition, while lower SES and higher ST were repeatedly associated with higher FMI. Exploratory comparisons additionally indicated potentially unfavorable between-wave differences in FFMI and PhA, whereas evidence for higher FMI was limited. These findings support continued monitoring of body composition and its correlates among children and adolescents in Germany.

Declarations

All procedures performed in studies involving human participants or on human tissue were in accordance with the ethical standards of the Institutional Research Committee and with the Declaration of Helsinki of 1975 and its subsequent amendments or comparable ethical standards. Ethical approval for the MoMo 2.0-Study was obtained from the Ethics Committee of the Karlsruhe Institute of Technology on 6 November 2023 (application number A2023-077). Informed consent was provided by legal guardians or participants (for those over 15 years).

Conflict of Interest

The authors declare no conflict of interest.

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16. Electronic supplementary material Online Resource 1 Supplementary Table S1: Descriptive characteristics of the [replication study blinded for peer review] and [original study blinded for peer review] samples by sex and age group
17. Online Resource 2 Supplementary Tables S2 and S3 Age- and sex-specific regression results for the [replication study blinded for peer review] and [original study blinded for peer review]

Figures

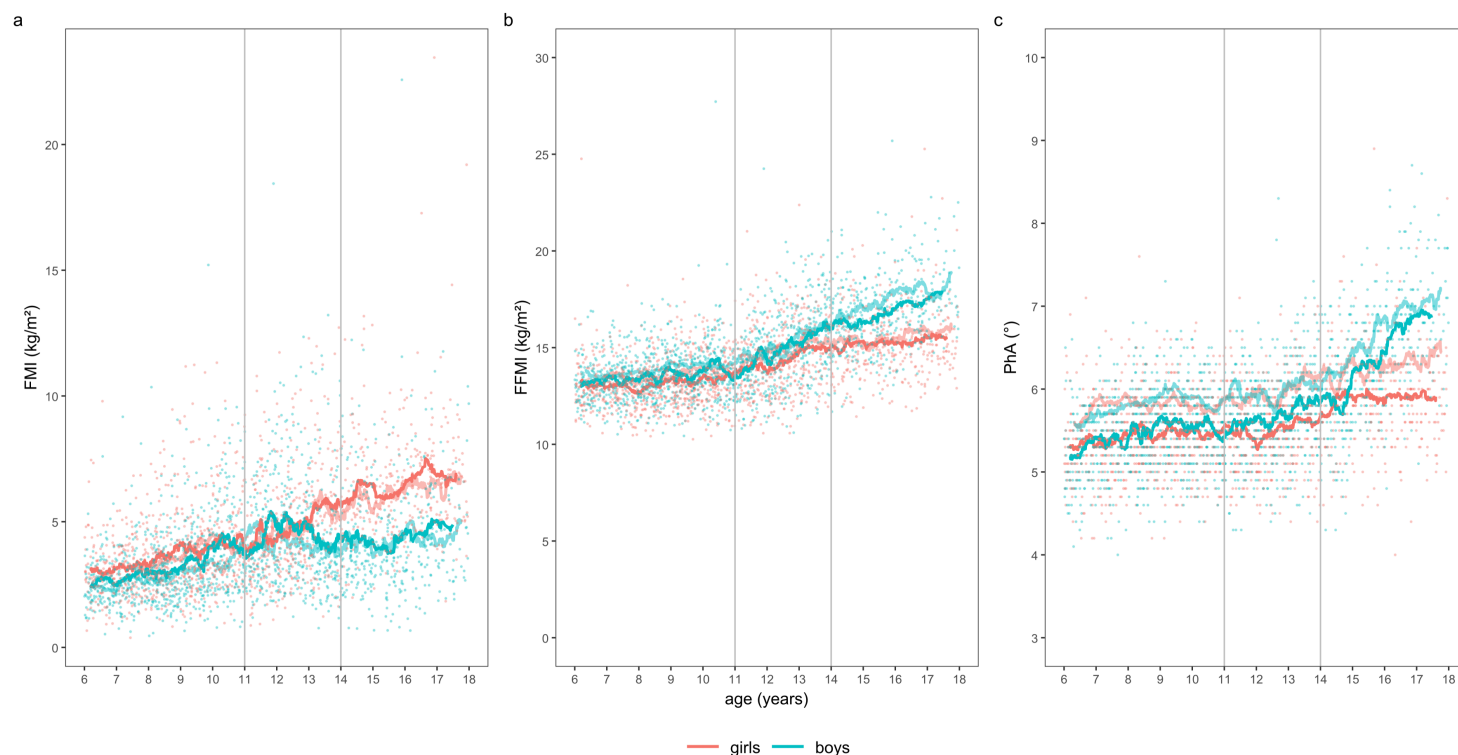


Figure 1

Age- and sex-specific distributions of (a) fat mass index (FMI), (b) fat-free mass index (FFMI), and (c) phase angle (PhA) in [original study blinded for peer review] and the [replication study blinded for peer review]. Lighter lines represent [original study blinded for peer review] and darker lines represent [replication study blinded for peer review]; red denotes girls and turquoise denotes boys. Vertical lines indicate the predefined age-group boundaries