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Title: Temporal trends in muscular fitness among French children and adolescents between 1999 and 2023.

Running head: Physical fitness trends.

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ABSTRACT

1 The aim was to estimate national temporal trends in muscular fitness for French youth
2 between 1999 and 2023. Data were obtained from five cross-sectional studies on 53,314
3 children and adolescents (age range: 6–16 years). Lower- and upper-body strength were
4 assessed by standing broad jump (SBJ) and handgrip strength (HGS). BMI z-scores (BMIz)
5 were calculated using WHO growth curves. We found a statistically significant negligible
6 decline in SBJ performance (standardised effect size (ES) trend per decade [95%CI]: –0.08 [–
7 0.10, –0.07] or –2.1 cm [95%CI: –2.4, –1.8]) and a statistically significant negligible
8 improvement in HGS (ES trend per decade [95%CI]: 0.11 [0.08, 0.13]) or 0.6 kg [(95%CI: 0.4,
9 0.8]). We found evidence of significant increases in distributional variability and asymmetry,
10 with poorer trends in the low performers (<25th percentile) and better trends in the high
11 performers (>75th percentile) compared to the average performers. Our data suggest negligible
12 trends in mean SBJ and HGS, coupled with increased distributional variability and asymmetry.
13 Trends were not uniform across the population distribution with data suggesting an increase
14 over time in the gap between low and high performers. These results reinforce the importance
15 of interventions and programs aiming at improving muscular fitness specifically in children and
16 adolescents with low muscular strength.

17

18 **Keywords:** Muscular strength, standing broad jump, handgrip strength, youth, trends.

INTRODUCTION

Physical fitness comprises several components such as cardiorespiratory fitness, muscular fitness, motor fitness, and body composition. Although cardiorespiratory fitness is the most studied component, there has been an increased interest in the health benefits of youth muscular fitness in recent years (1). Muscular fitness includes three components, muscular strength, endurance, and power (2). Muscular strength, specifically, refers to the ability of a muscle or muscle group to generate maximal force during a single contraction (3). Muscular strength has been found strongly and consistently associated with important health outcomes (cardiometabolic disease, adiposity, bone health, mental health) in childhood and adolescence, and is also strongly associated with health status in adulthood (1,4–6). Several large cohort studies have shown that lower muscular strength during childhood and adolescence is associated with increased risk of physical disability and early all-cause and cause-specific (cardiovascular and cancer) mortality in later life (7,8). Collectively, this evidence underlines the health-related importance of muscular fitness in children and adolescents.

Different field-based fitness tests are used to assess muscular strength and have utility for clinical screening and population health surveillance (9). The most commonly recommended tests, as endorsed by European experts, are the standing broad jump (SBJ) and handgrip strength (HGS) tests, which assess lower- and upper-body muscular strength, respectively (9). These simple, acceptable, inexpensive, feasible, safe and scalable tests are widely used to measure muscular strength in children and adolescents in school settings. The SBJ test shows moderate-to-high construct validity and the HGS shows high-to-very high construct validity (9,10). Both tests have high-to-very high reliability and negligible test-retest learning and fatigue effects (11–13). However, there are limitations to these tests that must be considered. For example, the positioning of the elbow (extended or flexed) can affect handgrip strength assessment, depending on the model of dynamometer used (14,15).

Given the link between youth muscular strength and health, the tracking of temporal trends in muscular strength may translate into trends in health and provide insight into the effectiveness of public health recommendations and fitness-enhancing interventions and programmes. Two recent large meta-analyses have found conflicting trends for upper- and lower-body muscular strength (16,17). For example, Dooley et al. (16) found a substantial improvement in mean HGS over time in 2.2 million children and adolescents from 19 countries followed between 1967 and 2017. In contrast, Tomkinson et al. (17) found that mean SBJ performance had declined in recent decades among 11 million children and adolescents from 29 countries. These global trends were similar for France, with a 0.4 standardised (Cohen's) effect size (ES) improvement per decade for HGS among 572 children aged 11–14 years between 1985 and 2008 (16), and a 0.3 ES per decade decline for SBJ performance among 2416 children aged 9–14 years between 1984 and 2008 (17). Unfortunately, published trends for muscular fitness among French children are outdated, based on small samples, and limited to a narrow age range. Since the 2024 Olympic Games in Paris (France), there is an increased interest in the assessment and interpretation of children's physical fitness levels among national policy makers. The aim of this study, therefore, was to describe current trends in muscular fitness among French children and adolescents aged 6 to 16 years.

MATERIALS & METHODS

Participants

This study uses raw data from five cross-sectional studies including French children and adolescents tested between 1999 and 2023. Participants represented 12 of 18 regions, including 12 of 13 metropolitan and no overseas French regions (Figure 1). Data from cohorts 1–4 collected between 1999 to 2023 have been previously described (18–21), while data from cohort 5 (2022) represent unpublished baseline data from a national intervention study (see Table 1 for participant characteristics). Data were pooled across studies, and we included only participants with complete data for year of testing, age, sex, geographical region, BMI, SBJ, and HGS.

From the total sample of 53,314 children and adolescents aged 6 to 16 years, complete data were available for SBJ in 48,584 (48.7% female; mean [SD] age: 8.5 [1.7] years) and HGS in 7267 (49.8% female; mean [SD] age: 11.5 [1.2] years) participants. Number of participants by sex and muscular fitness test according to cohort are presented in Figure 2.

*** Figure 1 about here***

*** Figure 2 about here***

*** Table 1 about here***

Ethics committee

All cohorts included in our analysis were approved by their respective Institutional Research Ethics Committees, and all procedures were performed in accordance with the ethical standards of the Helsinki Declaration and the European Good Clinical Practices. Data collection was also approved by the French personal informatics competent authority (Commission Nationale de l'Informatique et des Libertés) according to the General Data Protection Regulation.

Measures

A detailed description of measurement procedures for upper and lower body muscular strength of different cross-sectional studies included is presented in Table 2.

Lower body muscular strength

Explosive lower-body muscular strength was assessed by the SBJ test (9–11,22). From a starting position immediately behind a line on a nonslip hard surface and with the feet approximately shoulder width apart, participants jumped horizontally with a double-leg take-off as far as possible. The distance jumped in cm was recorded as the better of two trials (Table 2). While the SBJ test is primarily used to assess lower-body strength, it is also influenced by

motor coordination. Thus, performance on this test may reflect both strength and motor skills, which should be considered when interpreting the results.

Upper body muscular strength

Upper-body muscular strength was assessed by HGS (9). Participants stood with their testing arm slightly abducted (at 30° to their torso), elbow extended, and their forearm and wrist in a neutral position. Participants progressively squeezed the dynamometer maximally over a 2 to 3 second period. Across cohorts, the dynamometer (Takei, Japan, and Camry, China) was calibrated prior to data collection with an accuracy of 0.1 kg. Consistent instructions were provided to all children and adolescents regarding the test procedure (e.g., hand positioning). Testing and reporting protocols (e.g., hand used, number of trials per hand, summary statistics, model of the dynamometer used) differed among included studies (Table 2). HGS was expressed in kilograms.

Anthropometry

Body mass and height were measured using digital weighing scales and stadiometers. Body Mass Index (BMI) was calculated by dividing body mass (kg) by height-squared (m²). We adjusted BMI for sex and age by converting to BMI z-scores (BMIz) using the World Health Organisation's growth curves (23). These measures were taken at the same time as the SBJ and HGS tests.

Data treatment and statistical analysis

The method used to treat and statistically analyse the data is fully described in our sibling study (24). Briefly, we adjusted for sex and age by converting SBJ and HGS results to z-scores using European norms (25). Trends in mean z-scores were weighted using the regional population values for the year 2010 (26) and calculated using general linear models (proc GLM) in SAS EG 7.1 (Cary, North Carolina, USA). BMIz was added as a covariate. Trends were expressed as absolute rates of change and as standardized (Cohen's) effect sizes (ES), with ES

interpreted as negligible ($ES < 0.2$), small ($ES = 0.20 - 0.49$), moderate ($ES = 0.50 - 0.79$), or large ($ES \geq 0.80$) (27). Positive trends indicated increases in muscular fitness and negative trends indicated declines in muscular fitness.

Trends in distributional variability were examined as the ratio of standard deviations (SDs) (i.e., the latest SD divided by the earliest SD) (28). We interpreted substantial increases in variability as ratios > 1.1 , substantial declines in variability as ratios < 0.9 , and negligible trends in variability as ratios between 0.9 and 1.1. Trends in distributional asymmetry were examined visually using LOWESS (LOcally WEighted Scatter-plot Smoother) curves (tension = 66, which provided the best compromise between over-fitting and a lack of fit), by plotting the trends in z-scores across a range of percentiles (range: 5th to 95th) (29).

RESULTS

With adjustments for age, sex, and BMI_z, we found a statistically significant negligible decline in SBJ performance of -0.08 ES (95%CI: $-0.10, -0.07$) or -2.1 cm (95%CI: $-2.4, -1.8$) per decade. In contrast, we found a statistically significant negligible improvement in HGS of 0.11 ES (95%CI: $0.08, 0.13$) or 0.6 kg (95%CI: $0.4, 0.8$) per decade.

The per decade trend for both SBJ performance and HGS was non-uniform across the population distribution, evidenced by significant increases in distributional variability (ratio of SDs per decade [95%CI]: SBJ performance, 1.27 [$1.20, 1.34$]; HGS, 1.23 [$1.17, 1.31$]) and negligible trends in distributional asymmetry (Figure 3). Figure 3 shows that for SBJ performance, there were slightly larger declines (ES difference per decade: negligible) for the low performers (below the 25th percentile) than the average performers (at the 50th percentile) and improvements (ES difference per decade: negligible) for the high performers (above the 75th percentile). For HGS, slightly smaller improvements were experienced by the low performers (ES difference per decade: negligible), and slightly larger improvements for the high performers (ES difference per decade: negligible), compared to the average performers.

DISCUSSION

This study estimated the national temporal trends in means and distributional characteristics of HGS and SBJ performances for French children and adolescents between 1999 and 2023. Our main results suggest that there was a significant though negligible decline in SBJ performance and a significant but also negligible improvement in HGS. We also found that these trends were not uniform across the population distribution, with evidence that both ends of the distribution had moved slightly away from the middle of the distribution. These findings are of major public health importance, as muscular strength is a key predictor of current and future health in youth. A meta-analysis showed that high physical fitness in youth is linked with better long-term health, including lower BMI, improved insulin resistance, and reduced cardiovascular risk (1). Data from this study could serve as a crucial basis for informing and developing policies and public health strategies in France.

While data from large, international meta-analyses have reported a decline in SBJ performance and improvement in HGS among French children and adolescents between 1984 and 2008, our study provides a timely update extending data to 2023 (16,17). Our findings are similar to previously described international trends which indicate opposite trends for upper- and lower-body muscular strength in high-income countries (16,17). The opposing trends between SBJ and HGS (albeit negligible in magnitude) may reflect the different types of strength they measure (e.g., HGS reflects isometric strength, SBJ reflects explosive strength or power) or that the decline in SBJ performance reflected a general decline in motor skills (e.g., jumping skill competency) (17). In the same way, trends in muscular strength (HGS and SBJ) are consistent with the French national trend for other components of physical fitness, such as cardiorespiratory fitness (24). In our recent study of temporal trends in cardiorespiratory fitness for 15,420 children and adolescents (aged 9–16 years) between 1999 and 2022, we found a substantial decline in mean 20m Shuttle Run Test performance since 1999, but which slowed considerably after 2010 and became negligible (24). The observed

negligible trends are encouraging, but regular and comprehensive monitoring of physical fitness among French children and adolescents is needed to continue tracking these trends and to determine whether they are temporary or permanent. The non-uniform trends observed in both SBJ and HGS tests across our French youth population distribution highlight the complexity of our results that may have implications for public health. Indeed, our findings indicate significant increases in variability in both SBJ and HGS over these two last decades, suggesting widening disparities in muscular strength levels among children and adolescents. Trends in distributional asymmetry indicate that both ends of the distribution have moved away from the middle of the distribution, suggesting an increase in the gap between low and high performers. This disparity could be influenced by differences socioeconomic status, which have increased over the past decades in France (30). Indeed, children and adolescents with high socioeconomic status may have better access to organized sports (registration for sport clubs) and fitness facilities that require high registration fees, while French youth with low socioeconomic status may face additional barriers to participation. This suggests the importance of targeted interventions aimed at improving muscular fitness across all segments of the population, especially for French children and adolescents with low muscular strength. Public health strategies should continue promoting physical activity programs that specifically target muscular strength improvement as soon as possible, aiming to mitigate disparities, promote equity and enhance health-related fitness. Interventions could focus on both school and community programs. School-based initiatives have improved muscular fitness in children, while community programs increasing extracurricular activities, like sports clubs, may also help (5,31).

Temporal trends in HGS and SBJ among children and adolescents are likely influenced by changes over time in a network of physiological, behavioural, psychosocial, environmental, and social factors (32). First, increased body size may be involved. However, several studies have reported that temporal trends in muscular strength, as measured by HGS and SBJ, are independent of trends in body size (operationalised as height and mass, height, mass, and

BMI, or body composition) (33–35). Moreover, our trends in both muscular strength tests were adjusted for BMIz. Another factor that potentially influence trends in muscular strength is the trend in biological maturation. Although few studies have adjusted trends in muscular strength for trends in maturity status, one study of Spanish adolescents found that the decline in muscular strength between 2001 and 2007 was independent of trends in pubertal status (Tanner–Whitehouse scale) (36). Other studies, while not statistically adjusting for trends in pubertal status, have suggested that trends in muscular strength may be positively influenced by the trend towards earlier maturation (16,17). Sember et al (2023) reported a decline in gross motor coordination from 1983 to 2014 in a large sample of Slovenian children and adolescents (37). In contrast to HGS, SBJ performance requires fundamental motor skills or competency to execute a jump, employing a counter-movement swing of the arms to generate power and momentum. Therefore, it is possible that declining motor skills may have influenced the observed trend in SBJ performance among French children. Trends in SBJ performance are supported by the French Report Card on Physical Activity, which reported declining physical activity and increased screen time from 2018 to 2022 (38). Additionally, authors reported a 4% decline in youth registered with sports clubs since 2019 (38). As participation in organized sports is linked with better physical fitness, this decline may reflect reduced opportunities for structured physical activity and skill development, contributing to disparities in muscular fitness (39,40).

Muscular strength levels in children and adolescents can be improved in different ways. First, a systematic review showed that muscular strength was positively associated with daily physical activity levels, especially vigorous physical activity (41). In a systematic review and meta-analysis, Wang et al reported that mobile health app-based interventions may benefit muscle strength levels in children and adolescents (42). Second, Smith et al. reported that participation in sport was associated with better muscular strength (41). In addition to the decline in sports club memberships, COVID-19 worsened this trend by cancelling events and restricting extracurricular activities (38). While access to sports clubs has returned to normal,

further data are needed to monitor future trends. Third, improvements to the built environment (i.e., neighbourhood safety, walking and cycling infrastructure, presence and accessibility of sport and recreation equipment, green space...) that is associated with increased physical activity may also benefit muscular strength. In a European study investigating the associations between built environment characteristics on various components of health-related physical fitness, it was observed that adolescents who have a secure bicycle route from home to school and nearby gymnasiums have better HGS and SBJ performance compared to those without such access (43). Additionally, the authors also demonstrated that the presence of traffic lights in the neighbourhood was associated with better results in SBJ performance (43). Similar results have been found for U.S. children and adolescents (44). Policy makers in France need to develop new strategies in cities by prioritizing new infrastructure and safety to make children more active, as suggested by national experts (38). Fourth, because children and adolescent spend a substantial proportion of their time at school, better school-based opportunities for physical activity participation may improve fitness levels. Two recent systematic reviews and meta-analyses have shown that school-based interventions, which include muscle and bone strengthening exercises at least 3 days per week as recommended by WHO guidelines, have benefitted muscular strength levels in children and adolescents (45,46). While such school-based interventions may be a challenge, successful models have been reported in European countries such as Slovenia, Spain, UK and Spain (31). New educational policies are needed to improve muscular strength in children and adolescents. Currently, as part of the Olympic Games legacy, a specific program (30 minutes of daily physical activity) is being developed in French elementary schools. Although no evaluation has been conducted yet, future studies should assess the impact of this national program on physical fitness. Evidence suggests that school-based interventions, such as quality PE and within-school sports, are key for promoting physical activity (47). Policies should aim to increase the number of PE hours and enhance teachers' knowledge of muscular fitness through continued professional development, as most currently focus on cardiorespiratory fitness. Lastly, reducing sedentary behaviours, particularly screen time, could also potentially improve muscular strength. A study using data from the

2012 National Health and Nutrition Examination Survey (NHANES) and the National Youth Fitness Survey (NNYFS) found an inverse association between the time spent in front of screens and muscular strength levels in U.S. youth (48). This concern is particularly worrying because sedentary behaviours have increased dramatically during the COVID-19 pandemic, with the rise in digital learning and recreational screen use (38).

Our study has several strengths. First, this study pooled objective raw data from several large studies to present the most comprehensive analysis of national temporal trends in muscular strength for French children and adolescents. Compared to previous studies, we extended the end of the temporal picture by 15 years from 2008 to 2023 to describe current trends and added new information on trends in distributional characteristics. In addition, our adjustment for BMI_z and the conversion of HGS and SBJ results to z-scores using sex-and-age-specific European norms, allowed us to adjust for the confounding effects of body size, sex, and age.

However, our study also presents some limitations. First, we pooled data from several studies that used different sampling methods (non-probability and probability sampling) and sampling frames (national or region). Second, although our sample size was large, not all regions of France were represented, with urban and rural groups not equally represented which may have limited the generalizability of our findings. While this could have biased our trends, our post-stratification population weighting procedure ensured that our trends were proportionate to the population size for each studied region. Nevertheless, some residual bias may persist. Third, we did not adjust our trends in muscular fitness for trends in other potential mechanistic factors such as physical activity levels, socioeconomic status, and biological maturation because such trend data were unavailable. Fourth, unfortunately the testing procedures for HGS (e.g., dynamometer used, number of trials, arm assessed) varied among studies, although they were consistent for SBJ performance. To improve data pooling and estimates of future trends in HGS, we recommend that test protocols be standardised among studies to improve data commensurability. We encourage French investigators (e.g., researchers, physicians, PE

teachers, exercise scientists) to follow the new Youth Fitness International Test (YFIT) protocol, which is a standard fitness test and reporting protocol for children and youth endorsed by international fitness experts (49). However, a UK study reported a poor understanding of muscular fitness among PE teachers (50). Developing an online continued professional development program for effective muscular fitness interventions has proven beneficial, but this area remains unexplored among French PE teachers and requires further investigation (51).

In summary, our study showed a negligible decline in mean SBJ and a negligible improvement in mean HGS for French youth between 1999 and 2023. Importantly, we also found that these trends were not uniform across the population distribution with data suggesting an increase over time in the gap between low and high performers. These results reinforce the importance of interventions and programs aiming at improving muscular fitness specifically in children and adolescents with low muscular strength, who are generally from low socioeconomic backgrounds or rural areas. Considering the robust and consistent evidence between muscular fitness and health outcomes, the importance of regularly monitoring children's muscular fitness levels to continuously track trends cannot be overlooked. We therefore strongly support and encourage the development of national monitoring systems among children and adolescents to comprehensively monitor health and fitness levels over time. Two actions are being developed in France. Santé Publique France, planned for launch, next year, annual assessments in a representative sample of the French population, including children and adults. Additionally, a national plan will soon be launched to establish a regular monitoring system for physical fitness among middle-school children, aiming to surveil health and assess the Olympic Games legacy.

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Data availability statement: Data sharing is not applicable to this article as the data are not publicly available due to privacy or ethical restrictions.

Author contributions: JV, JLL and GRT designed research; JV, JLL and GRT conducted research; JV, DM, FC, DM, HO, TD, JMO, GB SB and LB acquired physical fitness data; JLL and GRT analysed data and performed statistical analysis; JV, JLL and GRT wrote the paper; JV had primary responsibility for final content. All authors read and approved the final manuscript.

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Table 1. Descriptive data for participants included in our analysis according to year (n = 53,314)

	Year	Boys			Girls			
		n	Mean	SD	n	Mean	SD	
BMI z-score	1999	355	0.37	1.29	317	0.24	1.27	
	2000	23	0.60	1.25	31	0.51	1.36	
	2001	16	1.00	1.52	12	0.89	1.27	
	2002	13	0.91	1.59	14	0.48	1.11	
	2005	37	0.79	2.13	29	0.32	1.03	
	2006	16	-0.19	0.64	22	-0.18	0.77	
	2007	586	0.16	1.24	619	0.25	1.18	
	2008	47	0.09	0.98	57	-0.05	0.93	
	2009	307	0.43	1.03	355	0.27	0.96	
	2010	1803	0.45	1.31	1776	0.35	1.20	
	2011	1401	0.40	1.36	1298	0.31	1.28	
	2012	2107	0.51	1.40	2006	0.44	1.32	
	2013	3664	0.51	1.41	3520	0.45	1.25	
	2014	1836	0.54	1.37	1702	0.40	1.22	
	2015	1466	0.25	1.40	1452	0.22	1.22	
	2016	2184	0.32	1.43	2069	0.29	1.36	
	2017	984	0.09	1.49	976	0.15	1.35	
	2018	431	0.35	1.44	427	0.36	1.33	
	2021	1010	0.05	1.23	971	-0.06	1.19	
	2022	1583	0.49	1.59	1422	0.35	1.40	
	2023	5044	0.31	1.56	4596	0.24	1.34	
	Standing Broad Jump (cm)	1999	355	152.7	20.4	317	135.0	18.3
		2000	23	129.7	22.1	31	118.4	21.3
2001		16	128.8	14.1	12	113.5	17.3	
2002		13	125.3	11.7	14	111.4	12.9	
2005		37	130.4	20.1	29	122.8	17.7	
2006		16	137.8	13.9	22	138.1	18.5	
2007		586	162.9	28.0	619	146.8	26.0	
2008		47	133.4	16.5	57	124.8	15.2	
2009		307	146.5	17.2	355	136.5	18.7	
2010		1803	124.1	21.5	1776	112.9	20.2	
2011		1401	128.2	24.4	1298	116.6	21.3	
2012		2107	127.9	25.3	2006	116.8	23.8	
2013		3664	129.1	23.1	3520	117.3	21.2	
2014	1836	123.9	25.2	1702	113.2	22.5		
2015	1466	126.4	23.9	1452	117.2	22.5		
2016	2184	119.4	23.6	2069	110.6	22.0		
2017	984	123.5	23.9	976	112.1	21.9		
2018	431	131.7	22.4	427	119.3	20.6		
2021	1010	141.3	25.0	971	129.3	22.5		

	2022	1577	121.7	25.7	1418	108.4	24.1
	2023	4869	127.1	25.3	4458	117.0	23.7
Handgrip strength (kg)	1999	355	18.7	4.5	317	17.1	4.6
	2000	22	15.5	3.9	31	14.4	3.8
	2001	16	14.4	5.4	12	11.1	2.3
	2002	13	14.4	2.9	14	12.5	2.9
	2005	38	15.5	3.1	30	16.4	4.2
	2006	16	14.8	2.9	22	15.1	3.3
	2007	586	26.5	9.0	620	22.8	5.8
	2008	46	13.0	2.7	57	12.0	3.0
	2009	8	10.4	1.4	13	8.7	1.2
	2022	2550	19.4	5.2	2501	18.7	5.0

Table 2. Procedures for standing broad jump and handgrip strength of the included cross-sectional samples.

Cohort	Standing Broad Jump			Handgrip test						Investigator role
	Arm swing	Trials (n)	Scoring	Standing/seated	Bent/straight arm	Single-both arms	Trials per arm (n)	Scoring	Device	
Cohort 1	Yes	2	Maximum	Standing	Straight	Single (dominant)	1	Maximum	Takei digital	Researcher
Cohort 2	Yes	2	Maximum	Standing	Straight	Single (dominant)	1	Maximum	Takei digital	Researcher
Cohort 3	Yes	2	Maximum	Standing	Straight	Both	2	Maximum	Takei digital	Researcher
Cohort 4	Yes	2	Maximum	Not done						PE Teacher
Cohort 5		Not done		Standing	Straight	Both	2	Maximum	Camry digital	PE Teacher

Figure captions

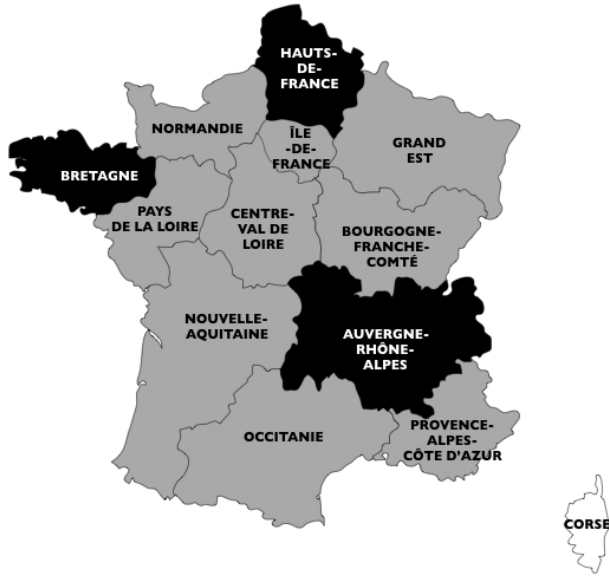
Figure 1. Available data for HGS and SBJ according to the administrative regions (both metropolitan and overseas) in France.




Figure 2. Number of participants by sex and muscular fitness test according to cohort.

Figure 3. Distributional trends (per decade) in handgrip strength and standing broad jump performance z-scores for French children aged 6–16 years between 1999 and 2023. Higher percentiles indicate better handgrip strength and standing broad jump performance and lower percentiles indicate poorer handgrip strength and standing broad jump performance. Higher trend values indicate smaller declines and lower trend values indicate larger declines. The solid lines are the LOWESS (LOcally Weighted Scatter-plot Smoother) curves (tension = 66), which represent the trends at various percentiles (range: 5th to 95th), with sloping lines indicating asymmetric trends and flat (horizontal) lines indicated symmetric trends.

Abbreviations: HGS = handgrip strength; SBJ = standing broad jump.

Metropolitan regions



-  HGS and SBj
-  Only SBj
-  No data available

Overseas regions



Figure 1.

	Total	Boys	Girls
SBJ	672	355	317
HGS	672	355	317

Cohort 1

	Total	Boys	Girls
SBJ	282	121	161
HGS	284	121	163

Cohort 3

	Total	Boys	Girls
SBJ	46,045	23,630	22,415
HGS			

Cohort 4

1999 2000 2007 2009 2022 2023

Cohort 2

	Total	Boys	Girls
SBJ	1262	629	636
HGS	1260	624	636

Cohort 5

	Total	Boys	Girls
SBJ			
HGS	5051	2550	2501

Figure 2.

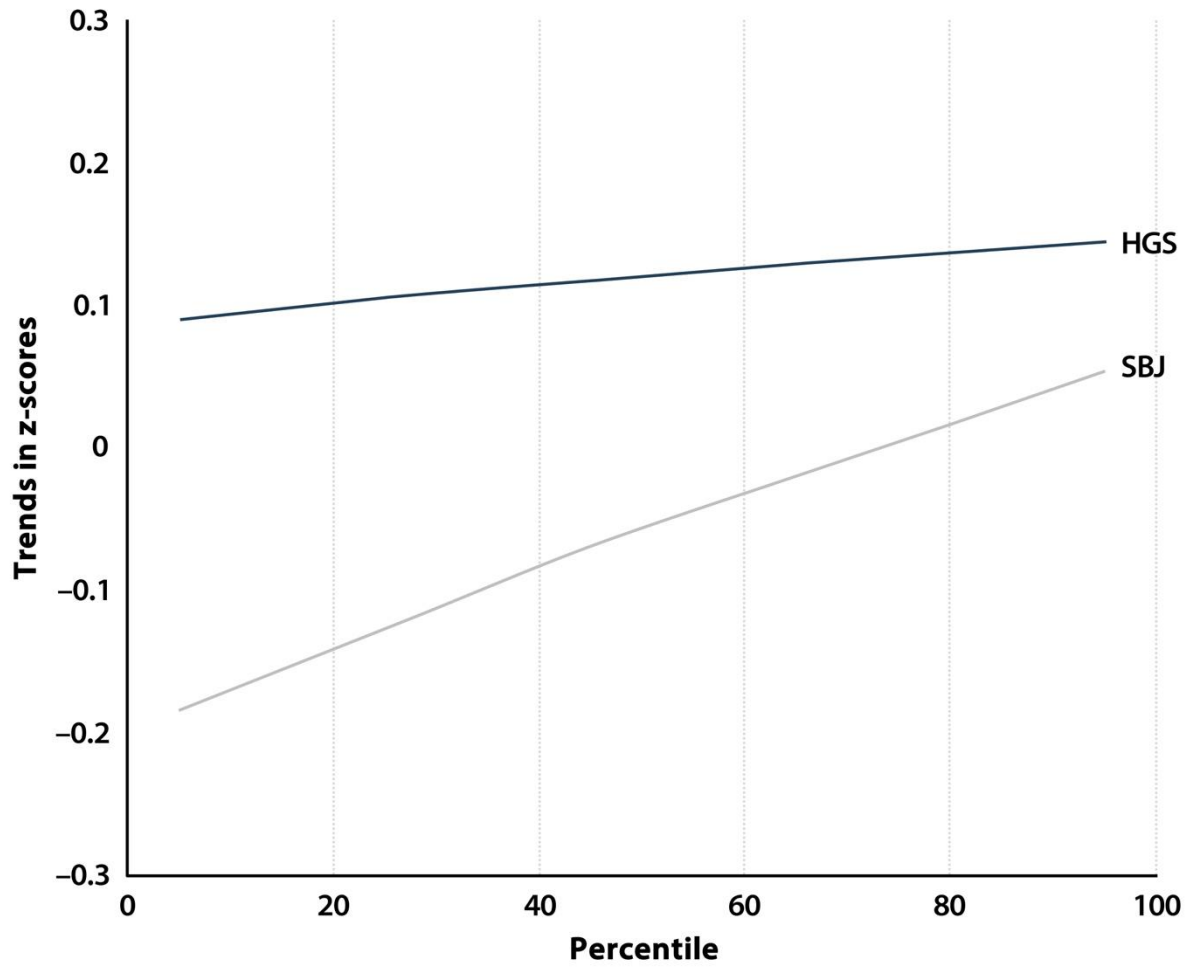


Figure 3.