



HAL
open science

Cardiorespiratory fitness has declined among French children since 1999, although the decline appears to be getting smaller

Jérémy Vanhelst, Justin Lang, David Matelot, François Carré, Daniel Mercier, Zékya Ulmer, Jean-michel Oppert, Georges Baquet, Serge Berthoin, Alicia Fillon, et al.

► To cite this version:

Jérémy Vanhelst, Justin Lang, David Matelot, François Carré, Daniel Mercier, et al.. Cardiorespiratory fitness has declined among French children since 1999, although the decline appears to be getting smaller. *Scandinavian Journal of Medicine and Science in Sports*, 2024, 34 (5), pp.e14641. 10.1111/sms.14641 . hal-04568076

HAL Id: hal-04568076

<https://hal.science/hal-04568076>

Submitted on 3 May 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Copyright

Cardiorespiratory fitness has declined among French children since 1999, although the decline appears to be getting smaller

Jérémy Vanhelst¹, Justin J Lang^{2,3,4}, David Matelot⁵, François Carré⁶, Daniel Mercier⁷, Zékya Ulmer⁸, Jean-Michel Oppert^{1,9}, Georges Baquet¹⁰, Serge Berthoin¹⁰, Alicia Fillon¹¹, Laurent Béghin¹², Grant R Tomkinson⁴.

¹Université Sorbonne Paris Nord and Université Paris Cité, INSERM, INRAE, CNAM, Center of Research in Epidemiology and Statistics (CRESS), Nutritional Epidemiology Research Team (EREN), F-93017 Bobigny, France.

²Centre for Surveillance and Applied Research, Public Health Agency of Canada, Ottawa, Ontario, Canada.

³School of Epidemiology and Public Health, Faculty of Medicine, University of Ottawa.

⁴Alliance for Research in Exercise, Nutrition and Activity (ARENA), University of South Australia, Adelaide, South Australia, Australia.

⁵Université de Bretagne Sud, Lorient, France.

⁶LTSI INSERM, U1099, University of Rennes 1, and Department of Sport Medicine, Pontchaillou Hospital, Rennes, France.

⁷Auxime, Lyon, France.

⁸Centre de ressources et de preuves dédié à la prévention de la perte d'autonomie, Direction des études et de la prospective, Caisse Nationale de la Solidarité pour l'Autonomie (CNSA), Paris, France.

⁹Sorbonne University, Department of Nutrition, Pitié-Salpêtrière Hospital (AP-HP), Human Nutrition Research Center Ile-de-France (CRNH IdF), Paris, France.

¹⁰Univ. Lille, Univ. Artois, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, F-59000 Lille, France.

¹¹Clermont Auvergne University, EA 3533, Laboratory of the Metabolic Adaptations to Exercise Under Physiological and Pathological Conditions (AME2P), CRNH Auvergne, Clermont-Ferrand, France; Observatoire National de l'Activité Physique et de la Sédentarité (ONAPS), Faculty of Medicine, Clermont Auvergne University, Clermont-Ferrand, France

¹²Univ. Lille, Inserm, CHU Lille, U1286 - INFINITE - Institute for Translational Research in Inflammation, and CIC 1403 – Clinical Investigation Center. F-59000 Lille, France.

Address correspondence to:

Jérémy Vanhelst

Equipe de Recherche en Epidémiologie Nutritionnelle (EREN)

UMR U1153 Inserm / U1125 Inrae / Cnam / Université Sorbonne Paris Nord

Centre de Recherche en Epidémiologie et Statistiques - Université Paris Cité (CRESS)

74 rue Marcel Cachin,

F-93017 Bobigny Cedex France

E-mail: jeremy.vanhelst@eren.smbh.univ-paris13.fr

ABSTRACT

Background: Cardiorespiratory fitness (CRF) is a strong marker of current and future health. The aim of this study was to assess the national temporal trends in CRF for French children and adolescents between 1999 and 2022.

Methods: CRF data were obtained from several cross-sectional studies on 15,420 (51.1% boys) French children and adolescents aged 9–16 years between 1999 and 2022. The 20-m shuttle run test (20mSRT) estimated CRF. Body mass index (BMI) was calculated from measured height and body mass, with BMI z-scores (BMIz) calculated using WHO growth curves. The 20mSRT results were corrected for protocol and converted to z-scores (20mSRTz) using international sex-and-age-specific norms. With additional adjustment for BMIz, temporal trends in mean 20mSRT performance (20mSRTz) were estimated using linear regression, with the distance max (D_{\max}) method used to locate a breakpoint and linear segments fitted to points below and above the breakpoint. Trends in distributional characteristics were assessed visually and described as the ratio of the coefficients of variation (CVs).

Results: After adjustment for protocol, age, sex and BMIz, a large decline in mean 20mSRT performance (trend per decade (95%CI): -1.42 SDs ($-1.45, -1.39$) or -18.4% (95%CI: $-18.8, -18.0$)) between 1999 and 2022 was found. D_{\max} located a breakpoint for the two-linear-segment model in year 2010. There was a large decline in mean 20mSRT performance pre-2010 (trend per decade (95%CI): -2.31 SDs ($-2.39, -2.24$)), which reduced 0.06-fold to a negligible decline post-2010 (trend per decade (95%CI): -0.15 SD ($-0.20, -0.10$)). We also found that the trend in mean 20mSRT performance was not uniform across the population distribution. Between 1999 and 2022, there was a small trend in distributional asymmetry, with slightly smaller declines experienced by the high performers (above the 75th percentile).

Conclusions: Our data suggest a large decline in the 20mSRT performance of French children and adolescents since 1999. This declining trend seems to have diminished considerably since 2010. Such declines in CRF could translate into declines in health status. Although a slowing in the declining trend in CRF in recent years is encouraging, more data are needed to confirm these findings.

Keywords: Aerobic fitness, 20-m shuttle run test, youth, trends.

INTRODUCTION

Robust and consistent evidence demonstrates that physical fitness is a key determinant of health in youth ¹. Attributes of physical fitness include cardiorespiratory fitness (CRF) also known as aerobic fitness or cardiorespiratory endurance, musculoskeletal fitness (muscular strength, power, endurance, and flexibility), motor fitness (agility, speed of movement, balance and coordination), and body composition/anthropometry (height, body mass, body mass index (BMI), and waist circumference) ^{1,2}. Among these, CRF is the most studied parameter with strong evidence of health-related associations ²⁻⁴. CRF can be assessed by laboratory tests (considered as the 'gold standard') or by field-based tests. Laboratory tests have limitations for monitoring and surveillance surveys because of their cost, the time needed, and the limited number of available laboratories with trained staff and testing equipment. Therefore, field-based tests are considered as an appropriate alternative for the assessment of CRF among children and adolescents especially in the school environment ⁴.

Different field-based fitness tests have been used to assess CRF among children and adolescents, including long-duration/distance running and endurance shuttle running tests ⁵. The most common among the latter is the 20-m shuttle run test (20mSRT) developed by Léger et al. ⁶. The 20mSRT allows an acceptable, feasible and scalable measure of CRF and functional/exercise capacity, which has moderate criterion validity and high-to-very high reliability, and is considered safe for youth ⁷. International and regional (European) sex- and age-specific 20mSRT performance norms for children and adolescents have been developed, and are widely used for health and fitness screening, profiling, monitoring, and surveillance ⁸⁻¹⁰.

Among youth, high 20mSRT is associated with better health, including reduced adiposity and better cardiometabolic health in later life ^{3,11}. However, fat mass may influence 20mSRT performance, as increased fat mass will decrease peak oxygen uptake (mL/kg/min) approximately on a pro rata basis ¹⁰, and confound associations between 20mSRT and health outcomes ¹². Because CRF is an important indicator of current and future health, temporal trends in CRF probably reflect corresponding trends in cardiovascular health and may provide insight into the effectiveness of public health recommendations and physical fitness/activity interventions and programmes ¹¹. Several meta-analyses have documented that children/adolescents CRF levels have declined in recent decades ^{13,14}. Tomkinson et al. found that CRF levels (20mSRT and long-duration/distance running performance) declined in over 25 million youth from 27 countries between 1970 and 2003 ¹⁵. In a follow-up meta-analysis using 20mSRT data on nearly 1 million youth from 19 countries from 1981 to 2014, Tomkinson et al. found the international decline in CRF had slowed and remained stable

since 2000¹⁴. Among countries analyzed, trends in CRF for French children were estimated in these meta-analyses, with the most recent report finding a moderate decline of 2.7 mL/kg/min (5.7%) per decade for 5763 children aged 9–14 years between 1985 and 2007¹⁴. While there is an increasing interest among policy makers and researchers to monitor CRF in French youth, current trend data (post-2007) and information related to recent trends among CRF changes in French children are lacking. Thus, the objective of this study was to update past research by calculating the most up-to-date trends in CRF among French children and adolescents aged 9–17 years.

METHODS

All studies detailed below were approved by the 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.

Participants

This study used raw data from several published or unpublished cross-sectional studies (n=5) of French children and adolescents tested from 1999 to 2022. Participants represented 13/18 administrative regions, including 11/13 metropolitan and 2/5 overseas French regions (Figure 1).

*** Figure 1 about here***

Data from 1999 to 2014 have been previously published^{16–19}. Data from cohort 5 (2022) are unpublished baseline data from a national intervention study. Characteristics of the included cross-sectional studies are presented in Table 1. These general population samples did not include special interest groups (e.g., children with clinically obesity), with eligibility criteria designed for broad participation. Data were pooled across studies and included only participants with a complete year of testing, age, sex, region, BMI, and 20mSRT data. From the total population of 19,970 children and adolescents in the French sample, complete data were available for 15,420 (77%) children and adolescents (7,882 (51%) boys, 7,538 (49%) girls) with a mean (SD) age of 12.0 (1.1) years (range: 9–16). Participant characteristics from five cohorts across time are reported in supplemental table (Table S1).

Table 1 about here

Table S1 about here

Measures

Cardiorespiratory fitness (CRF)

CRF was assessed by the 20mSRT⁶. Participants continuously ran between two lines 20-m apart, while keeping pace with audio signals emitted from a pre-recorded CD. The speed at the initial stage (minute) was 8.5 km/h, with speed increasing by 0.5 km/h each stage thereafter. Each test stage comprises numerous shuttles (laps) with children and adolescents instructed to run in a straight line, change direction at the end of each shuttle, and to maintain pace with the audio signals. Children and adolescents were instructed to run in a straight line, to pivot on completing a shuttle (lap), and to pace themselves in accordance with the audio signals. Participants were verbally encouraged to run as long as possible. The test finished when participants failed to reach the end line in time with the audio signals on two consecutive occasions. Otherwise, participants stopped when volitionally fatigued. The last completed half- or full-stage was recorded, with the speed corresponding to the last completed full stage calculated.

For the latest cohort (2022), CRF was assessed using the PREFIT (FITness testing in PREschool children)—an adapted 20mSRT²⁰. This test was designed for use in children aged 3–5 years and involves continuous running between two lines spaced 20-m apart. However, the pace of the audio signals differs to the 20mSRT, with the initial stage starting at 6.5 km/h and increasing by 0.5 km/h each minute. The speed at the last completed full stage was also retained. The PREFIT provides a feasible, reliable, and valid assessment of CRF among pre-schoolers aged 5-6 years^{21,22}.

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 curves²³.

Data treatment and statistical analysis

Because PREFIT running speeds at the last completed full stage systematically underestimate those from the 20mSRT, we increased PREFIT running speeds by 0.4 km/h as recommended by Mora-Gonzalez et al.²². To adjust for sex and age, 20mSRT speeds were converted to z-scores using previously published sex-and-age-specific international

norms (12). Trends in mean 20mSRT z-scores were calculated using SAS EG 7.1 (Cary, North Carolina, USA). General linear models (proc GLM) were used to assess trends, with the z-scores as the dependent variable and testing year as the independent variable. BMIz was added as a covariate. We calculated trends for the entire 1999–2022 period, and for sub-periods using two-linear-segment models. The D_{\max} method was used to locate a breakpoint between 1999 and 2022, with linear regressions fitted to points before and after the breakpoint ²⁴. All analyses were weighted using the regional population values for the year 2010 (<https://www.insee.fr/fr/information/2887348>). Trends were expressed as percent rates of change (i.e., the regression coefficient expressed as a percentage of the population weighted mean) and as standardized (Cohen's) effect sizes (ES) (i.e., the regression coefficient divided by the pooled SD). To interpret the magnitude of rates of change, ES of 0.2, 0.5, and 0.8 were used as thresholds for small, moderate, and large effects, respectively, with ES <0.2 considered to be negligible ²⁵. Positive rates of change indicated increases in mean 20mSRT performance and negative rates of change indicated declines in mean 20mSRT performance. We also conducted two sensitivity analyses to examine the influence of the 2022 cohort and the PREFIT running speed adjustment for the 2022 cohort.

Temporal trends in distributional characteristics were examined visually and as trends in the variability (the ratio of SDs) using the procedure described elsewhere ²⁶. Ratios >1.1 indicated substantial increases in variability (i.e., the magnitude of variability increased over time), ratios <0.9 indicated substantial declines in variability (i.e., the magnitude of variability declined over time), and ratios between 0.9 and 1.1 indicated negligible trends in variability (i.e., the magnitude of variability did not change substantially over time). Distributional trends were examined visually using LOWESS (LOcally WEighted Scatter-plot Smoother) curves (tension = 66) ²⁷, by plotting the trends in 20mSRT z-scores across a range of percentiles (range: 5th to 95th) ²⁸. LOWESS curves are model-free curves of best fit that are determined by the number of data points in each local area of the curve.

RESULTS

With adjustments for protocol, age, sex, and BMIz, we found a large decline in mean 20mSRT performance (trend per decade (95%CI): -1.42 SDs ($-1.45, -1.39$) or -18.4% (95%CI: $-18.8, -18.0$)) between 1999 and 2022 (Figure 2). D_{\max} analysis located a breakpoint for the two-linear-segment model in 2010. There was a large decline in mean 20mSRT performance pre-2010 (trend per decade (95%CI): -2.31 SDs ($-2.39, -2.24$)), which reduced 0.06-fold to a negligible decline post-2010 (trend per decade (95%CI): -0.15 SD ($-0.20, -0.10$)).

*** Figure 2 about here***

We found a negligible increase in the overall decline (trend per decade (95%CI): -1.61 SDs ($-1.64, -1.58$)) after removing the PREFIT running speed adjustment for the 2022 cohort. This was due to a small increase in the post-2010 decline (trend per decade (95%CI): -0.59 ($-0.64, -0.54$)). We also found a large per-decade decline of -2.31 SDs (95%CI: $-2.39, -2.24$) after removing the 2022 cohort from our trends analysis, which was identical to the observed pre-2010 decline.

The trend in mean 20mSRT performance was not always uniform across the population distribution. We found a negligible increase in distributional variability across the entire 1999 and 2022 period (ratio of SDs (95%CI): 1.07 ($1.02, 1.12$)). However, we found a substantial increase pre-2010 (ratio of SDs (95%CI): 1.40 ($1.32, 1.47$)), and no trend post-2010 (ratio of SDs (95%CI): 0.97 ($0.94, 1.00$)). Between 1999 and 2022, there was a small trend in distributional asymmetry, with slightly smaller declines experienced by the high performers (above the 75th percentile) (Figure 3). Pre-2010, we found that both ends of the distribution had moved away from the middle, with larger declines (differences >0.5 SDs per decade) in the low performers (below the 25th percentile) and smaller declines (differences >0.5 SDs per decade) in the high performers compared to the average performers (at the 50th percentile). The post-2010 trends were symmetric.

*** Figure 3 about here***

DISCUSSION

Our study focused on the national temporal trends in means and distributional characteristics of 20mSRT performance for French children and adolescents between 1999 and 2022. Our results suggest that there has been a substantial decline in CRF since 1999, which slowed considerably after 2010. We also found that the trends between children with low, moderate, and high CRF were not always uniform over time. Between 1999 and 2010, a larger decline was found in children with low CRF compared to those with high CRF, whereas post-2010, trends were similar across all children. These findings are important because declines in CRF are potentially an indication of declines in population health, as CRF is a strong marker and predictor of current and future health in children. Evaluating temporal trends in physical fitness, especially for CRF, may help identify sub-populations with low CRF, and therefore, in need of targeted primary prevention measures through physical activity and health promotion policies.

While previous studies have found rapid declines in CRF among French children and adolescents between 1980 and 2007, our study provides a timely update with data extending to 2022^{13,14}. Our finding of a slower decline in CRF post-2010 is similar to the previously described international trend where the decline slowed around 2000¹⁴. Results from our study showed that most of the pre-2010 decline was driven by the low fit youth dragging mean CRF values down. Similar results have been found in youth from other countries^{29–31} where declines in long-distance running performance were relatively larger for those with low CRF^{29–31}. This suggests that some factor has differentially affected sub-populations and that a more targeted preventive approach or early intervention should be considered for youth with low CRF. In contrast, we found a smaller, uniform decline in CRF after 2010, which suggests that over the past decade a generalized influence may have been at work. This may be important information for national health authorities and health professionals and provides opposing evidence to the belief that CRF has consistently declined in recent decades among all French youth. Indeed, the recent 0.06-fold reduction in the decline in CRF is encouraging for French youth because the large decline experienced in the first decade of the 21st century has slowed. Fitness-enhancing strategies are obviously required to further slow and possibly reverse this decline.

It has been argued that temporal trends in CRF are influenced by trends in a network of physiological, physical, behavioural, social, and environmental factors^{14,31}. Concerning the physical factors, trends in body size may have influenced trends in CRF. However, because our trends in CRF were adjusted for BMIz, which is strongly related to CRF, it is likely that the observed decline in CRF is due to trends in factors other than increased corpulence^{32–34}. The decline in BMIz-adjusted CRF is probably influenced by reduced physical activity levels^{14,15}. Using data from the Health Behaviour in School-aged Children (HBSC) World Health Organization (WHO) collaborative cross-national study, Guthold et al. found a small increase in the prevalence of insufficient physical activity (i.e., not achieving at least 60 minutes of moderate-to-vigorous physical activity everyday) among 11- to 15-year-old French youth from 86.2% in 2001 to 87.0% in 2016³⁵. Such trends are supported by the French Report Card on Physical Activity and Sedentary Behaviors in Children and Youth³⁶, which recently reported low and declining levels of overall physical activity and increased screen time between 2018 and 2022³⁶. While these trends in daily physical activity may have contributed to the decline in CRF among French youth, caution must be taken because such trends were self-reported. Another explanation could be a decline in motor skills. A recent study of Slovenian children found a decline in gross motor coordination between 1983 and 2014³⁷. Because the 20mSRT requires locomotor skills where children must change speed and direction, it is possible that declining motor skills may have influenced trends in CRF.

The promotion of physical activity, including sports, may help French youth develop the fitness habits for improving health now and in the future. First, research shows that youth who participate in organised sports have higher levels of physical fitness, including CRF, compared to their non-participating peers^{38,39}. In France, sport licenses between 2000 and 2022 have increased by 12%. If this increase is reflective of the past decade, then it may help explain the small decline in CRF since 2010⁴⁰. However, the 2022 French Report Card on Physical Activity and Sedentary Behaviors in Children and Youth reported a 4% decline in the number of French youth registered with a sporting club during to COVID-19 pandemic between 2019 and 2022³⁶. Current policy actions must be continued and improved to increase opportunities for access to (and participation in) sports clubs/associations. Second, increased active transportation (i.e., human powered travel like walking, cycling, skating, and scooting) to/from school may also benefit fitness. A systematic review of 68 studies found that higher levels of active transportation were related to higher CRF among youth⁴¹. In a Danish longitudinal study assessing the change in active transportation mode to/from school found that children who shifted to cycling were 9% more fit than their non-cycling counterparts⁴². For increased participation in active transportation, national experts have called for new and improved infrastructure and the prioritisation of strategies to improve safe engagement among youth³⁶. Third, because youth spend a substantial proportion of their time at school, better school-based opportunities for physical activity participation may improve fitness levels. A study comparing time spent in school found that a long school day was associated with higher levels of youth CRF compared to a short school day⁴³. This is because more time was spent being physically active and less time was spent being sedentary during a long school day⁴³. The ‘Structured Days Hypothesis’ suggests that youth fitness levels benefit from pre-planned, segmented, and adult-supervised environments^{44,45}. Educational policies aimed at developing/modifying the school environment (e.g., playground markings for physical activity zones) and increasing the availability of sports equipment increase daily PA and may improve youth CRF levels⁴⁶. Lastly, parental modelling is also a possible mechanism for child engagement in physical activity, but remains uncertain. Indeed, systematic review evidence indicates a weak positive association between relatives' physical activity engagement and youth physical activity levels, regardless of the age of the child, the gender of the parent-child dyad, and the type of physical activity⁴⁷.

This study pooled raw, objectively measured 20mSRT data from several large studies to estimate temporal trends in CRF for French youth. Compared to previous studies, we extended the end of the temporal picture by 15 years from 2007 to 2022 to describe the current trend and added new information on trends in distributional characteristics. Our

statistical adjustment for BMIz, correction of PREFIT results, and conversion of 20mSRT results to z-scores using sex-and-age-specific international norms controlled for the confounding effects of body size, sex, age, and protocol. However, our study also presents some limitations. First, we pooled data from five studies that used different sampling methods (non-probability and probability sampling), sampling frames (national or region). Second, although the present data represent a large sample of French administrative regions (72% of French territory), 5/18 regions were not represented. While including these regions may have led to different results, we did at least weight our trends using a post-stratification population weighting procedure to ensure that our trends were proportionate to the population size for each studied region. Third, it is possible that variations in weather (such as wind, rain, and sunshine) and seasonal conditions, which were not recorded, may have increased the variability of 20mSRT results. However, without evidence of trends in such conditions, it is challenging to estimate the impact on these trends in conditions in youth CRF. Fourth, while the 20mSRT is a true indicator of CRF because peak oxygen uptake is achieved at the end of a maximal performance⁴⁸, no concurrent physiological (e.g., heart rate) or perceptual (e.g., rating of perceived exertion) data were recorded with which to confirm maximal effort. Fifth, while we adjusted trends in CRF for body size, we were unable to adjust for trends in other potential mechanistic factors such as physical activity levels and biological maturation. Sixth, because trends in 20mSRT performance may be influenced by trends in fat mass, we statistically adjusted our trends in CRF for BMI z-scores although it is acknowledged that BMI z-scores may not have fully removed the effect of adiposity on 20mSRT performance. Seventh, the most recent cohort included in our study assessed CRF using the PREFIT protocol, originally designed for preschool children^{20,21}. Because most participants—particularly among the older kids—complete several stages, the differences in the early stages between the original 20mSRT and PREFIT protocols probably largely serve as a warm-up. While we statistically adjusted PREFIT running speeds as recommended by Mora-Gonzalez and colleagues²², our two sensitivity analyses indicated that the inclusion of the 2022 cohort and the PREFIT running speed adjustment had only a small influence on our overall findings. To improve data pooling and estimates of trends in youth CRF, we recommend that test protocols and weather/seasonal conditions be harmonized among studies to improve data commensurability. We encourage French investigators (e.g., researchers, physicians, PE teachers, exercise scientists) to follow previous expert recommendations for the assessment of 20mSRT to facilitate future data pooling efforts^{7,10}.

CONCLUSION

In conclusion, we found a large BMI-adjusted decline in 20mSRT performance for French youth since 1999, a decline which appears to have slowed since 2010. We also found that

this decline was not uniform across the population distribution, and that the larger pre-2010 decline was probably driven by youth with low CRF dragging mean values down. Although the recent slowing of the decline is potentially encouraging, additional data are needed to confirm whether this is temporary or permanent. Indeed, CRF data for French youth are currently scarce. However, with the 2024 Paris Olympic Games around the corner, there is an increased interest among policy makers to promote the increase of physical activity and decrease of sedentary behaviors among schoolchildren and to assess their physical fitness levels. We therefore strongly support the national plan to be launched in September 2024 to develop a regular monitoring system for physical fitness among middle school children to surveil health and to assess the Olympic Games legacy ⁴³.

REFERENCES

1. Ortega FB, Ruiz JR, Castillo MJ, Sjöström M. Physical fitness in childhood and adolescence: a powerful marker of health. *Int J Obes (Lond)* 2008;32:1–11.
2. Ruiz JR, Castro-Piñero J, Artero EG, Ortega FB, Sjöström M, Suni J, Castillo MJ. Predictive validity of health-related fitness in youth: a systematic review. *Br J Sports Med* 2009;43:909–923.
3. Lang JJ, Belanger K, Poitras V, Janssen I, Tomkinson GR, Tremblay MS. Systematic review of the relationship between 20m shuttle run performance and health indicators among children and youth. *J Sci Med Sport* 2018;21:383–397.
4. Lang JJ, Tomkinson GR, Janssen I, Ruiz JR, Ortega FB, Léger L, Tremblay MS. Making a Case for Cardiorespiratory Fitness Surveillance Among Children and Youth. *Exerc Sport Sci Rev* 2018;46:66–75.
5. Ruiz J, Castro-Piñero J, Vanesa ER, Artero E, Ortega F, Cuenca M, Jiménez-Pavón D, Chillón P, Girela-Rejón M, Mora J, Gutiérrez A, Suni J, Sjoström M, Castillo M. Field-based fitness assessment in young people: The ALPHA health-related fitness test battery for children and adolescents. *British journal of sports medicine* 2010;45:518–24.
6. Léger LA, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. *J Sports Sci* 1988;6:93–101.
7. Tomkinson GR, Lang JJ, Blanchard J, Léger LA, Tremblay MS. The 20-m Shuttle Run: Assessment and Interpretation of Data in Relation to Youth Aerobic Fitness and Health. *Pediatr Exerc Sci* 2019;31:152–163.
8. Ortega FB, Leskošek B, Blagus R, Gil-Cosano JJ, Mäestu J, Tomkinson GR, Ruiz JR, Mäestu E, Starc G, Milanovic I, Tammelin TH, Sorić M, Scheuer C, Carraro A, Kaj M, Csányi T, Sardinha LB, Lenoir M, Emeljanovas A, Mieziene B, Sidossis LS, Pihu M, Lovecchio N, Konstabel K, Tambalis KD, Štefan L, Drenowatz C, Rubín L, Gontarev S, Castro-Piñero J, Vanhelst J, O’Keeffe B, Veiga OL, Gisladottir T, Sandercock G, Misigoj-Durakovic M, Niessner C, Riso EM, Popovic S, Kuu S, Chinapaw M, Clavel I, Labayen I, Dobosz J, Colella D, Kriemler S, Salaj S, Noriega MJ, Bös K, Sánchez-López M, Lakka TA, Tabacchi G, Novak D, Ahrens W, Wedderkopp N, Jurak G, FitBack, HELENA and IDEFICS consortia. European fitness landscape for children and adolescents: updated reference values, fitness maps and country rankings based on nearly 8 million test results from 34 countries gathered by the FitBack network. *Br J Sports Med* 2023;bjsports-2022-106176.
9. Tomkinson GR, Carver KD, Atkinson F, Daniell ND, Lewis LK, Fitzgerald JS, Lang JJ, Ortega FB. European normative values for physical fitness in children and adolescents aged 9–17 years: results from 2 779 165 Eurofit performances representing 30 countries. *Br J Sports Med* 2018;52:1445–1456.
10. Tomkinson GR, Lang JJ, Tremblay MS, Dale M, LeBlanc AG, Belanger K, Ortega FB, Léger L. International normative 20 m shuttle run values from 1 142 026 children and youth representing 50 countries. *Br J Sports Med* 2017;51:1545–1554.
11. García-Hermoso A, Ramírez-Vélez R, García-Alonso Y, Alonso-Martínez AM, Izquierdo M. Association of Cardiorespiratory Fitness Levels During Youth With Health Risk Later in Life: A Systematic Review and Meta-analysis. *JAMA Pediatr* 2020;174:952–960.

12. Haapala EA, Kuronen E, Ihalainen JK, Lintu N, Leppänen MH, Tompuri T, Atalay M, Schwab U, Lakka TA. Cross-sectional associations between physical fitness and biomarkers of inflammation in children—The PANIC study. *Scandinavian Journal of Medicine & Science in Sports* 2023;33:1000–1009.
13. Tomkinson G, Léger L, Olds T, Cazorla G. Secular Trends in the Performance of Children and Adolescents (1980–2000). *Sports Medicine* 2003;33:.
14. Tomkinson GR, Lang JJ, Tremblay MS. Temporal trends in the cardiorespiratory fitness of children and adolescents representing 19 high-income and upper middle-income countries between 1981 and 2014. *Br J Sports Med* 2019;53:478–486.
15. Tomkinson GR, Olds TS. Secular changes in pediatric aerobic fitness test performance: the global picture. *Med Sport Sci* 2007;50:46–66.
16. Baquet G, Berthoin S, Gerbeaux M, Van Praagh E. High-intensity aerobic training during a 10 week one-hour physical education cycle: effects on physical fitness of adolescents aged 11 to 16. *Int J Sports Med* 2001;22:295–300.
17. Baquet G, Twisk JWR, Kemper HCG, Van Praagh E, Berthoin S. Longitudinal follow-up of fitness during childhood: interaction with physical activity. *Am J Hum Biol* 2006;18:51–58.
18. Ortega FB, Artero EG, Ruiz JR, España-Romero V, Jiménez-Pavón D, Vicente-Rodríguez G, Moreno LA, Manios Y, Béghin L, Ottevaere C, Ciarapica D, Sarri K, Dietrich S, Blair SN, Kersting M, Molnar D, González-Gross M, Gutiérrez A, Sjöström M, Castillo MJ, HELENA study. Physical fitness levels among European adolescents: the HELENA study. *Br J Sports Med* 2011;45:20–29.
19. Vanhelst J, Labreuche J, Béghin L, Drumez E, Fardy PS, Chapelot D, Mikulovic J, Ulmer Z. Physical Fitness Reference Standards in French Youth: The BOUGE Program. *J Strength Cond Res* 2017;31:1709–1718.
20. Ortega FB, Cadenas-Sánchez C, Sánchez-Delgado G, Mora-González J, Martínez-Téllez B, Artero EG, Castro-Piñero J, Labayen I, Chillón P, Löff M, Ruiz JR. Systematic review and proposal of a field-based physical fitness-test battery in preschool children: the PREFIT battery. *Sports Med* 2015;45:533–555.
21. Cadenas-Sanchez C, Martinez-Tellez B, Sanchez-Delgado G, Mora-Gonzalez J, Castro-Piñero J, Löff M, Ruiz JR, Ortega FB. Assessing physical fitness in preschool children: Feasibility, reliability and practical recommendations for the PREFIT battery. *Journal of Science and Medicine in Sport* 2016;19:910–915.
22. Mora-Gonzalez J, Cadenas-Sanchez C, Martinez-Tellez B, Sanchez-Delgado G, Ruiz JR, Léger L, Ortega FB. Estimating VO₂max in children aged 5–6 years through the preschool-adapted 20-m shuttle-run test (PREFIT). *Eur J Appl Physiol* 2017;117:2295–2307.
23. World Health Organization. Body mass index-for-age (BMI-for-age). <https://www.who.int/toolkits/child-growth-standards/standards/body-mass-index-for-age-bmi-for-age>. Accessed February 15, 2024.
24. Tomkinson GR, Kidokoro T, Dufner TJ, Noi S, Fitzgerald JS, Brown-Borg HM. Temporal trends in 6-minute walking distance for older Japanese adults between 1998 and 2017. *J Sport Health Sci* 2021;10:462–469.

25. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. New York: Routledge; 1988. 567 p.
26. Tomkinson GR, Kidokoro T, Dufner T, Noi S, Fitzgerald JS, Mcgrath RP. Temporal trends in handgrip strength for older Japanese adults between 1998 and 2017. *Age Ageing* 2020;49:634–639.
27. Cleveland WS, Devlin SJ. Locally Weighted Regression: An Approach to Regression Analysis by Local Fitting. *Journal of the American Statistical Association* 1988;83:596–610.
28. Liu Y, Tremblay MS, Tomkinson GR. Temporal trends in step test performance for Chinese adults between 2000 and 2014. *J Exerc Sci Fit* 2021;19:216–222.
29. Albon HM, Hamlin MJ, Ross JJ. Secular trends and distributional changes in health and fitness performance variables of 10–14-year-old children in New Zealand between 1991 and 2003. *British Journal of Sports Medicine* 2010;44:263–269.
30. Dollman J, Olds T, Norton K, Stuart D. The Evolution of Fitness and Fatness in 10–11-Year-Old Australian Schoolchildren: Changes in Distributional Characteristics between 1985 and 1997. *Pediatric Exercise Science* 1999;11:108–121.
31. Lovecchio N, Vandoni M, Codella R, Rovida A, Carnevale Pellino V, Giuriato M, Klug MG, Tomkinson GR. Trends in means and distributional characteristics of cardiorespiratory endurance performance for Italian children (1984-2010). *J Sports Sci* 2023;1–7.
32. Vanhelst J, Baudalet JB, Thivel D, Ovigneur H, Deschamps T. French youth trends in prevalence of overweight, obesity and underweight from 2008 to 2018. *BMC Res Notes* 2022;15:208.
33. Malina RM. Physical activity and fitness: pathways from childhood to adulthood. *Am J Hum Biol* 2001;13:162–172.
34. Ruiz JR, Rizzo NS, Hurtig-Wennlöf A, Ortega FB, Wärnberg J, Sjöström M. Relations of total physical activity and intensity to fitness and fatness in children: the European Youth Heart Study. *Am J Clin Nutr* 2006;84:299–303.
35. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1.6 million participants. *Lancet Child Adolesc Health* 2020;4:23–35.
36. Fillon A, Vanhelst J, Genin P, Larras B, Tardieu M, Porcherie M, Luiggi M, Aubert S, Verdot C, Rey O, Lhuisset L, Bois JE, Millet GY, Duclos M, Thivel D. 2022 French Report Card on Physical Activity and Sedentary Behaviors in Children and Youth: From Continuous Alarming Conclusions to Encouraging Initiatives. *J Phys Act Health* 2023;1–10.
37. Sember V, Đurić S, Starc G, Leskošek B, Sorić M, Kovač M, Jurak G. Secular trends in skill-related physical fitness among Slovenian children and adolescents from 1983 to 2014. *Scand J Med Sci Sports* 2023;33:2323–2339.
38. Riso EM, Toplaan L, Viira P, Vaiksaar S, Jürimäe J. Physical fitness and physical activity of 6-7-year-old children according to weight status and sports participation. *PLoS One* 2019;14:e0218901.

39. Barbry A, Carton A, Ovigneur H, Coquart J. Relationships between sports club participation and physical fitness and Body Mass Index in childhood. *J Sports Med Phys Fitness* 2022;62:931–937.
40. Les licences annuelles des fédérations sportives en 2022 - INJEP - Clément Anne, chargé d'études statistiques, INJEP. INJEP.
41. Larouche R, Saunders TJ, Faulkner GEJ, Colley R, Tremblay M. Associations between active school transport and physical activity, body composition, and cardiovascular fitness: a systematic review of 68 studies. *J Phys Act Health* 2014;11:206–227.
42. Cooper AR, Wedderkopp N, Jago R, Kristensen PL, Moller NC, Froberg K, Page AS, Andersen LB. Longitudinal associations of cycling to school with adolescent fitness. *Prev Med* 2008;47:324–328.
43. Vanhelst J, Béghin L, Drumez E, Casajus JA, De Henauw S, Widhalm K, Molina C, Karaglani E, Gottrand F. School time is associated with cardiorespiratory fitness in adolescents: The HELENA study. *J Sports Sci* 2021;39:2068–2072.
44. Olds T, Dumuid D, Eglitis E, Golley R, Fraysse F, Miatke A, Tomkinson GR, Watson A, Munzberg M, Maher C. Changes in fitness and fatness in Australian schoolchildren during the summer holidays: fitness lost, fatness regained? A cohort study. *BMC Public Health* 2023;23:2094.
45. Weaver RG, Hunt E, Rafferty A, Beets MW, Brazendale K, Turner-McGrievy G, Pate RR, Maydeu-Olivares A, Saelens B, Youngstedt S. The potential of a year-round school calendar for maintaining children's weight status and fitness: Preliminary outcomes from a natural experiment. *J Sport Health Sci* 2020;9:18–27.
46. Baquet G, Aucouturier J, Gamelin FX, Berthoin S. Longitudinal Follow-Up of Physical Activity During School Recess: Impact of Playground Markings. *Front Public Health* 2018;6:283.
47. Petersen TL, Møller LB, Brønd JC, Jepsen R, Grøntved A. Association between parent and child physical activity: a systematic review. *Int J Behav Nutr Phys Act* 2020;17:67.
48. Ruiz JR, Silva G, Oliveira N, Ribeiro JC, Oliveira JF, Mota J. Criterion-related validity of the 20-m shuttle run test in youths aged 13-19 years. *J Sports Sci* 2009;27:899–906.
49. Lang JJ, Zhang K, Agostinis-Sobrinho C, Andersen LB, Basterfield L, Berglind D, Blain DO, Cadenas-Sanchez C, Cameron C, Carson V, Colley RC, Csányi T, Faigenbaum AD, García-Hermoso A, Gomes TNQF, Gribbon A, Janssen I, Jurak G, Kaj M, Kidokoro T, Lane KN, Liu Y, Löf M, Lubans DR, Magnussen CG, Manyanga T, McGrath R, Mota J, Olds T, Onywera VO, Ortega FB, Oyeyemi AL, Prince SA, Ramírez-Vélez R, Roberts KC, Rubín L, Servais J, Silva DAS, Silva DR, Smith JJ, Song Y, Stratton G, Timmons BW, Tomkinson GR, Tremblay MS, Wong SHS, Fraser BJ. Top 10 International Priorities for Physical Fitness Research and Surveillance Among Children and Adolescents: A Twin-Panel Delphi Study. *Sports Med* 2023;53:549–564.

Table 1. Participants characteristics studied according to year (n = 15,420)

Cohort	Year	N	Age (years)	Mass (kg)	Height (cm)	BMI z-score	Speed at last completed stage (km/h)
<i>Total</i>							
A	1999	679	11.4 (0.6)	41.6 (10.0)	148.4 (7.6)	0.3 (1.3)	12.9 (0.5)
B	2000	43	10.0 (0.6)	37.1 (8.9)	141.9 (6.7)	0.5 (1.3)	12.9 (0.5)
B	2001	15	9.7 (0.5)	41.1 (14.1)	143.1 (9.1)	1.1 (1.4)	12.7 (0.5)
B	2002	11	9.8 (0.5)	34.6 (11.7)	136.2 (6.6)	0.5 (1.5)	12.6 (0.5)
B	2005	69	11.0 (0.7)	36.5 (8.6)	140.1 (8.7)	0.4 (1.0)	12.9 (0.4)
B	2006	34	11.0 (0.8)	31.1 (5.3)	135.2 (7.2)	-0.2 (0.7)	12.8 (0.6)
B, C	2007	1149	13.2 (1.4)	50.0 (12.7)	158.1 (10.3)	0.2 (1.2)	12.7 (1.2)
B	2008	6	9.4 (0.3)	25.6 (4.7)	129.9 (9.2)	-0.8 (0.7)	12.9 (0.5)
B, D	2009	1821	12.2 (0.9)	45.2 (10.6)	153.2 (8.8)	0.2 (1.2)	10.7 (1.2)
D	2010	1676	11.9 (1.0)	43.9 (10.6)	151.6 (8.9)	0.3 (1.2)	10.7 (1.2)
D	2011	2307	12.4 (1.0)	45.6 (11.5)	153.4 (9.2)	0.2 (1.2)	10.7 (1.2)
D	2012	1984	12.3 (1.0)	46.0 (11.3)	153.3 (8.7)	0.3 (1.2)	10.6 (1.4)
D	2013	1189	12.1 (1.1)	44.5 (12.5)	151.4 (9.6)	0.3 (1.3)	10.4 (1.1)
D	2014	23	12.6 (0.5)	45.9 (10.3)	155.7 (8.6)	0.0 (1.2)	11.3 (1.0)
E	2022	4414	11.2 (0.4)	38.4 (8.2)	147.8 (7.5)	-0.1 (1.2)	10.3 (1.1)
<i>Boys</i>							
A	1999	359	11.5 (0.6)	41.2 (9.5)	148.0 (7.3)	0.4 (1.3)	13.1 (0.5)
B	2000	20	10.0 (0.7)	37.5 (7.9)	143.2 (6.4)	0.6 (1.3)	13.1 (0.5)
B	2001	11	9.8 (0.5)	43.6 (15.7)	144.5 (10.1)	1.4 (1.5)	12.7 (0.6)
B	2002	6	9.8 (0.4)	37.2 (15.3)	135.7 (8.0)	0.9 (1.9)	12.5 (0.4)
B	2005	38	11.0 (0.8)	36.1 (8.4)	139.4 (8.6)	0.5 (1.1)	13.1 (0.4)
B	2006	13	11.1 (0.8)	30.2 (4.3)	134.2 (4.7)	-0.2 (0.7)	13.0 (0.4)
B, C	2007	565	13.2 (1.4)	49.6 (13.3)	159.0 (11.6)	0.1 (1.2)	13.1 (0.9)
B	2008	3	9.4 (0.4)	26.9 (4.4)	133.2 (10.4)	-0.7 (0.1)	13.3 (0.3)
B, D	2009	897	12.3 (0.9)	45.1 (10.7)	152.8 (9.0)	0.4 (1.2)	11.1 (1.2)
D	2010	811	11.8 (1.0)	42.9 (10.7)	150.5 (9.0)	0.3 (1.2)	11.0 (1.3)
D	2011	1172	12.5 (1.1)	45.9 (12.2)	153.4 (9.8)	0.3 (1.3)	11.0 (1.3)
D	2012	1017	12.4 (1.0)	46.1 (12.2)	153.4 (9.5)	0.4 (1.3)	11.0 (1.4)
D	2013	594	12.1 (1.1)	44.5 (12.4)	151.1 (10.1)	0.4 (1.3)	10.7 (1.2)
D	2014	13	12.6 (0.5)	42.7 (10.1)	153.8 (10.3)	-0.3 (1.2)	11.7 (0.8)
E	2022	2363	11.2 (0.4)	38.3 (8.1)	147.4 (7.4)	-0.0 (1.3)	10.5 (1.1)
<i>Girls</i>							
A	1999	320	11.4 (0.6)	42.2 (10.6)	148.8 (7.8)	0.3 (1.3)	12.7 (0.4)
B	2000	23	9.9 (0.6)	36.7 (9.8)	140.8 (6.9)	0.4 (1.3)	12.7 (0.4)
B	2001	4	9.4 (0.1)	34.2 (3.7)	139.5 (5.1)	0.5 (1.2)	12.6 (0.5)
B	2002	5	9.8 (0.7)	31.5 (4.8)	136.8 (5.4)	0.1 (0.8)	12.8 (0.4)
B	2005	31	11.0 (0.6)	37.0 (8.8)	141.0 (8.9)	0.3 (1.0)	12.8 (0.4)
B	2006	21	11.0 (0.8)	31.6 (5.9)	135.9 (8.5)	-0.2 (0.7)	12.7 (0.7)
B, C	2007	584	13.2 (1.4)	50.4 (12.0)	157.3 (8.7)	0.2 (1.2)	12.3 (1.3)
B	2008	3	9.4 (0.3)	24.3 (5.6)	126.7 (8.4)	-0.8 (1.1)	12.5 (0.0)
B, D	2009	924	12.2 (0.9)	45.2 (10.5)	153.7 (8.5)	0.1 (1.1)	10.4 (1.0)
D	2010	865	11.9 (0.9)	44.8 (10.3)	152.7 (8.5)	0.2 (1.2)	10.3 (1.1)
D	2011	1135	12.4 (1.0)	45.3 (10.7)	153.4 (8.6)	0.1 (1.1)	10.4 (1.1)
D	2012	967	12.3 (0.9)	45.8 (10.3)	153.2 (7.8)	0.2 (1.1)	10.3 (1.2)
D	2013	595	12.1 (1.0)	44.5 (12.6)	151.8 (9.1)	0.1 (1.3)	10.0 (0.9)
D	2014	10	12.6 (0.4)	50.1 (9.3)	158.1 (5.3)	0.4 (1.2)	10.7 (0.9)
E	2022	2051	11.2 (0.4)	38.5 (8.4)	148.2 (7.6)	-0.2 (1.2)	10.0 (0.9)

Notes: PREFIT speeds (Cohort E, 2022) were corrected as recommended by Mora-Gonzalez et al.²². A = Baquet Study 1; B = Baquet Study 2; C = HELENA Study; D = BOUGE Study; E = Inversons les courbes.

Figure captions

Figure 1. Data available according to the administrative regions (metropolitan and overseas) in France.

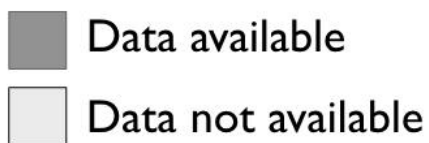
Figure 2. Scatterplot of the 20-m shuttle run test (20mSRT) z-scores for 15,420 French children aged 9–16 years between 1999 and 2022.

Notes: Higher z-scores indicate better 20mSRT performance and lower z-scores indicate poorer 20mSRT performance. Each open circle represents a single sex-age-year-specific z-score.

Figure 3. Distributional trends (per decade) in 20-m shuttle run test (20mSRT) z-scores for French children aged 9–16 years between 1999 and 2022.

Notes: Distributional trends (per decade) are separately shown for the periods 1999–2022, pre-2010 (1999–2010), and post-2010 (2011–2022). Higher percentiles indicate better 20mSRT performance and lower percentiles indicate poorer 20mSRT 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 (i.e., lines that slope upwards from the bottom left to the top right indicate smaller declines in those with high performance) and flat (horizontal) lines indicated symmetric trends (i.e., uniform trends across the percentiles or children with different 20mSRT performance levels).

Metropolitan regions



Overseas regions

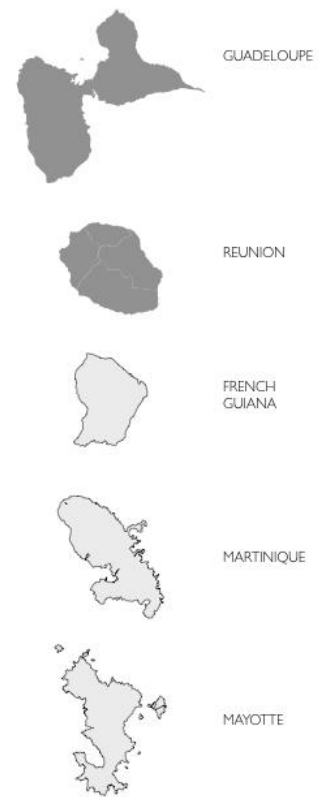


Figure 1

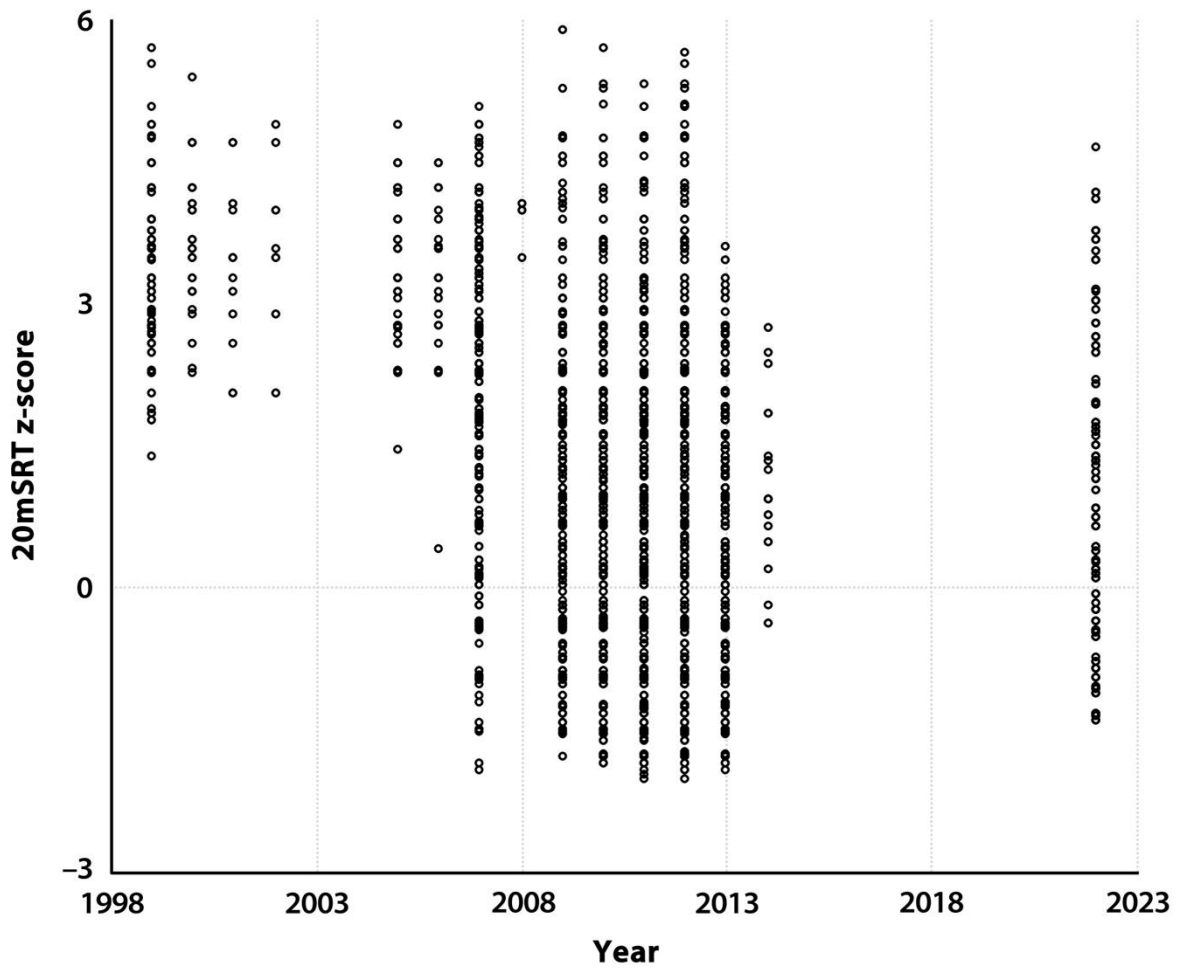


Figure 2

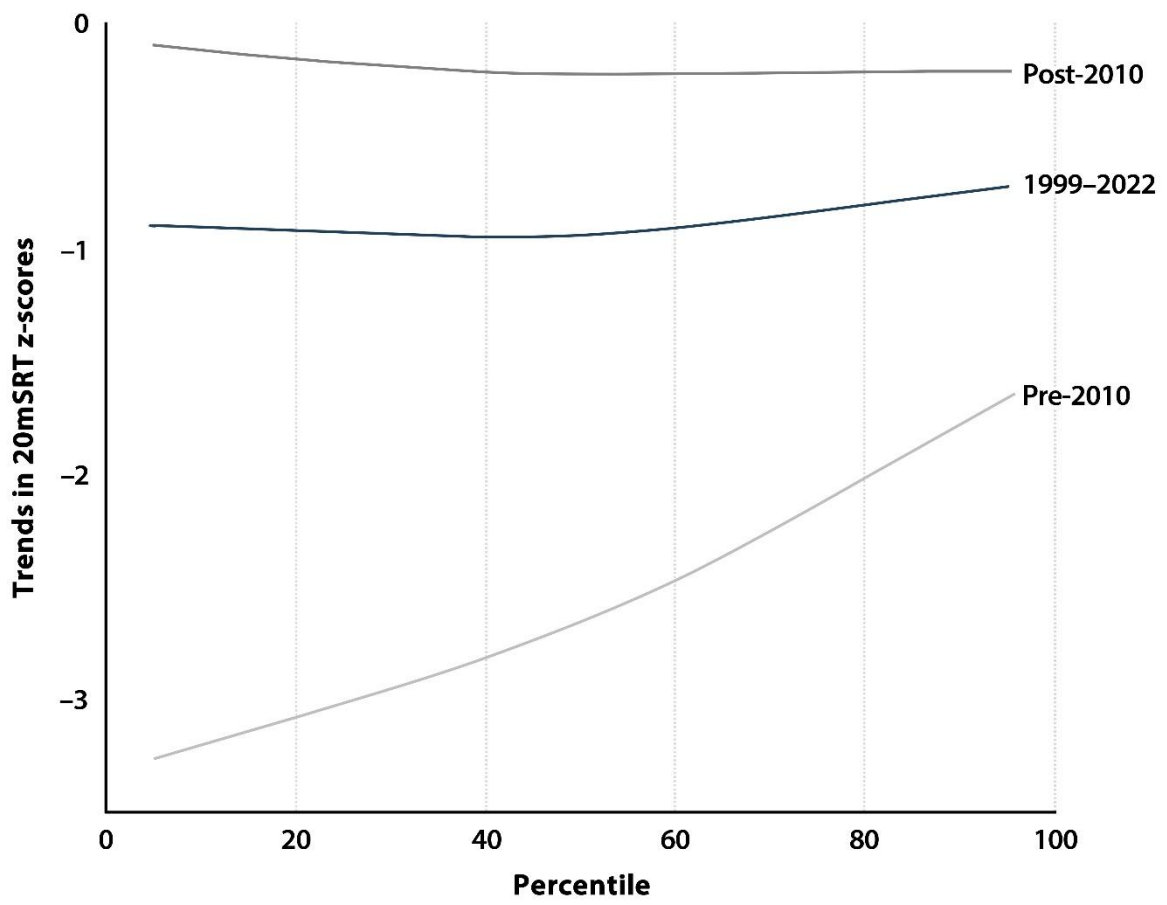


Figure 3