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# Changes in Catalan Adolescents' Agility over Two Decades: A Temporal Trend Study

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**Abstract:** Physical fitness is considered an important indicator of health in adolescents. Despite the recognized benefits of regular physical activity, recent studies indicate a decline in physical fitness among adolescents, including agility, a key component of fitness often overlooked in research. This study aimed to investigate trends in agility among urban Catalan adolescents over two decades. A total of 1439 students, aged 13–15 years, participated in the 8 × 10 m shuttle run test between 2002 and 2022. The results revealed a significant decline in agility performance across both boys ($F_{(3,839)} = 392$, $p < 0.001$, $\eta_p^2 = 0.584$) and girls ($F_{(3,593)} = 414$, $p < 0.001$, $\eta_p^2 = 0.677$) over time, with notable differences observed between consecutive five-year periods. The findings underscore the urgency of addressing declining physical fitness among adolescents and advocate for enhanced physical education programs and community-based interventions to promote regular physical activity. Recognizing the importance of agility and other aspects of physical fitness in adolescent health, policymakers, educators, and healthcare professionals are urged to collaborate on initiatives to mitigate the risk of future health issues. Further research is recommended to explore the multifaceted influences on adolescent physical fitness and develop targeted interventions to improve overall health outcomes in this population.

**Keywords:** adolescents' health; urban health; physical activity; adolescents' habits; trends

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**Citation:** Arboix-Alió, J.; Peralta-Geis, M.; Morales, J.; Moragas, M.; Buscà, B.; Solà, J. Changes in Catalan Adolescents' Agility over Two Decades: A Temporal Trend Study. *Appl. Sci.* **2024**, *14*, 8290. https://doi.org/10.3390/app14188290

Academic Editors: Nikolaos Zaras and Marios Hadjicharalambous

Received: 27 June 2024
Revised: 5 September 2024
Accepted: 13 September 2024
Published: 14 September 2024



## 1. Introduction

Physical fitness encompasses a collection of measurable attributes associated with the capacity to engage in physical activity, serving as a significant indicator of overall health [1]. It can be conceptualized as a comprehensive measure of several body functions, including skeletal–muscular, cardiorespiratory, circulatory, psychoneurological, and endocrine–metabolic systems, all of which are crucial for daily physical exertion [2]. Furthermore, regular physical activity yields numerous health benefits, positively impacting aspects such as self-esteem and social relationships [2–5]. Consequently, physical fitness closely correlates with overall health, as individuals with higher fitness levels generally exhibit better health statuses [6,7].

Adolescence, spanning ages 11 to 19 according to the World Health Organization (WHO) (with early adolescence from 11 to 13 years, middle adolescence from 14 to 16 years, and late adolescence from 17 to 19 years), represents a pivotal period for cultivating healthy lifestyle habits, including engagement in physical activity during leisure time [8,9]. However, adolescents often encounter behaviors posing health risks, such as alcohol and tobacco consumption [10]. These formative years are crucial because behaviors established during this time significantly impact long-term health outcomes [11]. Notably, adolescents frequently abandon positive habits like sports or exercise, contributing to physical inactivity and declining fitness levels [12], which, in turn, increase the risk of various diseases like obesity and diabetes [13].

Recent studies have highlighted a marked decline in physical fitness levels among children and adolescents [14–18]. Additionally, factors such as insufficient physical activity (less than the 60 min per day recommended by the WHO), consumption of high-calorie diets, and sedentary behaviors (including extended periods of sitting, excessive use of technology, and reliance on motorized transportation) negatively impact health and quality of life. The PASOS (Physical Activity, Sedentarism, and Obesity in Spanish Youth) study found that only 36.7% of children and adolescents adhere to WHO exercise guidelines [19]. Furthermore, the study indicated that inactivity rates were higher in girls than boys (70.1% vs. 56.1%) and in adolescents compared to children (69.9% vs. 56.1%). As a result, epidemiologists suggest that physical fitness could be essential in combating overweight and obesity in this demographic [20]. This is particularly concerning as a physically active lifestyle is known to positively influence brain structure and function during childhood [21–23]. Beyond the physiological benefits of exercise [24], its positive effects on mental health [25], bone health [26], cognitive abilities [27,28], and children's learning processes have been extensively researched.

Most scientific evidence on cross-sectional changes in adolescent fitness has centered on analyzing aerobic capacity [29]. This approach can erroneously convey the idea that other capabilities like speed, strength, or agility are not important, thus biasing the impression that only aerobic fitness is key for health and locomotive function maintenance [30]. In fact, abilities such as speed or agility are strongly correlated with bone mineral density and the accumulation of bone mass during the lifespan [2,7]. Moreover, a significant portion of physical activities undertaken by children and adolescents consists of high-intensity exercises, necessitating anaerobic energy production [31]. In support of this, Bailey et al. [32] observed that children aged 6 to 10 years often participate in activities characterized by short bursts of intense effort. Consequently, variations in anaerobic capacity, including abilities like changing direction or performing interval sprints, can be indicative of shifts in these routine physical activities.

Beyond the scientific evidence supporting the importance of aerobic fitness in childhood and adolescence, there is limited evidence for anaerobic fitness [31]. Similarly, there is a scarcity of studies analyzing the evolution of physical condition, specifically the development of abilities such as agility, in Catalan adolescents. Furthermore, although the majority of these studies have shown a similar trend, significant differences have been noted depending on the geographic area [33], suggesting the importance of research in specific local populations. Therefore, the aim of this study was to examine and contrast the agility levels among various groups of Catalan urban adolescents aged 13–15 years over a span of 20 years (2002–2022). The hypothesis proposed that this adolescent population would show a decline in performance across the observed time periods.

## 2. Materials and Methods

### *2.1. Sample*

A total of 1439 participants, comprising 842 boys and 596 girls, with a mean (SD) age of 13.16 ± 0.42 years, were recruited for this ex post facto descriptive and cross-sectional study [34]. Tests were administered by physical education teachers as part of various schools' physical education programs in Barcelona between 2002 and 2022. Each year, at the beginning of the physical fitness assessments, the teachers responsible for administering the tests would meet to ensure that the tests were conducted consistently across all schools and throughout all years. This practice aimed to maintain a uniform testing procedure, providing reliable and comparable results across different schools and timeframes. Using EpiData 3.1 software (EpiData Association, Odense, Denmark), a sample size of 1224 subjects was estimated, considering a confidence level of 95% and an accuracy of 2.5%. To maintain this accuracy for both genders, a minimum sample size of 1350 students was determined. Participants were considered to be of medium-high socio-economic status based on the criterion of home proximity, which determined the admission process of students to schools. They were selected through intentional non-probability sampling (convenience sample). Inclusion criteria were being between 13 and 15 years years old and regular school attendance (>80% attendance), while exclusion criteria included health problems that could bias results or prevent participation in study tests, as well as high absenteeism (≥20% absences). No anthropometric data were considered due to inconsistencies in data uniformity and variations in measurement instruments.

To facilitate comparisons over time, the sample was disaggregated by gender and divided into four groups corresponding to consecutive five-year periods. Thus, Group 1 ($n$ = 327) comprised students from 2002 to 2006; Group 2 ($n$ = 325) from 2007 to 2011; Group 3 ($n$ = 392) from 2012 to 2016; and Group 4 ($n$ = 395) from 2017 to 2022. The distribution of the four time periods was arbitrary to ensure a similar number of subjects in each period, thus facilitating comparisons.

Informed consent was obtained from the parents and legal guardians of all participants, following thorough explanations of the experimental procedures, exercise protocol, and potential benefits and risks involved. The study received approval from the Clinical Research Ethics Committee of Sagrat Cor Hospital in Barcelona, Spain, under reference number L-GENZ-E 004. All procedures were conducted in accordance with the principles of the Declaration of Helsinki (revised in Fortaleza, Brazil, 2013).

### 2.2. Procedure

To assess agility, the 8 × 10 m shuttle run test was employed [35]. The test protocol involved placing cones or marking lines at ten-meter intervals on a straight, flat surface. Participants were required to sprint to the 10 m line, touch it, and return to the starting point, repeating this sequence eight times and covering a total distance of 80 m. The trajectory was a straight line, ensuring that the total distance covered was precisely 80 m. The test was conducted on an outdoor track, and participants wore their regular sports shoes to ensure comfort and familiarity. The surface was standard track material, which provided adequate grip and minimized the risk of slipping. Physical education teachers at each school administered the test, using manual stopwatches to record the times. To maintain consistency, each participant was verbally encouraged throughout the test to ensure maximal effort. A standardized warm-up routine, including dynamic stretching and light jogging, was performed before the test to reduce the risk of injury and ensure participants were adequately prepared. Each student completed two attempts, with a three-minute rest period between each attempt to minimize the effects of fatigue. The faster of the two times was used for further analysis. This test was part of a larger battery of fitness assessments, but was conducted on an isolated day to avoid any influence of fatigue from other activities. The involvement of trained physical education teachers ensured consistency in timing and provided a standardized approach to administering the test across all participating schools. This kind of shuttle run test has demonstrated good test–retest reliability, making it a robust measure of agility in the school context [36].

### 2.3. Statistical Analysis

Statistical analyses were performed using SPSS® software (Version 25 for Windows; SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was applied to assess data normality. The descriptive analysis included calculations of the variables' mean and standard deviation. Additionally, the within-session reliability of test measurements was assessed via the two-way random intraclass correlation coefficient (ICC) with absolute agreement (95% confidence intervals). The ICC values were interpreted as follows: >0.9 = excellent, 0.75–0.9 = good, 0.5–0.75 = moderate, and <0.5 = poor [37]. Differences in physical fitness (dependent variable) among groups (independent variable) were assessed using one-way ANOVA. Bonferroni post-hoc tests were employed to examine pairwise differences between groups. The significance level was set at $p < 0.05$ for all statistical analyses. Additionally, effect sizes were reported as partial eta-squared ($\eta_p^2$), with cut-off values of 0.01–0.05 for small, 0.06–0.13 for medium, and >0.14 for large effects, respectively [38]. Cohen's *d* effect size was calculated for pairwise comparisons, with interpretations of <0.2 as trivial, 0.2–0.6 as small, 0.6–1.2 as moderate, 1.2–2.0 as large, and >2.0 as very large [39].

## 3. Results

Table 1 shows the descriptive results of the 8 × 10 m shuttle test divided by gender.

**Table 1.** Descriptive analysis of the 8 × 10 m shuttle test results categorized by gender. Data are presented as mean ± SD.

| | Boys (*n* = 842) | Girls (*n* = 596) | Total (*n* = 1439) | ICC (95% CI) |
|---|---|---|---|---|
| 8 × 10 m shuttle run test (s) | 25.42 ± 3.11 | 27.14 ± 3.26 | 26.16 ± 3.28 | 0.86 (0.81–0.90) |

ICC—intraclass correlation coefficient; CI—confidence intervals; m—meters; s—seconds.

Table 2 illustrates the outcomes of the 8 × 10 m shuttle test for each group across both genders. The results indicate a significantly diminished agility performance in both male and female groups when comparing various time periods ($p < 0.05$). Among boys, there was a notable decline in agility capacity, becoming significant from the 2007–2011 period onwards ($F_{(3,839)} = 392$, $p < 0.001$, $\eta_p^2 = 0.584$). Group 1 (2002–2006) exhibited a superior performance (22.76 ± 1.84) compared to Group 3 (2012–2016) and Group 4 (2017–2022) (at 27.57 ± 2.38, $p < 0.001$, $d = 2.48$ (2.25–2.70) and 27.42 ± 2.53, $p < 0.001$, $d = 2.36$ (2.14–2.59), respectively). Similarly, Group 2 (2007–2011) also demonstrated higher performance (22.97 ± 1.73) in contrast to Group 3 (2012–2016) and Group 4 (2017–2022) ($p < 0.001$, $d = 2.37$ (2.15–2.60) and $p < 0.001$, $d = 2.26$ (2.03–2.48), respectively), indicating a decline in results (Figure 1).

**Table 2.** Descriptive analysis of results in 8 × 10 m shuttle run test over a 20-year period. The data are shown as mean ± SD.

| | Group 1: 2002–2006 | Group 2: 2007–2011 | Group 3: 2012–2016 | Group 4: 2017–2022 |
|---|---|---|---|---|
| Boys | 22.76 ± 1.84 | 22.97 ± 1.73 | 27.57 ± 2.38 *† | 27.42 ± 2.53 *† |
| Girls | 23.79 ± 1.53 | 24.54 ± 1.46 § | 29.52 ± 2.16 §‡ | 29.57 ± 2.12 §‡ |

*—statistically different to Group 1; †—statistically different to Group 2; §—statistically different to Group 1; ‡—statistically different to Group 2.

The girls' trend showed a similar pattern. There was significantly lower agility over time ($F_{(3,593)} = 414$, $p < 0.001$, $\eta_p^2 = 0.677$). Girls reported the highest performance in the 2002–2006 Group (23.79 ± 1.53). Group 1 (2002–2006) exhibited a superior performance (23.79 ± 1.53) compared to Group 2 (2007–2011), Group 3 (2012–2016), and Group 4 (2017–2022) (at 24.54 ± 1.46, $p = 0.009$, $d = 0.39$ (0.15–0.63), 29.52 ± 2.16, $p < 0.001$, $d = 3.09$ (2.80–3.38), and 29.57 ± 2.12, $p < 0.001$, $d = 3.09$ (2.80–3.38), respectively). Similarly, Group 2 (2007–2011) also demonstrated a higher performance in contrast to Group 3 (2012–2016) and Group 4 (2017–2022) ($p < 0.001$, $d = 2.70$ (2.42–2.96) and $p < 0.001$, $d = 2.71$ (2.43–2.97), respectively), indicating a decline in results (Figure 2).

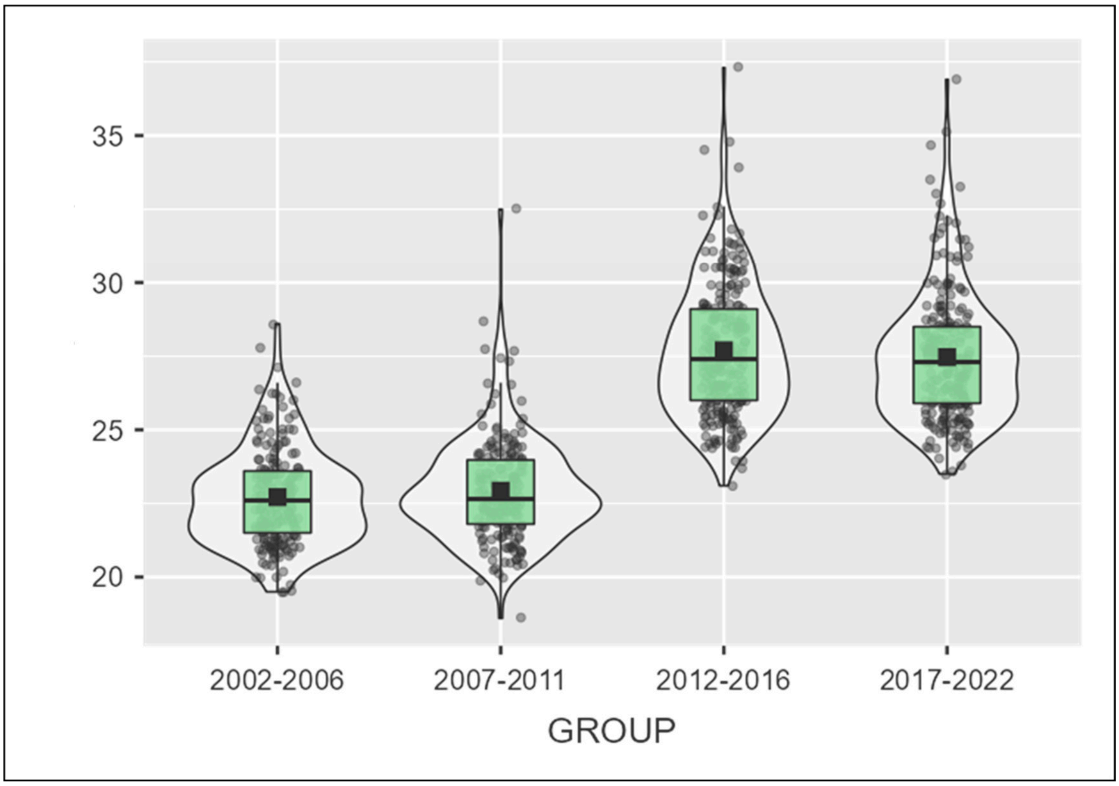


**Figure 1.** Comparison of 8 × 10 m shuttle run test results between the boys' groups.

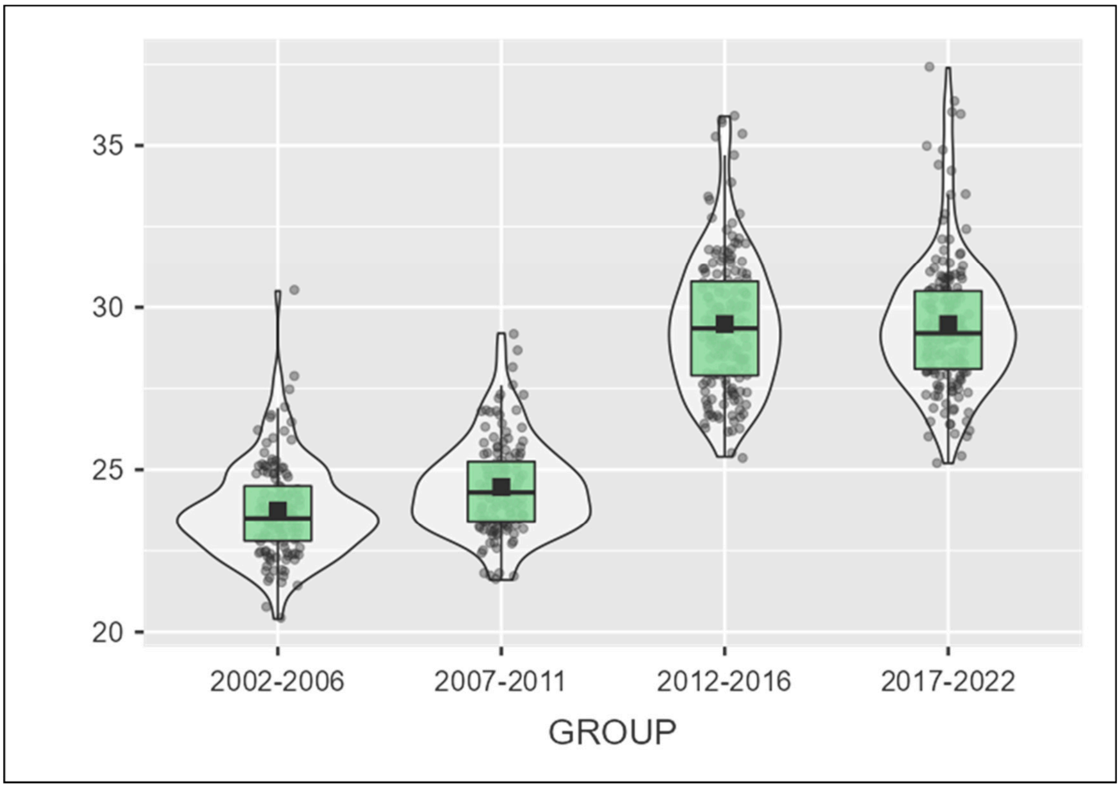


**Figure 2.** Comparison of 8 × 10 m shuttle run test results between the girls' groups.

## 4. Discussion

The objective of this study was to investigate and measure the alterations in physical fitness among urban Catalan adolescents spanning a 20-year period (2002–2022). The primary outcome revealed a notable decline in the performance of the 8 × 10 m shuttle run test over the past two decades, observed in both male and female participants. This decline suggests a deterioration in the physical agility of adolescents during this timeframe.

The observed decline in the 8 × 10 m test performance over the past two decades aligns with findings from various studies indicating a gradual deterioration in the overall physical condition of adolescents compared to previous generations [40–45].

Although no single factor can fully account for the downward trend in agility performance observed in this study, it is likely influenced by a combination of environmental, social, behavioral, physical, psychosocial, and physiological factors [11,40,46]. Among these factors, the rise in obesity rates among the youth population stands out as a significant contributor to declining physical fitness [47]. Changes in body composition have often coincided with alterations in physical fitness levels in many countries [48,49]. Globally, the prevalence of overweight and obesity among children and adolescents has surged, particularly in industrialized nations, posing a significant public health challenge [50]. Southern European countries have witnessed a concrete and notable increase in rates of overweight children [51]. This obesity epidemic has become a pressing concern in the twenty-first century due to its substantial healthcare costs [52,53]. Obesity, characterized by an imbalance between caloric intake and expenditure, leads to the accumulation of body fat, resulting in various physiological disorders such as dyslipidemia, diabetes, and certain types of cancer [54]. Additionally, it can contribute to psychological and social issues such as low self-esteem, depression, and antisocial behavior [55]. While there is no singular factor responsible for obesity development, physical inactivity is closely associated with poor physical fitness [56]. In terms of agility performance, Artero et al. [57] observed that overweight adolescents tended to fare worse in tests requiring the propulsion or elevation of body mass, such as the 8 × 10 m test.

Another factor potentially contributing to the decline in adolescents' agility could be the widespread use of technology. While technology offers significant educational and communicative benefits, its inappropriate or excessive usage can have detrimental effects on adolescents. In recent years, the prevalence of technology use, including social networks, the internet, smartphones, video games, and television, has skyrocketed. According to the National Institute of Statistics (Spain), 91.8% of children aged 10 to 15 are regular internet users, with a substantial proportion spending more than 4 h per day in front of screens, doubling the recommended limit [58]. Nationally, data from the Pfizer Foundation indicate that 98% of Spaniards aged 11 to 20 use the internet, with 70% spending over 1.5 h online daily [59]. The extensive time spent on technology by children and adolescents is concerning as it is considered a sedentary behavior that competes with physical activity for leisure time [60]. This sedentary lifestyle resulting from excessive technology use may lead to a decline in physical activity performance [61].

In contrast to evidence suggesting a general decline in physical fitness, some countries have reported positive trends in specific components of physical fitness. For instance, in Finland, an increase in muscular fitness has been observed among adolescents aged 13 to 16 over a 25-year period from 1976 to 2001 [62]. Similarly, in Canada, there has been a notable increase in cardiorespiratory fitness and strength [63], which may be attributed to the country's additional exercise programs at schools. Portugal has also reported an upward trend in speed performance [64]. This increase is likely the result of government policies promoting additional exercise programs [33]. The implementation of these exercise-focused policies underscores the potential impact of public health initiatives on physical fitness trends. The recorded growth in Finland, Canada, and Portugal suggests that changes in government policies, particularly those that emphasize the development and implementation of health-enhancing programs, can play a significant role in reversing the negative effects of sedentary lifestyles. This is particularly relevant in the context of a growing urban sedentary population, where physical inactivity has become a major public health concern. Furthermore, the results of the present study reflect the effects of the recreational area's loss reported in Barcelona over the past decades [65]. Indeed, beyond the impact of tech use among children and adolescents, the difficulties in finding an adequate space for playing basketball, soccer or other popular games might contribute to the present findings. Such practices are particularly connected with agility performance and fast skills, which are partially reflected in a shuttle 8 × 10 m test.

Despite the utility of these findings, the current study has several limitations that must be acknowledged and should be addressed in further research. Firstly, crucial data such as anthropometric values, including the weight status, body composition, nutritional status, and sedentary habits of the sample, were not examined. The test may be affected by both fat and muscle mass, which can impact agility, acceleration, and deceleration. A larger body mass, whether due to increased fat or muscle, could hinder performance on this test, as it involves repeated directional changes. Consequently, relative power may differ between lighter and heavier individuals, potentially affecting the results. Considering the potential impact of these factors on fitness test outcomes, future research should prioritize their inclusion. Secondly, another limitation is the reliance on a single test, the 8 × 10 shuttle run, to measure agility. As with all physical capacities, it is important to evaluate agility using multiple tests to obtain a comprehensive assessment. Additionally, future studies should consider the economic and demographic characteristics of the sample to provide a more comprehensive understanding of the evolution of physical fitness among children and adolescents. This study underscores the importance of further research to elucidate the causal relationship between physical fitness and these aforementioned factors. Moreover, the calculation of participants' peak height velocity was not conducted. Given the influence of biological maturity on physical fitness test results, it would be beneficial to include this variable in future studies involving children and adolescents. Furthermore, variations in test conditions such as climate, practice environment, running surfaces, and measurement errors may have occurred, despite efforts to minimize methodological biases through a large sample size. Future research should aim to standardize these conditions to enhance the validity and reliability of the procedures. Moreover, future research should prioritize longitudinal studies to monitor changes over time, fitness surveillance to inform policy and decision-making, and the use of internationally standardized, valid, and reliable fitness tests. Additionally, creating targeted interventions to enhance fitness among children and adolescents is essential. The priorities highlighted in this study can direct international collaborations and research initiatives over the coming decade and beyond, providing a framework to address current gaps and deepen our understanding of physical fitness in young populations [66].

## 5. Conclusions

In conclusion, this study reveals a concerning decline in the agility performance of urban Catalan adolescents over the past two decades, as evidenced by diminished results in the 8 × 10 m shuttle run test. These findings underscore the importance of addressing the deteriorating physical fitness among adolescents, as it may have significant implications for their future health outcomes.

Given the results of this study and the WHO's indication that many adolescents fail to meet the recommended levels of weekly physical activity, school- and community-based youth programs must intensify efforts to promote physical exercise among children and young people. Moreover, the findings of this investigation are pertinent from a curricular perspective, as the observed downward trend in agility among adolescents underscores the importance of elevating the status of physical education in educational institutions. Traditionally perceived as less significant than other conventional subjects, physical education should be recognized as a critical component of the curriculum [67]. By addressing the underlying factors contributing to the decline in agility performance, such as obesity and sedentary behavior, policymakers, educators, and healthcare professionals can collaborate to foster healthier lifestyles and reduce the risk of cardiovascular disease and other health complications in adulthood. Further research is warranted to delve into the intricate interactions among various factors influencing adolescent physical fitness and to develop targeted interventions aimed at enhancing overall health outcomes.

**Author Contributions:** Conceptualization, J.A.-A., B.B., M.M. and J.S.; methodology, B.B., J.A.-A. and J.M.; formal analysis, B.B., J.A.-A. and M.P.-G.; data curation, B.B., J.A.-A. and M.P.-G.; investigation, J.A.-A., M.P.-G. and B.B.; writing—original draft preparation, B.B., J.A.-A. and M.P.-G.; writing—review and editing, B.B., J.A.-A., M.M., J.S., M.P.-G. and J.M.; project administration, B.B. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Clinical Research Ethics Committee of Sagrat Cor Hospital (Barcelona, Spain), with reference number L-GENZ-E 004.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The raw data supporting the conclusions of this article will be made available by the authors on request.

**Acknowledgments:** We are grateful to all the study subjects for their participation.

**Conflicts of Interest:** The authors report no potential conflicts of interest.

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