

REVIEW PAPER

ARTYKUŁ PRZEGLĄDOWY

**SURVEILLANCE OF PHYSICAL ACTIVITY AND SEDENTARY BEHAVIOR IN  
POLISH CHILDREN AND ADOLESCENTS: A SCOPING REVIEW OF  
LITERATURE FROM 2000 TO 2022**

**BADANIE POZIOMU AKTYWNOŚCI FIZYCZNEJ I SEDENTERYJNEGO STYLU  
ŻYCIA U POLSKICH DZIECI I MŁODZIEŻY: PRZEGLĄD LITERATURY  
Z LAT 2000-2022**

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### Summary

The aim of this study is to map available data related to PA and sedentary behavior (SB) in Polish children and adolescents and, based on the collected conclusions, to present suggestions for promoting PA and reducing sedentary behavior. The analysis of literature was performed according to PRISMA-ScR, based on the Medical Subject Headings System of National Library of Medicine. MEDLINE and PubMed databases were used. We searched for publications between January 2000 and December 2022. 634 publications were identified, and 47 were included. The publications conducted focused on adolescents who were approximately 15 years of age. Larger percentage of girls participated in the survey. Publications have confirmed non-fulfilment of PA recommendations for maintaining the health of Polish children and youth. The 33% representation of publications dealing with the issue of PA and SB in an international context is positive. The diversity and breadth of approaches to solving PA and SB issues are beneficial, but at the same time, it draws attention to the lack of a national system for monitoring

the physical and sedentary behavior of children and youth in Poland. Future research should focus more on monitoring of health-related 24-hour time use patterns, usage of wearable monitors for measurement of PA, use of a combination of quantitative and qualitative methods, as well as the use of an all-Polish representative research sample.

**Keywords:** sedentary behavior, PRISMA, adolescents, physical activity, children

### Streszczenie

Celem niniejszego badania jest zmapowanie dostępnych danych dotyczących aktywności fizycznej (PA) i zachowań sedenteryjnych (SB) u polskich dzieci i młodzieży, a na podstawie zebranych wniosków przedstawienie sugestii dotyczących promowania PA i ograniczenia zachowań sedenteryjnych. Analizę dostępnego piśmiennictwa przeprowadzono zgodnie z PRISMA-ScR i w oparciu o Medical Subject Headings System of the National Library of Medicine. Wykorzystano bazy danych MEDLINE i PubMed. Przeszukano publikacje, które ukazały się między styczniem 2000 roku a grudniem 2022 roku. Zidentyfikowano 634 publikacje, z których 47 włączono do badania. Większość badanych stanowiła młodzież w wieku około 15 lat, z większym odsetkiem dziewcząt. Publikacje potwierdziły niewypełnianie zaleceń PA dla zachowania zdrowia polskich dzieci i młodzieży. Pozytywnie należy ocenić 33% reprezentację publikacji poruszających problematykę PA i SB w kontekście międzynarodowym. Różnorodność i szerokość podejść do rozwiązywania kwestii PA i SB jest korzystna, ale jednocześnie zwraca uwagę na brak krajowego systemu monitorowania zachowań fizycznych i siedzących dzieci i młodzieży w Polsce. Przyszłe badania powinny w większym stopniu koncentrować się na monitorowaniu 24-godzinnych wzorców wykorzystania czasu związanych ze zdrowiem, szerszym wykorzystaniu urządzeń do noszenia, zastosowaniu

kombinacji metod ilościowych i jakościowych, a także wykorzystaniu ogólnopolskiej reprezentatywnej próby badawczej.

**Słowa kluczowe:** siedzący tryb życia, PRISMA, młodzież, aktywność fizyczna, dzieci

## Introduction

In scientific discourse, there exists a contrasting relationship between sedentary behavior (SB) and physical activity (PA). Specifically, as the level of PA increases, the occurrence of SB decreases [1-3]. After 2000, there has been a significant increase in publications on PA and SB. One finds a multi-level analysis of the issue in a group of school children and adolescents. PA is one of the most essential elements of a healthy lifestyle [4,5]. It is particularly important for children and adolescents, who invariably, in the last two decades, have not met the minimum PA needed for health [6-8]. Importance is given to low-to-moderate intensity PA [9,10] as well as high intensity PA [5,11]. It should be noted that PA affects not only the physical aspect of health but also mental health and social contacts [1]. Organized PA has better results against SB than self-organized PA by students [4-7], giving children and adolescents a chance to achieve PA recommendations [12]. There are differences in PA between girls and boys, and girls show lower PA volume [13,14]. The weekly PA profile is also not uniform. Decreases in physical activity on days off and days devoid of PA are noted [7]. Actions for reducing SB among children and adolescents should be comprehensive and multifaceted. Consideration is directed towards the notable impact exerted by two educational settings, crucial in shaping the PA levels of children and adolescents. The influence of the family is recognized here, which should motivate children and adolescents to PA [15]. The school is not insignificant when it comes to health behavior, which is becoming a more supportive environment for the PA of children and adolescents than in the past [4]. A significant influence

on health behavior is in the physical education classroom, and it is on the shoulders of the physical education teacher to guide children and adolescents into health behavior [16]. Local governments should be more effective in promoting all activities for PA [4,17], and government activities should be more focused on recreational PA rather than sports [4]. Studies show the need for nationwide intervention programs that, by design, increase the PA of children and adolescents and reduce SB [14]. The WHO also notes the importance of a nationwide analysis of PA in the context of SB. Such analyses allow for the optimization of nationwide efforts to reduce SB and thus increase PA [18].

### **Aim of the work**

In this article, a systematic literature analysis of PA in the context of SB was conducted. The area of analysis was Poland, and the study group was children and adolescents. The scope of the analysis includes publications that appeared after the year 2000. The characteristics of the study brought together the main findings of the research papers and developed suggestions for additional steps to promote more effective PA and decrease sedentary behavior among children and teenagers in Poland.

### **Methods**

#### *Search strategy*

The materials underwent analysis following the guidelines outlined in the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews" (PRISMA-ScR) [19]. The analysis was based on the Medical Subject Headings (MeSH) system

within the National Library of Medicine (NLM). The MEDLINE and PubMed databases were used. Publications published between January 2000 and December 2022 were searched for. The search strategy included three groups of factors describing the study population included in the analysis: age (school children and adolescents), health behavior (PA and SB) and country (Poland). The accuracy of the analysis was increased by including only full texts. Quantitative, qualitative and mixed methods studies were included to account for different ways of analyzing PA and SB. The final search strategy was created on the basis of discussions among team members and is presented in the Appendix.

The publications selected for analysis were sorted. Repeated publications were removed, and the remaining publications were collected alphabetically before further analysis; the name of the first author was chosen as the criterion. The final database contained unique identifiers for the analysis and bibliographic information: article identifier, the first author's name was chosen as the criterion, year of publication, study title, abstract and journal title. A Peer Review of Electronic Search Strategies (PRESS) checklist was created for included and excluded publications.

For full consistency, all researchers received the selected publications and then conducted the analysis. The entire team discussed discrepancies regarding the selection of studies and data for analysis. If there was general agreement, the article remained in the analysis. At the next stage, two independent researchers checked the entire articles against the assumptions. The whole was divided for the analysis into three groups: irrelevant, potentially relevant, relevant publications. If doubts arose during the division, the entire text was analyzed, and it was then decided whether to include or exclude the publication in question. If doubts about relevance still arose, the publication was given to a third person, and he or she made the final decision on inclusion or exclusion. Additionally, manual exploration was undertaken to locate articles beyond the scope of the MEDLINE and PubMed databases. The focus was on

Polish publications, taking into account the same process for other publications. The collected material was presented in detailed tables and summary charts showing PA and SB relationships in the analyzed publications.

#### *Inclusion and exclusion criteria for studies*

Research articles containing information on PA and SB concerning children and adolescents 6 to 20 years of age from Poland were analyzed. Publications were not included in the analysis if the research concerned Poland but were within international studies in which Poland was not explicitly mentioned. Only studies conducted between January 2000 and December 2022 were included in the analysis. If the publication appeared in the analyzed period, but the research was conducted earlier, the publication was rejected. An allowance was granted specifically for cross-sectional studies carried out across various years. Such publications were not rejected if at least part of the research was conducted in the analyzed period and only that part of the research which was in the analyzed period was included in the analysis. Publications were omitted if they were within the scope of the study and concerned Polish children and adolescents with different disease entities – disabilities. Children and young people from Poland were omitted if their health condition was limited or did not allow them to participate in PA. The analysis did not take into account children and young people from Poland training professionally in any sport discipline. Children and young people who did not attend school and, for example, received their education at home were omitted. Although a link was found between SB and nutrition, these publications were omitted in the analysis, and the focus was on PA in the context of SB. Nutrition is an integral part of a healthy lifestyle, but to include it would have taken it outside the scope of the analysis and reduced its effectiveness in relation

to PA in the context of SB. The minimum number of study participants included in the analysis was 50.

### *Data extraction*

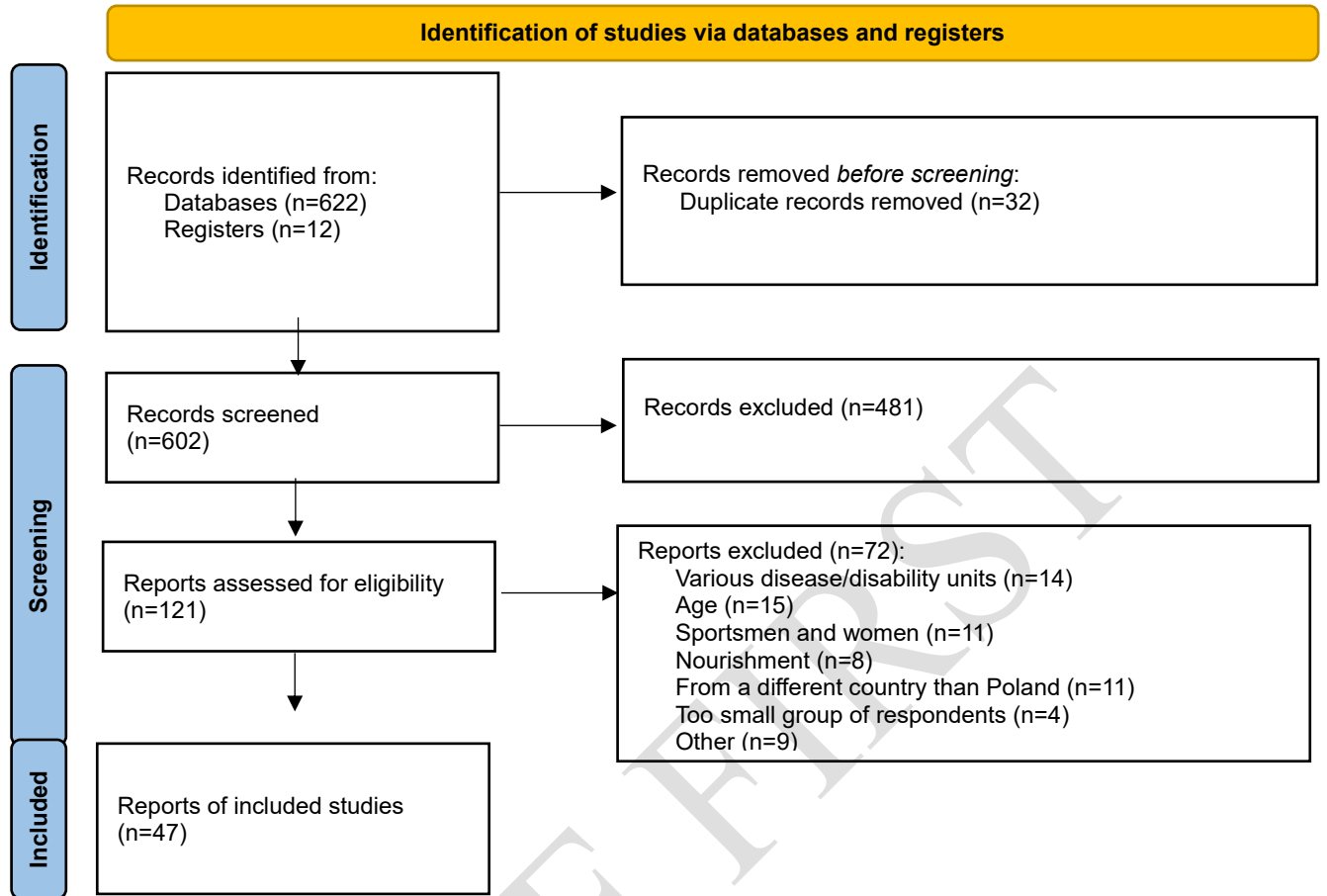
The identified group of study inclusions (design, main results and main conclusions) was characterized. When a systematic review was identified, the number of included studies that potentially met the inclusion criteria was counted, and it was noted how many studies were omitted by the search. A description of the study sample (sample size, gender breakdown, age, country of Poland) was made. The methods used for measurement (self-reported, device-measured) were noted. Attention was paid to PA and SB. Finally, the main findings and results of the included studies were summarized.

### *Data extraction procedure and bibliographic characteristics*

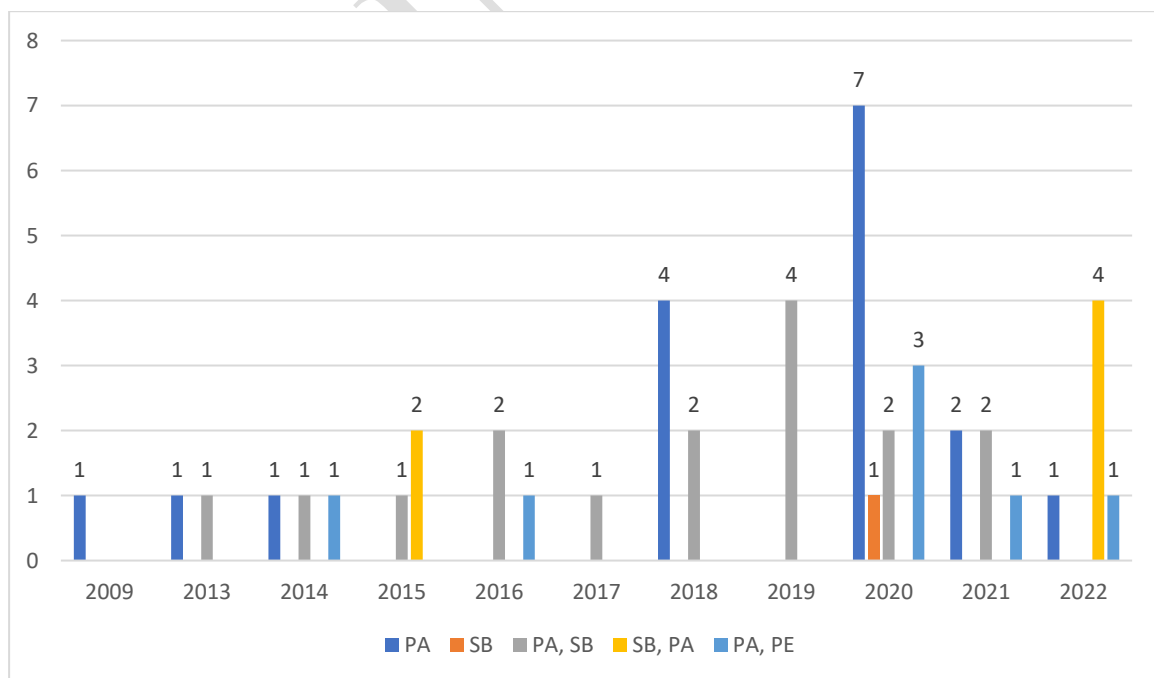
A search of the PubMed.gov database revealed 622 articles that may have met the study criteria. To these were added 12 manually searched articles from outside the database. 32 articles that were duplicates were removed. Of the 602 remaining, 481 articles were then discarded that did not meet the inclusion criteria after initial analysis. The remaining 121 articles were analyzed in detail. From this group, 72 articles were rejected, and 49 articles were included in the study (Figure 1). During the analysis, the assessors disagreed on 4 articles, and the decision to include or exclude them from the analysis was then made by a third party. Although January 2000 was acknowledged as the cut-off date, the earliest article within the analysis dated back to 2009. Among the 121 articles accepted for detailed analysis, only 11 were from the period January 2000 to December 2009, and the remaining 110 were from the



period January 2010 to December 2022 (Figure 2). Within the articles, there were publications documenting PA and SB, drawing from international studies encompassing Polish individuals between 6 and 20 years of age. Only if the presentation of the data made it possible to distinguish people from Poland in both the data and inference were such articles included in the analysis. Despite meeting all other criteria, one article in which the analysis was conducted in a music school was rejected due to specificity [20]. One article was a summary and referred to Poland's 2022 Report Card and, in addition to the 2022 report, comparatively analyzed analogous reports from 2016 and 2018. The 2022 article was included in the analysis [4]. The literature pays particular attention to the role of the school in counteracting SB and promoting PA through PE; therefore, this issue was noted in the analysis. In total, the specific role of physical education (PE) was given in 7 articles [8,16,21-25]. A total of 3 articles were based on intervention programs [26-28,29]. One article included in the analysis was in Polish [29], the other 46 in English.



**Figure 1.** Flow of information through the different phases of the review



**Figure 2.** Number of articles from 2000 to 2022 by main research problem

## **Descriptive characteristics of the available evidence**

### *Study purposes*

The main aim of the study was to diagnose PA in the context of SB among people from Poland. Articles were included in the study because of the multifaceted analysis of PA in the context of SB. The 18 articles selected were most focused on PA diagnosis [2,6,12,15,29-41]. One article focused on SB [42]. 15 publications focused more on PA but analyzed PA in the context of SB [5,10,26,27,43-53]. 6 articles more strongly analyzed SB but in the context of PA [3,4,54-57]. Also noteworthy is the group of 7 articles that considered PA in the context of PE [8,16,21-25].

### *Study sample*

Forty-seven articles were analyzed, all presenting the authors' findings. The youngest study participants included in the analysis were 6 years of age, and the oldest were 20 years of age. The students were not allowed to train competitively in sport and were not restricted from participating in PA. All analyzed articles focused on adolescents – usually around 15 years of age. The widest age ranges of subjects were reported in 2 articles [4,55]. Children up to 10 years of age were studied in 3 articles [1,4,55]. In 2 articles, 100% of the participants were girls [26,29]. In 2 articles, more participants were boys [3,21]. In 45 articles, more than 50% were girls. In one article, there was an option not to specify gender, with 10.5% of respondents giving this answer [55]. The number of respondents ranged from 97 to 14,044 participants. Some of the articles accepted for analysis originated from studies of the same group. The review identified 17 articles arising from international collaborations. Polish researchers only wrote 33

articles. Most of the articles did not specify from which exact region of Poland the researchers were from. Groups from southern Poland were analyzed within 6 articles [2,5,6,30,54]. Respondents from eastern Poland appeared in 2 articles [5,39]. In addition, the authors conducted studies in the cities of: Wrocław and Katowice [5], Wrocław [29], Warsaw [43], Katowice [30,32,34], Gorzów Wielkopolski and Poznań [44], Biała Podlaska [51], Szczecin [56], Kalisz [25] (Table 1).

ONLINE FIRST

**Table 1.** Characteristics and findings of the included studies

First author and year of publication	Characteristics of study sample	Methods	Primary outcome(s)	Main finding(s)
Rocka et al., 2022 [3]	n=3127 47% girls 12.1±3.4 years	Author's questionnaire SB, PA and nutrition behaviors	SB, PA	On weekdays, a significant proportion of individuals, specifically 71%, dedicated more than four hours to engaging in educational activities through electronic devices, while 43% allotted a span of 1-2 hours for recreational screen utilization. It is worth noting that an astonishing 89% of participants were exposed to screens while partaking in meals, and 77% engaged in the consumption of snacks in between their primary meals. This investigation noted a correlation between the duration of screen usage and the frequency with which screens were employed during meal times. Furthermore, a relationship between the amount of time spent on screens and the length of PA was identified.
Jaskulska et al., 2022 [55]	n=1955 43.3% girls 9-20 years	Author's questionnaire SB, PA	SB, PA	Efforts should be made to implement programs aimed at effectively assessing students' requirements and mitigating the adverse consequences of distance learning. It is recommended the development of strategies for alleviating stress and countering information overload, while also fostering innovative approaches to leisure activities. Furthermore, it is imperative to provide assistance to families in the management of their children's leisure time and the expansion of their social support networks. According to the obtained results, boys exhibited superior physical well-being in comparison to girls ( $p<0.001$ ). The students acknowledged modifications in the quality of their recreational activities, with boys expressing higher levels of contentment with their free time during the pandemic ( $p<0.001$ ). Additionally, the age of the learners played a significant role in evaluating their physical well-being ( $p<0.001$ ) and leisure time ( $p<0.001$ ).
Frömel et al., 2022 [2]	n=1927 56% girls 15-19 years Southern Poland	IPAQ-LF WHO-5 before the COVID-19 pandemic (2010-2019)	PA	Recognizing and leveraging the connections between the motivations for different types of PA and the actual types of PA, both in boys and girls with varying levels of motivation, can contribute to enhancing the enjoyment of PA, increasing overall PA levels, facilitating the attainment of recommended PA levels, and fostering healthier lifestyles among adolescents. Notably, during the COVID-19 and the transition to distance education, significant decreases were observed in VPA among boys. School-based PA, AT, recreational PA, VPA, moderate PA, walking, and total weekly PA were among the factors considered in the study. Likewise, girls also observed a decrease in school-based PA, vigorous PA, and overall PA. Prior to the outbreak, boys consistently achieved markedly higher levels of PA compared to girls across various categories, such as school-based PA ( $p<0.001$ ), recreational PA ( $p=0.037$ ), VPA ( $p<0.001$ ), MVPA ( $p<0.001$ ), and overall PA ( $p<0.001$ ). However, during the duration of the pandemic, there were no statistically significant disparities in PA levels between boys and girls.
Zembura et al., 2022 [4]	5-19 years	Poland's 2022 Report Card (Global Matrix 4.0 project)  Compared in the article with the 2016 and 2018 reports	SB, PA	The evaluation demonstrated that there was an improvement in the scores for OPA and PA, School and Physical Fitness indicators compared to the previous GM (Global Matrix), indicating positive advancements in those domains. However, the scores for AT and Government indicators were lower, implying challenges in those areas. Regrettably, there were no positive changes observed in relation to OPA or SB. One notable constraint in the promotion of PA in Poland is the excessive focus of government-level PA policies on OPA, potentially neglecting other crucial aspects. The situation concerning PA and screen-time behaviors is particularly disconcerting. In contrast, the school environment plays a significant role in Poland in promoting PA, primarily due to the high participation in OPA and the obligatory time allocated to PE. To overcome these challenges and foster a cultural shift

				towards daily PA among Polish children and youth, a strong commitment from the government at all levels is imperative. This commitment is vital in order to develop a more comprehensive approach to PA promotion and effectively address the issues associated with screen time behavior.
Kolanowski et al., 2022 [21]	n=245 48% girls age at the beginning of the study: 10.27, and at the end, 12.26 years	OMRON M3 automatic blood pressure monitors	PA, PE	Commencing from a comparable starting point, the data demonstrates notable disparities following a span of two years. In the standard-PE group, the proportion of children with normal blood pressure diminished from 83.25% to 78.03%, whereas in the elevated-PE group, it rose from 83.15% to 86.13%. The occurrence of both prehypertension and hypertension escalated by approximately one-third in the standard-PE group, surging from 16.74% to 21.97%. Conversely, the elevated-PE group witnessed a decrease of roughly one-sixth, with the prevalence declining from 16.85% to 13.87%. Remarkably, the prevalence of hypertension itself surged by one-third in the standard-PE group, escalating from 9.82% to 13.12%. In the elevated-PE group, it decreased by about one-fifth, dropping from 9.60% to 7.75%.
Łuszczki et al., 2022 [1]	n=1016 51.3% girls 6-15 years	Author's questionnaire Tanita MC-980MA FFQ-6 before and during the COVID-19 lockdown	SB, PA	The study determined variations in diet and modifications in daily activity patterns, specifically a decrease in sleep duration accompanied by an increase in sleep quality and a reduction in physical activity. The study revealed a rise in overall media consumption during the pandemic, coupled with a decrease in smartphone usage. These findings collectively suggest an increase in sleep duration, PA, and a decrease in media usage and screen time among Polish children and adolescents amidst the COVID-19 crisis. The average number of days with PA lasting 60 minutes or longer declined from 3.89 to 3.30. There was also a decrease in sleep duration on both weekdays and weekends. The average duration of sleep (including naps) was 8.83 hours before the COVID-19 pandemic and decreased to 8.55 hours during school days. Similarly, on weekends, the average duration of sleep decreased from 10.11 to 9.52 hours. The amount of time spent playing computer games also increased (from 1.29 hours to 1.64 hours; $p<0.0001$ ), particularly on weekdays. However, the use of smartphones on a typical day decreased during the pandemic, from 3.14 to 2.81 times per day ( $p=0.0016$ ).
Bronikowska et al., 2021 [15]	n=127 52% girls 15.4±0.5 years	PASM	PA	The negative ramifications of COVID-19 on PA of young individuals necessitate a proactive approach from PE teachers and parents to encourage and provide support for youths in adopting a systematic PA regimen. Among adolescents who failed to meet the recommended levels of MVPA prior to the pandemic, a notable 13.4% experienced an increase in the frequency of PA (from 2.9 to 5.4 days per week) ( $p=0.01$ ) during the COVID-19 period. Conversely, within the cohort that did meet these recommendations before the onset of the pandemic, a substantial 50% witnessed a significant decline in their MVPA levels below the recommended thresholds ( $p=0.01$ ). Furthermore, the self-assessed health status pertaining to PA exhibited a strong and statistically significant correlation with MVPA in the group of students who adhered to WHO guidelines before the pandemic ( $r=0.76$ ; $p<0.05$ ), only to falter in maintaining said recommendation throughout the COVID-19 restrictions.
Chmelik et al., 2021 [5]	n=828 56% girls 16.31 years Katowice, Wrocław	IPAQ-LF BQ WHO-5	PA, SB	Supporting the current subjective well-being in schools and promoting OPA both within and after school, with a specific focus on attaining VPA recommendations, can contribute to enhancing general life satisfaction (LS) and fostering a healthy lifestyle among adolescents. Boys with the highest LS were 1.94 times more likely to meet the weekly VPA recommendations than boys with the lowest LS. Similarly, girls with the highest LS were 1.77 times more likely to achieve these recommendations.
Groffik et al., 2021 [6]	n=3499 55% girls 16.38 years Silesian region	IPAQ-LF	PA	Schools, sports clubs, and recreational institutions should aim to enhance the involvement of adolescents in OPA. It is crucial for comprehensive PE programs to incorporate various forms of OPA that cater to individual health vulnerabilities, specific aptitudes for particular types of PA, and preferred PA modalities among adolescents. In terms of gender disparities, boys exhibited higher levels of PA compared to girls in school environments ( $p=0.016$ ), recreational settings ( $p=0.001$ ), VPA ( $p<0.001$ ),

				and overall PA ( $p<0.001$ ). Conversely, girls displayed greater PA than boys in terms of walking ( $p<0.001$ ). When considering the two-year intervals (2012-2013, $p=0.002$ ; 2014-2015, $p=0.020$ ; 2016-2017, $p<0.001$ ; 2018-2019, $p=0.099$ ), it was found that boys reported significantly higher levels of VPA. However, no significant gender differences were observed in other types of weekly PA. Importantly, there was no decline in OPA participation among boys (38.6% in 2012-2013 and 41.1% in 2018-2019) or girls (29.0% in 2012-2013 and 32.6% in 2018-2019).
Drywień et al., 2021 [43]	n=616 76% girls 16-19 years Warsaw	KomPAN	PA, SB	Implementing interventions to enhance nutrition knowledge and PA among high school students is crucial for fostering healthier dietary habits.
Frömel et al., 2021 [16]	n=2864 59% girls 12-18 years	Yamax Digiwalker SW-700 pedometers	PA, PE	The utilization of pedometers to monitor the number of steps taken during PE classes and to obtain a simplified estimation of PA holds substantial value in the natural school environment. Furthermore, it possesses the potential to serve as a powerful catalyst for enhancing health and physical literacy. The data obtained from measuring step counts in PE lessons serves as a crucial starting point for determining PA promotion strategies, as well as for the future advancement of PE and the exploration and validation of novel online PE formats. Notably, it has been observed that, on average, boys exhibit a higher level of PA during PE lessons compared to girls, as evidenced by the recorded step counts. In the context of school practice, boys tend to report a greater number of steps during PE classes than girls. Similarly, in PE lessons conducted by student teachers, girls tend to record more steps per class compared to those led by PE teachers.
Baran et al., 2020 [10]	n=1002 53% girls 9.36 years $\pm$ 3.52	Accelerometer Actigraph wGT3X-BT monitor	PA, SB	Failing to meet the recommended standards of PA is linked to an increased probability of developing overweight and obesity. The magnitude of PA has a noteworthy influence on the prevalence of overweight and obesity. Gender discrepancies were observed in levels of PA, particularly among individuals in the oldest age bracket ( $p = 0.002$ ). Boys between the ages of 12 and 15 participated in an average of 12.7 minutes more of MVPA compared to girls. Even among the youngest children (4-6 years), the disparity was statistically significant ( $p=0.016$ ), with boys averaging 9.1 minutes more of MVPA in their favor. Age played a significant role in distinguishing the activity levels of girls ( $p=0.037$ ). In this context, it was the youngest and oldest age groups that demonstrated the lengthiest duration of MVPA.
Frömel et al., 2020 [8]	n=6380 52% girls 16-17 years	IPAQ-LF Digi-Walker SW-700 pedometers ActiTrainer accelerometers	PA, PE	PA recommendations aimed at bringing about positive changes in the educational process and school lifestyle have been proposed. Previously, recommendations for PA within the school setting were suggested, which included achieving 3,000 steps during school time, engaging in 20 minutes of MVPA during school time (equivalent to at least 3 metabolic equivalents), engaging in 20 minutes of MVPA during school time (equivalent to at least 60% of maximum heart rate), and ensuring that 25% of school time is dedicated to PA. Nevertheless, our school PA recommendations complement general PA recommendations and consist of the following: engaging in VPA for a minimum of 20 minutes at school (approximately 360 METs-min) at least three times per week; engaging in MVPA for a minimum of 30 minutes at school (approximately 600 MET-min) at least five times per week; engaging in walking for a minimum of 30 minutes at school (approximately 500 MET-min) at least five times per week; and, the most challenging recommendation, engaging in any form of MVPA for a minimum of 60 minutes at least five times per week, as well as engaging in VPA for a minimum of 20 minutes at least three times per week (approximately 1260 MET-min). On average, Polish adolescent boys and girls achieved 10,799 $\pm$ 3,692 and 10,130 $\pm$ 3,121 steps per day, respectively.

Pluta et al., 2020 [22]	n=902 55% girls 16.4±0.7 years	SSYSS	PA, PE	Interventions targeting adolescents within school settings should prioritize the inclusion of family, teachers, and peers as crucial sources of social support in promoting overall PA and elevating its levels. The level of MVPA was determined by five variables: engagement in sports training, support from teachers, support from parents, gender, and BMI. Notably, both the support from teachers and parents exhibited comparable direct effects, signifying that the social support provided by both teachers and parents significantly impacts adolescent MVPA.
Kuśnierz et al., 2020 [23]	n=1340 50% girls 13-19 years	“Which version of PE presented below is closest to the one you would like to pursue at your school?”	PA, PE	Teachers should adhere to the preferences of students when it comes to PE programs. Specifically, they should organize PE classes in a more enjoyable manner for girls and focus on exercise-related activities for boys. Throughout adolescence, there should be a shift in the proportions of these preferred PE profiles, with an increase in exercise-related forms and a decrease in fun-related ones. The data shows that the majority of students (63%) participated in PE for fun, pleasure, and entertainment, while only one third (31%) preferred PE classes focused on exercise, sweat, and fitness. Interestingly, the preference for fun-related PE classes decreased by 41% for boys and 31% for high school students. On the other hand, the preference for exercise-related PE classes increased by 56% for boys and 31% for high school students.
Groffik et al., 2020 [34]	n=2284 59% girls 15-19 years Katowice region	Yamax Digiwalker SW-700 pedometers	PA	Between the years 2011-2014 and 2015-2018, no notable disparities were discerned in the number of steps taken during an average day of the week, a typical day at school, or a weekend day. The majority of boys and girls individuals failed to meet the prescribed recommendation. Friday emerged as the day when both boys and girls exhibited the highest level of PA, while Sunday witnessed the lowest level. The quantification of PA, as indicated by the daily step count, did not diminish over the course of the two consecutive four-year periods. On average, boys completed 10,799 steps per day, while girls achieved 10,130 steps per day. The objective of attaining 11,000 steps per day was fulfilled by 42.2% of boys and 35.3% of girls. An appreciable decline of 8.6 percentage points in achieving the 11,000 steps per day benchmark was solely witnessed in boys between the two four-year intervals.
Laudańska-Krzemińska et al., 2020 [44]	n=231 53% girls 14.8±1.1 years Gorzów Wielkopolski and Poznań	PASM Tanita MC-980MA multi-frequency analyzer	PA, SB	Differences were observed between active and inactive girls concerning body satisfaction, highlighting how PA contributes to emotional well-being. PA not only assists in achieving recommended levels of MVPA for health but also acts as a protective factor for emotional health. It is crucial to promote health-oriented behaviors, particularly emphasizing individual responsibility for one's health. Greater consideration should be given before exempting young individuals from mandatory PE, as these classes often represent their primary form of PA.
Frömel et al., 2020 [31]	n=596 62% girls 15-19 years	IPAQ-LF WHO-5	PA	The female and male individuals who conveyed the highest levels of despondent indications and the most minimal level of prosperity experienced a notably lesser amount of leisurely PA on a weekly basis. The connection between depressive indications and PA was even more pronounced among females. Adolescents who are at the highest risk of experiencing depressive indications have the greatest potential for modifying their behavior through the encouragement of recreational PA. Females who experienced the fewest depressive indications had a 2.12 times greater likelihood of meeting the recommended daily step count of 11,000.
Myszkowska-Ryciak et al., 2020 [42]	n=14044 54% girls 13-19 years	NHANES Tanita MC-980MA multi-frequency analyzer	SB	The study presents data on the screen time and nutritional habits of adolescents in two important aspects. Further research is needed to establish effective programs that promote health by clarifying the potential causal relationships between dietary behavior and screen time. The duration of average screen time increases with age, going from 2.6 hours for 13-year-olds to 3.2 hours for 19-year-olds. There are also significant differences in screen time between genders, with boys having notably higher screen time in all age groups (2.7 hours vs 2.5 hours in the youngest group and 3.5 hours vs 3.0 hours in the oldest



				group). The probability of meeting the recommended screen time for girls, regardless of age, was almost 50% higher compared to boys.
Groffik et al., 2020 [32]	n=1599 59% girls 15-19 years Katowice region	Pedometer Digi-Walker SW-700	PA	The focus on promoting PA among less active adolescents, particularly on Mondays, seems to be beneficial. This targeted approach may help compensate for the lower levels of PA observed on weekends and contribute to reducing the gap between individuals with different PA levels during the following days. Encouragingly, throughout the 8-year study period, there was no decline in PA among adolescents with the lowest activity levels. Importantly, regardless of gender, there were no significant differences in the composition of 7-day PA among participants with different PA levels. The differences in daily step counts related to PA levels were smallest on Mondays and most pronounced on Fridays and Saturdays, seen in both boys and girls. The disparities between average school days and weekends were most noticeable among less active girls (1677 steps/day) and boys (1886 steps/day). During the school week, a higher percentage of less active girls met the recommendation of 11,000 steps/day on Fridays (21.9%), which was a statistically significant difference compared to other school days. Similarly, less active boys (22.2%) showed significantly lower activity on Fridays compared to other school days, except for Mondays.
Frömel et al., 2020 [33]	n=1343 57% girls 15-17 years	IPAQ-LF	PA	The integration of AT recommendations should be included in comprehensive school-based PA programs. Policymakers at the state, school, and municipal levels in the Central European region should prioritize enhancing well-being and developing the built environment to facilitate AT among secondary school adolescents. Notably, AT contributes to 24.2% of the weekly PA among boys and 24.5% among girls.
Groffik et al., 2020 [30]	n=292 65% girls 15-17 years	IPAQ-LF ActiTrainer accelerometers YAMAX Digi-Walker SW-700 pedometers	PA	The educational system in Poland provides a higher likelihood for adolescents to meet recommendations for MVPA compared to the Czech system. Additionally, PE constitutes a greater proportion of daily PA in the Polish system compared to the Czech system. The total daily step count between Polish and Czech adolescents did not show statistical significance. Specifically, PE accounted for 30-37% of the daily PA measured by step count in Polish girls (compared to 23-30% in Czech girls) and 28-39% in Polish boys (compared to 25-37% in Czech boys).
Pasek et al., 2020 [35]	n=220 experimental 52% girls control group 46% girls Initial test: Experimental group 11.26 years old ( $\pm 0.32$ ), control group 11.28 years ( $\pm 0.32$ ). Final test, experimental group 12.96 years ( $\pm 0.32$ ), control group 12.98 years ( $\pm 0.32$ )	International Physical Activity Test	PA	The initial measurement did not reveal any statistically significant differences in the levels of specific components of physical fitness (with p-values ranging from $p=0.340$ to $p=0.884$ ). However, notable distinctions emerged in three tests: running speed ( $p=0.001$ ), leg power ( $p=0.001$ ), and endurance ( $p=0.000$ ). These findings provide encouragement to further explore pedagogical experiments concerning PA in outdoor natural environments.
Kudlacek et al., 2020 [36]	n=3513 54% girls	QPAP IPAQ-LF	PA	For boys, physical fitness ranked third among their preferences, following team and individual sports. Conversely, girls showed an increased inclination towards physical fitness while diminishing their preference for dance and outdoor PA. Importantly, among boys, those who favored physical fitness were more likely to achieve the recommended weekly PA level compared to those who did not prefer it. In promoting adolescents' PA, it is crucial to consider their preferred types of PA. Nearly 33% of adolescents who expressed a preference for physical fitness met the PA recommendation, whereas only

				22% of those who did not favor fitness activities achieved this recommendation. This underscores the significance of OPA in meeting PA recommendations.
Malinowska-Cieślak et al., 2019 [45]	n=2562 15-17 years	PAS HBSC	PA, SB	The study results emphasize the necessity of integrating the enhancement of interpersonal skills, the promotion of PA, and the support for school performance within mental health promotion programs tailored for adolescents, especially girls. The score of 13.25 (SD=3.74), within a scale ranging from 0 to 20. From the initial variables, eight out of 18 were incorporated into the final model, elucidating 25.1% of the variability observed.
Wadolowska et al., 2019 [46]	n=464 53% girls 11-12 years	Author's questionnaire	PA, SB	In preventing obesity among pre-teenagers, educational interventions should prioritize the elimination of unhealthy dietary habits while also focusing on fostering pro-healthy dietary habits, increasing PA, and reducing screen time. Strengthening pro-healthy dietary habits in pre-teenagers may necessitate educational programs targeted at adults responsible for children's nutrition. After a nine-month period, the group that received education (compared to the control group) exhibited a significantly greater improvement in their nutrition knowledge scores (mean difference in change: 1.8 points). However, they also showed a notable decrease in PA (mean difference in change: -0.20 points), non-healthy dietary index (nHDI) (-2.3% points), z-score for waist-to-height ratio (-0.18 SD), and z-score for waist circumference (-0.13 SD). Logistic regression analysis, adjusting for confounding factors, indicated that after nine months, individuals in the educated group had more than twice the chance of achieving a nutrition knowledge score at least equal to the median. Conversely, the likelihood of being in the nHDI category at least equal to the median was notably lower (by 35%) in the educated group compared to the control group.
Kolmaga et al., 2019 [47]	n=622 50% girls 12-18 years Lodz	HBSC	PA, SB	Excess body weight was evident in 23.5% of the examined youth. Factors significantly influencing the occurrence of overweight or obesity, as revealed by multivariate logistic regression analysis, included: irregular dinner habits (either daily or occasional, OR=1.98); inadequate daily consumption of fruits and vegetables (OR=1.57); prolonged periods of passive relaxation involving TV or internet usage (OR=3.08); and low levels of PA (OR=1.76). An intensive promotion of a healthy lifestyle, emphasizing increased awareness and knowledge among schoolchildren, fostering proper eating habits, and encouraging active leisure activities, can significantly contribute to reducing risk factors associated with obesity. Health education should be incorporated within school curriculums aimed at both children and their parents, along with teachers, to address these concerns effectively.
Jodkowska et al., 2019 [26]	n=1173 100% girls	<i>Healthy Me</i> intervention program	PA, SB	Public health interventions directed towards adolescents should underscore the positive aspects of health and endorse a lifestyle that prioritizes health-promoting behaviors. Consistent participation in PE classes emerged as a significant predictor, nearly as impactful as the absence of chronic diseases or disabilities. Approximately two-thirds of the girls assessed their health as excellent or good, with only 5% reporting an "extremely negative" evaluation. In the final multivariate analysis, five factors retained significance as significant predictors of high self-rated health scores: regular involvement in PE, engaging in VPA, consuming breakfast daily, eating fruit at least once a day, and ensuring a minimum of 8 hours of sleep per day. These elements significantly contribute to how adolescents perceive their health and overall well-being.
Wadolowska et al., 2018 [27]	n=1549 51% girls 11-13 years	ABC of Healthy Eating national multicentre project	PA, SB	There is need for targeted health interventions specifically tailored for Polish adolescents, particularly those who come from less privileged backgrounds. These interventions should focus on encouraging the consumption of foods that promote health, establishing regular eating habits, and promoting a more active lifestyle. It was observed that adherence to the Prudent-Active pattern was significantly lower in 12- and 13-year-olds compared to 11-year-olds, with a reduction of 29% and 49% respectively.

				Furthermore, adherence to the Prudent-Active pattern was significantly higher in the middle or upper tertile of nutrition knowledge scores compared to the bottom tertile, with an increase of 57% or 2.4 times. On the other hand, adherence to the Fast-food-Sedentary pattern was much lower in the middle or upper tertile of nutrition knowledge scores compared to the bottom tertile, with a decrease of 41% or 58%. In terms of health outcomes, it was found that adherence to the Prudent-Active pattern was associated with a notably lower likelihood of central obesity and overweight/obesity compared to the notPrudent-notFast-food-lowActive pattern, with reductions of 47% and 38% respectively, depending on the standard used. However, in the Fast-food-Sedentary pattern, the likelihood of central obesity was 2.22 times higher compared to the Prudent-Active pattern.
Kleszczewska et al., 2018 [48]	n=4085 52 % girls	SLSS Health and School 2015	PA, SB	It's vital to establish an environment conducive to sports participation, particularly targeting youths from underprivileged families, by offering access to free sports classes, sports scholarships, and other forms of support during their leisure time. This approach serves to bolster the satisfaction of adolescents' lives and fosters social inclusivity. The average score on the Students' Life Satisfaction Scale was M=4.66 (SD=2.23), with approximately 36.9% of its variability primarily explained by self-esteem. The influence of PA on self-esteem was notably more pronounced as family affluence declined, indicating that socioeconomic status may alter how behavioral factors impact the variability of SLSS scores during adolescence.
Król-Zielińska et al., 2018 [37]	n=1231 58% girls 16.3±0.6 years	IPAQ-LF Motives for Physical Activity Measure-Revised	PA	Increased scores in competence and appearance-related motivations for PA were identified as predictors for a higher level of VPA intensity among adolescent boys and girls. For boys, all motivations collectively predicted a 10.4% variation in VPA intensity ( $F(5, 509) = 11.822, p < 0.001$ ). Similarly, in girls, these motives accounted for a 7.4% variance in VPA intensity ( $F(5, 710) = 11.292, p < 0.001$ ).
Frömel et al., 2018 [12]	n=729 59% girls 15.9 years	IPAQ-LF	PA	The educational framework appears effective in promoting increased levels of PA among young individuals by offering a broader range of organized PA opportunities. Girls were observed to engage less in VPA compared to boys, underscoring the need for more involvement of girls in OPA initiatives. VPA recommendations were met by 64.5% of boys and 51.3% of girls. Adolescents, participation in OPA was identified as the primary factor associated with meeting the recommendations for VPA ( $p < 0.001$ ; CI = 1.99-5.37).
Mitáš et al., 2018 [38]	n=2001 57% girls 15.8 years	IPAQ-LF NEWS- Abbreviated	PA	Adolescents meeting the recommended amount of leisure-time walking is significantly higher when they perceive their neighborhood environment as the safest. On average, adolescents residing in the safest environment achieved 11,024 steps per day, while those in the least safe environment achieved 9,686 steps per day.
Wasilewska et al., 2018 [39]	n=916 51% girls 16-18 years Eastern region of Poland	IPAQ-LF	PA	PA levels among young individuals in Eastern Poland tend to decline as they grow older, evident in both girls and boys. Hence, it is crucial, particularly for the emerging adult group, to introduce diverse, updated, engaging, age-specific, and gender-oriented PA classes within schools. These programs should be adaptable for practice outside the school setting to enhance PA levels during leisure time. In terms of total PA, girls averaged 5,345.5 MET-minutes/week, while boys averaged 6,556.6 MET-minutes/week. Notably, pupils from small towns and villages exhibited higher PA levels compared to youth residing in larger cities and medium-sized towns.
Kopcakova et al., 2017 [49]	n=3003 51% girls 13.8 years	Health Behaviour in School-aged Children cross- sectional study from	PA, SB	A positive perception of the environment, in terms of its facilitation of PA, is associated with an increased probability of adolescents meeting the recommended PA guidelines (odds ratio (OR) for one standard deviation (SD) change = 1.11, 95% confidence interval (CI) 1.05-1.18). Conversely, this perception is linked to a decreased likelihood of excessive engagement in screen-based activities (OR

		four European countries		for 1 SD improvement = 0.93, 95% CI 0.88-0.98). Investing in an environment that promotes physical activity can significantly contribute to the promotion of active lifestyles among adolescents.
Bronikowski et al., 2016 [24]	n=196 65 adolescents (mean age 17.2±0.2) 54% girls, 74 (mean age 15.3±0.2) 43% girls, 57 (mean age 11.5±0.4) 53% girls	Classmate and Teacher Support scales Garmin Vivofit activity trackers	PA, PE	There were no observed interactional effects between gender and teacher support concerning MVPA and step count. Despite a reported high level of support from classmates in PE, the study indicates that it does not notably influence the increase in MVPA behaviors among young individuals. However, the issue of considerably lower support provided to adolescent girls by PE teachers warrants attention within the context of PE student teaching and needs to be addressed within school settings.
Frömel et al., 2016 [50]	n=97 60% girls 17 years	ActiTrainer accelerometer	PA, SB	The study addressed significant aspects concerning global public health within school environments. It highlighted the crucial relationships with family, aiming to raise awareness and comprehension of public health issues among the researched sample. Findings suggested reduced time spent in physical inactivity but revealed increased screen time during weekends. Interestingly, boys and girls engaged in comparable levels of PA during school and weekend days, with more participation in lower-intensity PA during weekends in contrast to school days.
Dmitruk et al., 2016 [51]	n=175 63% girls 16-19 years Biała Podlaska	Diet – Author’s questionnaire IPAQ-SF	PA, SB	The majority of girls and boys displayed high levels of PA. Surprisingly, there wasn't a clear correlation found between dietary habits and PA levels. Girls in high and moderate PA groups differed mainly in terms of their daily meal frequency, along with the consumption of meat and sweets. Similarly, among boys, significant differences between PA groups were found in the consumption frequencies of whole-wheat bread, meat, and fast food. Notably, those food items were more frequently consumed by girls and boys with higher PA levels.
Tabak et al., 2015 [52]	n=1484 53% girls 14.6-16.5 years	HBSC	PA, SB	Boys exhibited higher levels of both MPA and VPA compared to girls ( $p<0.001$ ). Within the 30 days preceding the study, 39.0% of respondents reported alcohol consumption, 23.5% smoked cigarettes, and 10.7% used marijuana. Among boys, higher engagement in PA was associated with lower rates of tobacco smoking and marijuana use. However, no confirmed association between alcohol use and PA was observed among both boys and girls. Boys who dedicated at least one hour four times a week to MPA had about 2-4 times higher chances of abstaining from cigarettes and marijuana.
Goluch-Koniuszy et al., 2015 [56]	n=1342 50% girls 13 years Szczecin	BMI WC Author’s questionnaire	SB, PA	Adolescents in Szczecin displayed comparable rates of adopting slimming diets to reduce body mass when compared to other regions in Poland and Europe. The methods predominantly involved pro- or anti-healthy nutritional behaviors rather than focusing on PA or specific slimming diets. Consequently, monitoring the nutritional status of adolescents and imparting education on healthy nutrition appear crucial. Approximately 73% of the subjects demonstrated normal or adequate nutritional statuses. Notably, half of those attempting to lose body mass (13.04%), primarily girls, exhibited normal BMI indicators. Common strategies employed for weight loss included reducing food portions, skipping dinner, intermittent fasting for 1-3 days, increasing PA, reducing sweet intake, abstaining entirely from sweets, and augmenting fruit and vegetable consumption. Slimming diets were adopted by 13.1% of the subjects.
Jodkowska et al., 2015 [57]	n=3346 52% girls 10-16 years	BBA	SB, PA	Identifying barriers to PA among adolescents is crucial for devising effective interventions, especially for high-risk populations. Among the reported obstacles, lack of energy, time, and support were three out of five hindrances identified by over 40% of adolescents. This trend was more pronounced among older youth than younger ones and was more commonly reported by girls than boys. For boys, predictors contributing to low PA included lack of time (OR=2.56; CI=1.66-3.96), skills (OR=2.35; CI=1.94-3.95), willpower (OR=1.71, CI=1.05-2.80), and support (OR=1.64, CI=1.11-2.41). In contrast, among girls, lack of skills (OR=3.16, CI=1.62-6.18), energy (OR=1.84, CI=1.14-2.96), support (OR=1.64, CI=1.07-

				2.54), and time (OR=1.61, CI=1.00-2.60) were significantly associated with physical inactivity. These perceived barriers to PA significantly impact achieving recommended PA levels. Among girls, lack of skills emerged as the strongest predictor of low PA, while for boys, lack of time was identified as the primary barrier. A more precise understanding of these barriers among adolescents could aid in developing more effective interventions, particularly for high-risk populations.
Wojtyła-Buciora et al., 2014 [25]	n=1100 16-19 years Kalisz District	Author's questionnaire	PA, PE	Encouraging a healthy lifestyle through educational programs targeted at teenagers is essential, especially during the crucial period of their physical development. This phase of transitioning into adulthood is pivotal for acquiring the necessary knowledge, beliefs, skills, and attitudes that contribute to a pro-healthy lifestyle in later years. A significant proportion of students, 87% in elementary, 96% in middle, and 89% in secondary schools, actively participated in PE. However, a considerable number of pupils across these school levels spent significant daily or near-daily time on a computer (52%, 60%, and 70% for elementary, middle, and secondary schools, respectively) and watching TV (70%, 62%, and 48% for elementary, middle, and secondary schools, respectively). These statistics underscore the importance of promoting more active and healthier pursuits during leisure time among school-age children and teenagers.
Jodkowska et al., 2014 [53]	n=574 50% girls 13 years	Self-reported their physical activity Regularity of breakfast eating and fruit and vegetable consumption	PA, SB	Unhealthy habits have a tendency to accrue more frequently in the teenage population, particularly in girls, thereby increasing the susceptibility to various chronic ailments. In order to reap substantial health benefits in the future, it would be advantageous to widely disseminate guidelines on leading a healthy lifestyle among adolescents, their parents, and teachers, as well as implement interventions aimed at mitigating these unhealthy behaviors. The proportion of surveyed teenagers who adhered to each health recommendation varied: 69% consumed breakfast on 5 school days, 46.9% consumed fruits and vegetables at least once daily, and 27.5% engaged in the recommended daily physical activity. Boys exhibited significantly higher rates of PA ( $p<0.001$ ) and consumed breakfast more frequently compared to girls ( $p<0.04$ ). There was no statistically significant gender disparity in fruit and vegetable intake. However, only 11.5% of adolescents fulfilled all three recommendations, with boys being more inclined to meet all three compared to girls ( $p=0.020$ ). Almost 54% of teenagers displayed multiple unfavorable health behaviors, with 14.1% adhering to all three unhealthy behaviors, a trend that was significantly more prevalent in girls than boys ( $p=0.011$ ). The identification and addressing of these patterns of unhealthy behaviors, especially in girls, is of paramount importance in the promotion of improved health outcomes in adolescents.
Bergier et al., 2014 [40]	n=2974 60% girls 16-18 years	IPAQ-SF	PA	It has been observed that girls exhibit lower levels of PA compared to boys. The study confirms that the place of residence does not have a correlation with the level of PA. However, the frequency of attending PE has emerged as a significant factor for both boys and girls. Furthermore, adolescents who lead a more sedentary lifestyle tend to have lower overall levels of PA. There is no variation in SB between girls and boys in relation to the overall scope of physical activity or its three intensity levels (low, moderate, high).
Cych et al., 2013 [54]	n=450 50% girls 13-15 years South-Western Poland	GYTS	PA, SB	Engaging in PA is particularly advantageous for girls, as those who remain physically inactive may have a higher tendency to turn to alcohol. Nevertheless, it's crucial to consider the specific type of PA and the nature of the effort expended, as highlighted by the authors of similar studies.

Vašíčková et al., 2013 [41]	n=495 55% girls 15.8±0.9 years	IPAQ-LF Digi-Walker SW-700	PA	Pedometers have shown to enhance lifestyle awareness among students in school settings, particularly garnering acceptance among girls. Interventions utilizing PA monitoring through pedometers have effectively promoted PA in both adolescent boys and girls. These findings suggest the need for PE teachers to design school PE and extracurricular PA programs that integrate pedometers, given their positive impact on PA, especially for girls. Interestingly, boys exhibited the lowest level of PA on Sundays (n=10,390±3,728 steps•day <sup>-1</sup> ), while they generally had higher step counts on school days compared to weekends ( <i>p</i> <0.01). Conversely, following the intervention, girls displayed increased step counts throughout the week. Moreover, the four-week intervention successfully reduced the disparity in overall PA between adolescent girls and boys, as well as the difference in activity levels between school days and weekends among girls.
Piotrowska et al., 2009 [29]	n=409 100% girls 16-18 lat Wrocław	Author's questionnaire PA	PA	20.6% achieve PA recommendations, 42.5% practice PA outside of school activities, 18.1% do not practice PA. Motivation for undertaking PA is weight reduction (PA correlated with reduction diet)

Notes: **IPAQ-LF** International Physical Activity Questionnaire-Long Form, **IPAQ-SF** International Physical Activity Questionnaire--Short Form, **WHO-5** Well-Being Index, **FFQ-6** Food Frequency Questionnaire, **BQ** Bern Subjective Well-Being Questionnaire, **KomPAN** The Beliefs and Eating Habits Questionnaire, **SSYSS** Physical Activity Screening Measure Short Scale of Youth's Social Support Assessment, **PASM** Physical Activity Screening Measure, **NHANES** Anthropometry Procedures Manual by National Health and Nutrition Examination Survey, **QPAP** Questionnaire on Physical Activity Preferences, **PAS** Positive Attitude Scale, **HBSC** Health Behavior in School-Aged Children, **SLSS** Students' Life Satisfaction Scale, **BMI** Body Mass Index, **WC** Waist Circumference index, **BBA** Barriers of being active. What keeps you from being more active?, **GYTS** Core Questions Global Youth Tobacco Survey, **PA** physical activity, **SB** sedentary behavior, **PE** physical education, **OPA** organized physical activity, **AT** active transport, **MPA** Moderate Physical Activity, **MVPA** Moderate to Vigorous Physical Activity, **VPA** Vigorous Physical Activity.

### *Measurement*

None of the articles used qualitative research methods. All used quantitative methods and a measurement tool to assess PA or SB. In 7 articles, the author's questionnaire was one of the tools [1,3,25,29,46,51,55]. Physical activity levels were assessed using questionnaires and objective tools. One article diagnosed physical activity levels using the International Physical Activity Test [35]. Twelve articles used the International Physical Activity Questionnaire-Long Form (IPAQ-LF) [2,5,6,8,12,30,34,36-39,41], and 2 articles used the International Physical Activity Questionnaire-Short Form (IPAQ-SF) [40,51]. Physical activity levels were assessed in 3 articles using the Physical Activity Screening Measure [15,22,44]. The questionnaire used in one article was a self-report on their physical activity (MVPA – Moderate-to-Vigorous Physical Activity) [53]. Physical activity levels were assessed in 6 articles using Yamax Digiwalker SW-700 pedometers [8,16,30,32,34,41]. In one article, an Actigraph accelerometer wGT3X-BT monitor was used [10]; while in the another article, Garmin Vivofit activity trackers were used [24]. An ActiTrainer accelerometer was used in 2 publications [34,50].

The variables that allow for a more detailed analysis of PA and SB are PA factors. Students' attitudes towards health behaviors were examined in one article using the Positive Attitude Scale [PAS] [45]. Two articles used the Motives for Physical Activities Measure-Revised (MPAM-R) to assess motives for engaging in physical activity among adolescents [37]. Sport and recreation preferences were examined in one article using the Questionnaire on Physical Activity Preferences (QPAP) [36]. Life satisfaction was examined in one article using the Students' Life Satisfaction Scale (SLSS) [28,48]. The level of well-being was assessed in one article using the Bern Subjective Well-Being Questionnaire (BQ) [5], and 3 studies applied the WHO-5 Well-Being Index [2,5,8]. Adolescents' support from the educational environment for PA was examined in one article using the Short Scale of Youth's Social Support Assessment

(SSYSS) [22], and in another article, the Classmate and Teacher Support scales were used [24]. Barriers to physical activity were investigated in one article using the questionnaire “Barriers of being active. What keeps you from being more active?” [57]. The relevance of PE to PA was investigated in one article with the question: “Which version of physical education presented below is closest to the one you would like to pursue at your school?” [23]. Health behavior of school-aged children and adolescents was investigated in 4 articles through the Health Behaviour in School-Aged Children questionnaire [45,47,49,52]. Eating habits were studied through the Beliefs and Eating Habits Questionnaire (KomPAN) [43], whilst regularity of eating breakfast and fruit and vegetable consumption [53] was assessed using the Food Frequency Questionnaire (FFQ-6) [1]. An article examining the relationship of stimulants on PA was found that used the Core Questions Global Youth Tobacco Survey (GYTS) [54]. The OMRON M3, for checking blood pressure, was also used in one study [21]. The differentiating variable in 3 articles was body parameters (mostly weight), calculated using the Tanita MC-980MA multi-frequency analyzer [1,42,44,56].

### **Main findings related to physical activity and sedentary behavior**

#### *Physical activity recommendations*

The 18 articles included in the analysis raised the issue of PA recommendation. We know the volumes and intensities of PA needed to maintain health. Information for students alone is not sufficient to create an attitude for PA. They should be equipped to meet PA requirements. The attainment of 11,000 steps per day was successfully reached by 42.2% of male individuals and 35.3% of their female counterparts. It is noteworthy that, over the course of an 8-year observational study on PA, there was no statistically significant decline in the mean



daily step count for both male and female participants. However, it is worth noting that the majority of boys and girls did not comply with the aforementioned recommendation [30]. At least 2,000 steps or 10 minutes of MVPA before school and a minimum of 6,000 steps or 30 minutes of MVPA after school is recommended. During school hours, it is suggested to achieve at least 500 steps/hour or 3,000 steps during school time, along with 20 minutes of MVPA ( $\geq 3$  METs or 60% HR<sub>max</sub>) and at least one HR<sub>submax</sub>/max response to significant stress during physical activity to alleviate educational stress and reduce sedentary behavior. PA should encompass at least 25% of school time, even on days without scheduled physical education lessons [8]. Participation in PE was linked to a higher likelihood of meeting school physical activity recommendations [34]. However, the level of PA among young people in the eastern region of Poland is declining with age [39], and only 27.5% of adolescents achieved the recommended daily PA [53]. 20.6% achieved recommended PA, 42.5% engaged in PA outside school, while 18.1% did not participate in any PA [29]. There wasn't a significant difference observed in other types of PA concerning meeting the recommendation of 11,000 steps/day. A preference for fitness-related PA was associated with an increased probability of meeting PA recommendations [36]. Moreover, an environment perceived as activity-friendly was linked to higher odds of meeting PA recommendations and lower odds of excessive screen-based activities [49]. Pedometer use appeared to narrow the disparity in physical activity levels between adolescent girls and boys, including during school and the weekend, over a four-week period [41]. Social support from teachers and parents significantly predicted MVPA, emphasizing their influential role [22]. However, classmates' support in PE did not significantly affect the increase of MVPA behavior in adolescents [24]. Adolescents with the most depressive symptoms and lower well-being engaged in fewer weekly recreational activities [30]. PA was shown to positively correlate with self-esteem, particularly influencing overall life satisfaction, more noticeably among less affluent adolescents [28,48]. Associations between VPA and life

satisfaction (LS) were robust among adolescent boys and girls, highlighting the significance of VPA within weekly school PA, PA outside school and organized PA. Programs supporting at least three periods of no less than 20 minutes of VPA per week should be encouraged in school PA initiatives [5]. Overweight and obese children spent less time per day on moderate-to-vigorous physical activity [10]. During the COVID-19 pandemic, adolescents who did not meet WHO recommendations for MVPA before lockdown showed increased PA frequency (from 2.9 to 5.4 days/week) ( $p=0.01$ ) during lockdown. However, 50% of those who met the recommendations before the lockdown significantly reduced their MVPA levels below the WHO recommendations ( $p=0.01$ ). Self-rated PA health strongly correlated with MVPA in students who met the WHO recommendations before the pandemic but did not maintain this during the lockdown [15].

#### *Weekdays versus weekend days*

The weekly cross-section of PA and the comparison between weekly and weekend PA was analyzed in 2 articles. It is important to note that the significant impact of school on SB and PA (mainly through PE) is related to whole-week PA. Overwhelmingly, how time is spent at the weekend was self-selected by students. Between the years 2011 to 2014 and 2015 to 2018, no noteworthy disparities were discerned in the quantities of steps taken on an average weekday, school day or weekend day. Consequently, there is neither a decline nor an enhancement evident during the latter segments of the week in relation to physical activity. Both male and female individuals were most physically active on Fridays and least active on Sundays [30]. The disparities in the compositions of weekly physical activity among adolescents with lower and higher levels of physical activity are not statistically significant. Adolescents with lower physical activity levels tend to be most active on Fridays (boys with

8,409 and girls with 8,591 steps per day) and least active on Sundays (boys with 5,449 and girls with 5,694 steps per day), with less than 5% of them adhering to the recommended 11,000 steps per day. Similar patterns were observed in the group with higher overall levels of physical activity. The most noticeable discrepancy between the lower and higher physical activity level groups was observed on Saturdays, while the least difference was noticed on Mondays [32].

### *Active transportation*

The essence of active transportation was analyzed in 2 articles. Considering the recommendations by segments of the day (before school, during school and after school), active transportation is extremely important for PA. Poland's 2022 Report Card comparing the results from 2016, 2018 and 2022 shows that the effectiveness of active transportation in Poland has decreased [4]. The association between a greater incidence of active transportation and heightened well-being was found to be statistically significant solely in girls. Nevertheless, the probability of adhering to the weekly PA guidelines was amplified in both girls and boys when active transportation recommendations are met in conjunction with a higher level of well-being. Specifically, active transportation contributed to 24.2% of boys' weekly PA, whereas in the context of girls in Poland, it constituted 24.5% of their weekly PA [33].

### *Organized leisure-time activities/physical education lessons*

The literature draws attention to the importance of organized PA (OPA) – the analysis found 6 articles on this topic. OPA, regardless of whether individual or group PA, brings better results when it comes to achieving PA recommendations – volume and intensity. The Poland 2022 report comparing the results of 2016, 2018 and 2022 shows that no positive changes were

observed in terms of OPA and SB [4]. The primary organized PA for children and young people is PE. 87% of elementary, 96% of middle and 89% of secondary school pupils were involved in PE lessons [25]. Increased PA through more PE sessions positively affects children's arterial blood pressure [21]. A significant majority of students (63%) participated in PE for the sake of "fun–pleasure–entertainment", while a smaller portion (31%) preferred the "exercise–sweat–fitness" profile in PE classes. The preference for "fun–pleasure–entertainment" decreased by about 41% among boys and 31% among high school students, while the inclination for "exercise–sweat–fitness" increased by about 56% for boys and 31% for high school students [23]. Furthermore, emphasis should be placed on afternoon organized PA, as contemporary PA offers a diverse array of options for students to choose their preferred form of organized PA. Schools in Poland serve as a significant setting for promoting PA due to high levels of participation in organized sports and mandatory time allocated to PE [4]. Adolescents engaged in OPA demonstrated notably higher levels of PA ( $p < 0.001$ ) compared to non-participating peers. The strongest associations were seen between OPA participation and vigorous PA. Students who engaged in three or more OPA sessions per week were more likely (61%) to meet the weekly recommendation for vigorous PA compared to those participating in one or two sessions (29%) or those not involved in OPA (24%). Therefore, boys and girls who do not participate in OPA are at a higher risk of potential health issues [6]. Taking part in outdoor activities showed indications of improved performance in motor skills, which subsequently increase the likelihood of satisfactory PA participation. Over a two-year span of outdoor PE lessons, significant enhancements were observed in students' speed, jumping ability and aerobic endurance [35].

*Differences between boys and girls*

In 11 articles, the variable of PA was gender. The perception of physical activity (PA) and sedentary behavior (SB) demonstrated significant gender differences, impacting both the volume and intensity of PA, as well as perceptions of various PA-related factors like forms, motives and barriers. While there were no significant variations in step counts per PE lesson between adolescents in teaching practice and school practice, boys tended to be more active during PE lessons compared to girls [16]. Considering that girls exhibit lower activity levels at high PA intensities, it is crucial to involve them more in organized PA [12]. Boys tend to engage more in intensive and moderate efforts, whereas girls are more inclined towards activities related to walking [40]. Adolescents' preferences for fitness-related PA influence their likelihood of achieving recommended weekly PA levels, emphasizing the importance of considering preferred PA types when promoting PA among adolescents [36]. Body satisfaction varies by gender and becomes a more sensitive issue during adolescence among girls than boys. Physical activity plays a protective role for emotional well-being, impacting not just meeting the recommended MVPA levels for health [44]. Boys are inclined to demonstrate greater motivation for PA compared to girls, specifically in terms of enjoyment, competence, fitness and social incentives, while girls are primarily driven by motives related to appearance. Notably, there were statistically significant disparities between individuals with low and high motivation, particularly in relation to the connections between recreational/vigorous PA and various forms of motivation in both genders. The most robust associations were observed between motives of enjoyment/competence and participation in recreational/vigorous PA [2]. Among boys, different motives accounted for a 10.4% variation in the intensity of vigorous PA, with higher ratings in competence and appearance-related incentives being linked to increased levels of vigorous PA. Similarly, among girls, these motives elucidated a 7.4% variation in the

intensity of vigorous PA [37]. Girls exhibiting fewer depressive symptoms showed greater odds of meeting the 11,000 steps/day recommendation compared to those with more depressive symptoms. No statistically significant differences in meeting this recommendation were observed among boys with different levels of depressive symptoms. The negative association between depressive symptoms and PA was more pronounced in girls [8]. The disparity in support provided to adolescent girls by PE teachers should be addressed within the teaching context of PE students and rectified in school settings [24]. Notably, significant gender disparities exist in barriers to engaging in PA. Lack of energy, time and support were prevalent barriers, particularly among girls and older youth, influencing physical inactivity. For boys, lack of time, skills, willpower and support were predictors of low PA levels, whereas for girls, lack of skills, energy, support and time were significantly associated with physical inactivity. These perceived barriers strongly impact recommended PA levels, with lack of skills being the strongest predictor for low PA among girls and lack of time for boys [57].

#### *Use of electronic devices*

Seven articles highlighted the impact of electronic device use on PA levels. Technological developments and the emergence of mobile devices are causing a significant decrease in PA precisely in favor of time spent in front of screens. The possibilities offered by modern technology and the easy achievement of goals and the "effortless" stimulation of the happiness center is a serious problem. The percentages of students who spent time on a computer daily or almost daily were 52%, 60% and 70% for elementary, middle and secondary schools, respectively. Similarly, for watching TV, the percentages were 70%, 62% and 48% for elementary, middle and secondary schools [25]. Unfortunately, electronic devices are rarely used for purposes related to PA, e.g. monitoring, looking for information on how to exercise or

places or people for PA. The COVID-19 pandemic further exacerbated the problem [1]. Children and adolescents spent more time in a sedentary position during remote learning than previously. The effectiveness of PE also declined during the pandemic. Shorter sleep duration with higher sleep quality was also reported [1]. Poland's 2022 Report Card comparing the results from 2016, 2018 and 2022 shows that screen-time behaviors is particularly concerning [4]. Significant demographic differences in the perception of distance learning were noted. During the distance learning period: 21% rated physical well-being as bad or very bad, and 15% rated the quality of leisure time as bad or very bad [55]. On typical weekdays, the majority of children (71%) devoted more than 4 hours to educational activities via electronic devices. Additionally, 43% of children allocated 1-2 hours for recreational purposes using electronic devices. A significant portion (89%) were exposed to screens during meal times, while a majority (77%) consumed snacks between main meals [3]. Further examples of the association of using electronic devices with SB were found. The unfavorable associations between daily screen time and less healthy dietary habits were confirmed. What was not confirmed was the relationship between screen time and body weight status [42]. The study highlighted the significant role of family relationships, aiming to raise awareness and understanding of public health issues within the studied research sample. The findings revealed reduced time spent on physical activity and highlighted a concerning trend of increased screen time, particularly during weekends [50].

#### *Other sedentary behaviors*

Nine publications identified direct links between SB and PA. Analysis of the literature revealed a significant number of associations between SB and a healthy lifestyle. The findings revealed that adolescents having more SB tend to have lower overall levels of PA [40]. A mere

11.5% of adolescents met all three health recommendations, with boys meeting them more frequently than girls ( $p=0.020$ ). A significant proportion, almost 54%, exhibited multiple unfavorable health behaviors, with 14.1% displaying all three, a pattern more prevalent in girls than boys ( $p=0.011$ ) [53]. Active promotion of a healthy lifestyle – increasing awareness among schoolchildren, fostering healthy eating habits and encouraging engagement in leisure activities – can notably reduce the risk factors associated with obesity [47]. Emphasis should not be overlooked on cultivating health-oriented dietary habits, modifying lifestyle by enhancing physical activity and reducing screen time [46]. Among boys, greater engagement in physical activity correlated with reduced tobacco and marijuana usage, although no confirmed association was found between alcohol and psychoactive substances with physical activity, both in boys and girls [52]. Physical activity appears to play a role in preventing excessive alcohol consumption [54]. Predictors of high self-rated health among 15-year-old girls included regular participation in physical education classes, vigorous physical activity, daily consumption of breakfast and fruit and at least eight hours of sleep daily [26]. The results underscored the significance of teenagers' nutrition knowledge in molding health-promoting dietary habits and an active lifestyle, aiding in reducing the risk of adiposity and countering negative influences associated with lower family affluence that foster unhealthy behaviors in diet and lifestyle [27]. Communication within families and with peers, as well as the social capital of neighborhoods, exhibited the most substantial impact on positive attitudes in adolescents. Furthermore, physical activity, regular breakfast consumption and school performance were identified as important predictive factors [45].



## Discussion

This comprehensive study underscores the paramount importance of PA in maintaining the well-being of children and adolescents. By examining articles from 2009 to 2022, it illuminates the critical role of PA and SB in shaping health behaviors among the youth [1-5]. The most frequent respondents were teenagers around 15 years of age. Among those included in the analysis, the largest group were articles from the year 2020 (n=12). Relative to the early 2000s, there is a definite increase in interest in PA issues for children and adolescents in the context of SB, as evidenced by the greater number of publications in the last 3 years than in the previous 19 years in total. The study considered articles from 2009 to 2022 on PA and adolescents between 6-20 years of age and summarized the descriptive characteristics and main conclusions of the available evidence. The majority of the articles were cross-sectional (67%), approximately two thirds of the articles (31%) examined only PA, 2% examined only SB, and 26% articles employed device-based assessments. In 55.1% of cases, PA diagnosis was made using questionnaires, and in 16.3% using accelerometers. In 8.1%, both tools were used. 35% of the publications analyzed students' achievement of PA recommendations [5,8,10,15,22,24,28-30,34,36,38,39,41,48,49,51,53]. The most common determinant was average daily steps. Attention was also paid to the intensity of PA: VPA and MVPA. The authors divide the study into two parts, PA and SB. The study reveals that the values of the variables being researched were not consistent throughout the week (n=4%). This is influenced by the division between "school" days and the weekend [30,32]. An important component of children and young people's PA was active transport, analyzed in 4% of the articles accepted for analysis [4,34]. The primary PA for children and young people was PE. Its importance is highlighted in the literature. PE and teacher activities directly influenced the decision to undertake PA during out-of-school time. Recreational PA should be an important component

influencing the achievement of PA recommendations. OPA has better outcomes than when students prepare PA activities for themselves [6]. PE teachers, whose main task is to prepare students for independent PA, also have a direct impact. This primarily concerns creating an attitude towards PA but also equipping the student with skills, an appropriate level of motor skills and knowledge. This issue was addressed in 12% of the articles included in the study [4,6,21,23,25,35]. Significant differences in PA levels between girls and boys were found. They also relate to factors influencing the decision to participate in PA: forms, motives, barriers. The study considered 20% of the publications addressing this issue [2,12,16,24,34,36,37,40,44,57]. Technological developments and the emergence of mobile devices are causing a significant decline in PA precisely in favor of time spent in front of screens. A total of 16% of the included publications addressed this issue [1,3,4,25,42,50,55]. In the publications included in the analysis, a group of publications were found that fulfilled the search criteria but did not fit into any of the above issues. They represent 14% of all publications and highlight health behavior issues in the context of PA and SB [40,45-47,52-54]. Moreover, it is essential to note the array of tools utilized to evaluate PA and SB and the diverse data processing methods, particularly in accelerometer-based studies. Additionally, variations in defining adequate levels of PA and SB across the studies contribute to the potential inconsistency in findings concerning gender-specific PA and SB or the prevalence of satisfactory PA.

#### *Strengths and limitations of the study*

This investigation represents an initial comprehensive examination that systematically appraises the existing facts concerning PA and SB in Polish youth. Furthermore, it delineates potential avenues for future advancements in a nationwide monitoring system dedicated to tracking these behaviors. Nevertheless, it is imperative to acknowledge several constraints. To

start with, the search strategy did not encompass "grey literature", which could potentially introduce a bias in publication by excluding valuable data found in conference proceedings, theses or reports. However, the strict search criteria ensured that all studies included in this analysis underwent a peer review and met the acceptable methodological standards. Secondly, while this analysis extensively described various research designs, samples, assessment methods for PA and SB and significant findings from 49 articles, it did not perform a methodological quality assessment for comparative analysis of research outcomes. The primary findings presented in this analysis were derived from studies utilizing diverse tools, sample sizes and definitions of PA and SB. Hence, comprehending these findings and their implications necessitates meticulous deliberation and analysis.

### **Conclusions and recommendations**

The review included 47 articles presenting the author's PA research in the context of SB. The research covered the period from January 2020 to December 2022. There is a significant increase in interest in the issues covered. There is a correlation: more SB translates into less PA. Students overwhelmingly failed to achieve PA recommendations. This applied to the number of steps, as well as to the proportion of MVPA. It would be worth finding and more widely diagnosing the children and young people who achieved the PA recommendations. It might be possible to translate the steps taken by active children and young people into those who do not achieve the PA recommendations. The authors draw particular attention to the importance of PE in achieving the PA recommendations. Failure to achieve PA recommendations translates directly into reduced health potential. The likelihood of overweight and obesity is also increased.

Among the articles we analyzed, we found studies that were conducted over multiple years. We didn't observe any significant decreases in PA, but at the same time, we didn't notice an increase in PA among children and adolescents. The analysis made it possible to propose specific measures for PA among children and adolescents in Poland:

- active transportation to and from school can allow nearly 30% of the recommended daily physical activity to be achieved;
- increasing the quality and quantity of PE classes;
- PE should take into account the individual needs of the student in the first instance. It is worth considering the forms, motives and barriers to PA. Adapting PE to the needs of students can increase the PA of students of both sexes;
- a wide range of structured PA should be provided. Both in the activities of the school and in the overall operation of the educational environment. Activities should be moved outside if possible;
- organizing joint active parent-child, sibling, child-grandparent or pupil-pupil time can increase PA levels and bring pupils closer to the recommendations;
- limiting time in front of screens is important, but it is also worthwhile to activate students during time in front of screens. Solutions could include: active breaks during time in front of screens, implementing games (computer, console, mobile devices) aimed at PA, developing apps to support PA (monitoring PA, helping with exercise selection, finding PA companions, etc.).

It is worth mentioning that the effectiveness of PA and SB research among children and young people requires the involvement of the entire educational environment. The importance of the school, especially PE classes, and the family as an educational environment in PA effort is invaluable. It is worth introducing intervention programs on a national scale aimed at increasing the volume of PA of children and young people but also focusing on factors of

physical activity (forms, motives, barriers). It should be taken into account that PA factors are age and gender specific and change over the years. It is also necessary to increase knowledge of the importance of PA for health and therefore for a long active life. It is also worth asking the question: why do children and young people so often choose passive activities? All these activities are of great prospective importance. The nature of the problem requires further research to show trends but also to allow action to be taken. The results presented in this study already allow for the immediate implementation of changes for the regular PA of children and young people. What is needed here is structured top-down action on the part of the government. Achieving PA recommendations should be prioritized and in opposition to SB.

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## Appendix

### *Search strategy for the PubMed.gov*

1. exp Exercise/
2. \* Physical activity/
3. \*Leisure Activities/
4. \*Healthy Lifestyle/
5. \*Locomotion/
6. ((light or moderate or vigorous or "moderate to vigorous" or "moderate-to-vigorous")  
and (intensity or "physical activity" or PA)).tw
7. LPA or LIPA or MPA or MVPA or VPA.tw
8. ((physical activit\* or movement) adj3 (recommendation\* or guideline\*)).tw
9. "active lifestyle" or "physical activity".tw
10. exp Accelerometry/
11. accelerometer or pedometer or steps or "step count" or "steps per day" or "actigraphy".tw
12. (fitness or consumer-wearable or activity) and tracker\*.tw
13. "physical activity questionnair\*" or " IPAQ" or " international physical activity  
questionnaire" or "GPAQ" or "global physical activity questionnaire".tw
14. exp Play and Playthings/
15. exp Sports/
16. ((organized or participation or preference or individual or team) adj3 sport\*).tw
17. \*Transportation/
18. "active transport" or "cycling" or "walking" or "roller skating".tw
19. \*"Physical Education and Training"/

20. ("before school" or "in school" or "after school" or "school-based" or "school based")  
and ("physical activit\*" or PA).tw
21. ("physical activity" or PA or sedentary) adj3 (break\* or bout\*).tw
22. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or  
18 or 19 or 20 or 21
23. exp Sedentary Lifestyle/
24. "sedentary behavior\*" or " physical inactivity" or "screen time" or "screen-time" or  
"sedentarism" or "sedentary time" or "sitting" or "lying".tw
25. (electronic devices, computer or "video game" or smartphone or tablet or internet) adj3  
(time or 'use' or usage).tw
26. 23 or 24 or 25
27. exp Child/
- 28 exp Adolescent/
29. childhood or adolescence.mp
30. (teen\* or "young person" or youth\* or school-age or adolescent\* or child\* or juvenile).mp.
31. 27 or 28 or 29 or 30
32. exp Poland/