Physical Activity and Sedentary Behaviour Surveillance in Czech Children and Adolescents: A Scoping Review of the Literature from the Past Two Decades

Eliška Materová
Palacký University Olomouc

Jana Pelclová (✉️ jana.pelclova@upol.cz)
Palacký University Olomouc

Aleš Gába
Palacký University Olomouc

Karel Frömel
Palacký University Olomouc

Research Article

Keywords: prevalence, insufficient physical activity, youth, health

Posted Date: October 6th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-637632/v1

License: © This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License
Abstract

Background: This study aimed to map the available evidence related to physical activity (PA) and sedentary behaviour (SB) in Czech children and adolescents and suggest future directions and improvements to strengthen surveillance on PA and SB in the Czech Republic.

Methods: The search of studies published between January 2000 to December 2020 included the Medline and Medvik databases and a hand search in eight Czech journals related to the topic. This review followed the "Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews".

Results: Out of 350 identified studies, 79 met the selected criteria. The majority of studies were cross-sectional (89%), approximately two-thirds of the studies (61%) examined only PA, and half of the studies (51%) employed device-based assessments. Approximately 47% of studies reported the prevalence of physical inactivity based on inconsistently defined recommendations. Approximately, 14%, 23%, and 10% of studies focused on active transport, organized PA (including physical education or leisure-time PA), and parent-child PA, respectively.

Conclusions: Future studies need to focus on longitudinal design and interventions, randomly selected samples, a mix of devised-based and self-reported methods, and recognition of health-related 24-h time-use patterns. This review advocates the governmental-supported development of a national surveillance system helping to the reduction of insufficient PA and excessive SB.

Background

In children and adolescents, physical activity (PA) is an important part of the healthy lifestyle. Sufficient PA is associated with improved physical fitness, cardiometabolic health, bone health, cognitive outcomes, mental health, and reduces adiposity [1, 2]. And conversely, insufficient PA accompanied by high sedentary behaviour (SB) negatively influence health [3] and they are considered as the key drivers of non-communicable diseases [4] with a possible transfer to adulthood [5]. Currently, the Global action plan on PA 2018–2030 which mission is to ensure access to safe and enabling environments and to diverse opportunities to be physically active to all people, draws attention to 81% of adolescents who are not sufficiently active [6]. Moreover, the prevalence of insufficient engaging in everyday PA increases over adolescence and seems to be higher among girls [7].

PA is complex movement behaviour and might be performed at varying intensities, body posture, domains, bout duration, and for multiple reasons. In many countries across the globe, the relevant issues related to insufficient PA resulted in the development of the national PA guidelines which provide consensus on the amount, intensity, frequency, and type of PA necessary for chronic disease prevention and for supporting collective health [8]. Besides promoting an optimal level of PA, limiting SB is also recommended in the majority of these countries. SB is defined as any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining, or lying posture [9].
Specifically, time spent using a device such as a computer, television, or games console, which is called “screen time” (ST), is a more specified component of total SB with several negative effects on health [10]. Achieving a required level of PA and SB offers significant health benefits and mitigates health risks which have been recently highlighted by the World Health Organization (WHO) in the last edition of “WHO Guidelines on Physical Activity and Sedentary Behavior” [1].

WHO also announced national surveillance on PA as an essential part of the global initiatives for the reduction in the global prevalence of insufficient PA by providing a means to assess compliance with PA and SB guidelines and subsequently serving for monitoring progress over time [11]. Moreover, the national data could help to adopt global PA and SB recommendations with adequate adjustment to the social, cultural, and environmental conditions of the state. In the Czech Republic, the national surveillance system, as well as country-specific recommendations for children and adolescents’ PA, are lacking. The inadequacy in the area of PA research is seen in a recently published systematic review of global, regional, and national trends and patterns in PA research since 1950 where the Czech Republic with a total of 105 papers is in nineteenth place among high-income European countries [12]. Likewise, no study has summarized and reviewed existing research on PA and SB in Czech children and adolescents. Such a comprehensive analysis describing up-to-date surveillance and main findings is critical ahead of further steps which could lead to the development of a national surveillance system and recommendations.

Therefore, the purpose of this study was to systematically review the best available evidence on PA and SB in Czech children and adolescents published in the last two decades. Specifically, we aimed to (1) summarize the descriptive characteristics and main conclusions of the available evidence and (2) suggest future directions and improvements to strengthen surveillance on PA and SB in Czech children and adolescents.

Methods

The search strategy

This scoping review conforms to the "Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews" (PRISMA-ScR) [13]. The checklist was followed to report this study (Supplementary file 1). The search included the Medline (via Ovid) and Medvik databases. We searched for studies published from January 2000 to December 2020 but only studies whose data were obtained during this period were included in the review. The search strategy was arranged in three sets of terms that cover the target population (i.e., school-aged children), movement behaviors (i.e., PA and SB), and country (Czech Republic). The search strategy builds mainly on the Medical Subject Heading (MeSH) terms. Subsequently, selected free-text terms were included in the search strategy to increase the sensitivity of the search. The complete search strategy in electronic databases is presenting in Supplementary file 2. The search results were imported into the EndNote programme (Version X7; Thomson Reuters, San Francisco, CA, USA), all duplicates were deleted, and an online Excel spreadsheet was produced for screening purposes. The final database included several unique identifiers for each
study and several pieces of bibliographic information (article identifier, authors, year of publication, study title, abstract and journal title).

Then, the title and abstract of the studies were screened by two independent evaluators. The studies were divided into three groups: relevant, irrelevant, and potentially relevant studies. In the case of potentially relevant studies, their full-texts were analyzed, and then the studies were included or excluded. In the event of a disagreement between the evaluators concerning the relevance of a particular study, the final decision as to inclusion or exclusion was made by a third person.

In addition to searching the databases mentioned above, the authors performed a hand search in the references of studies included in the review. A hand search was also carried out in main Czech journals related to the topic of interest and which were not indexed in the Medline and Medvik databases during part or the whole period of past 20 years. Namely, we performed the hand search in Tělesná kultura, Acta Gymnica, Česká Kinantropologie, Studia Kinanthropologica, Medicina Sportiva Bohemica et Slovaca, Tělesná výchova a sport mládeže, Acta Universitatis Caroliniae – Kinanthropologica, Studia Sportiva.

Study inclusion and exclusion criteria

Studies with any research design were included in this scoping review if they: a) targeted Czech children and adolescents aged 6–19 years, b) reported PA, SB, or both, c) were written in English or Czech language, d) were published between 2000 and 2020, and e) were published as a peer-reviewed journal article. The international studies without a clearly defined Czech sample were excluded. The minimal sample size was set at least 50 participants for cross-sectional studies and was not set for longitudinal studies.

Data extraction

The basic characteristics about included studies (design, primary outcomes, and main findings) and descriptive characteristics of the study samples (sample size, percentage of girls, age category or average age, and region of Czech Republic) were extracted. We also extracted information on the use of methods in measurement (self-reported, device-measured) and dealt with more detailed information on PA and SB. Finally, we summarized the main findings and results of the included studies.

Results

Data extraction procedure and bibliographic characteristics

In the Medline and Medvik databases, a total of 316 studies were identified based on the search strategy, and 34 studies were identified by hand search (Figure 1). After the removal of duplicates, the exclusion of studies based on predetermined criteria was done. Out of 160 full-text articles assessed for eligibility, there was a disagreement between the evaluators concerning the relevance of a particular study in 8 studies, and the final decision as to inclusion or exclusion was made by a third person. Although these papers were related to PA and SB of Czech children and adolescents, the main reasons for exclusions
were: a) impossibility to separate Czech results from results of other countries [14], b) PA and SB results related to very specific samples (with different mental load or academic achievement) without clear summary findings [15–17], and c) specific studies examined test-retest reliability [18, 19].

The final sample included 79 studies, the overview of which is shown in Table 1. Sixty-one papers were published in the English language and 18 were published in the Czech language. Out of 79 studies, 18 studies [20–37] were part of international surveys with clearly identified results related to PA and/or SB in Czech children and adolescents.

Table 1.  

Characteristics and findings of the included studies

| a | Longitudinal study |
| b | International study |
| c | Intervention study |
| d | Representative sample |

PA – Physical activity, SB – Sedentary behaviour, ST – screen time, AT – Active transport, PI – Physical inactivity, PE – Physical education, MVPA - Moderate to vigorous physical activity, MPA – Moderate physical activity, VPA – Vigorous physical activity, LPA – Light physical activity, BMI – Body mass index, OLTA – Organized leisure-time activities, HBSC – Health Behaviour in School-Aged Children, IPAQ-LF - International Physical Activity Questionnaire – long form, IPAQ-SF – International Physical Activity Questionnaire – short form, IPEN - International Physical Activity and the Environment Network, QPAP – Questionnaire on Physical Activity Preferences, SONIAA – Social Norms Intervention for Active Adolescents, COSI – Childhood Obesity Surveillance Initiative.

An apparent increasing trend of published studies is shown in Figure 2. Although the first two studies related to PA of Czech children and adolescents were published in 2007, data from identified studies cover the whole 20-year period with the first data collection in 1998–2000 [38], 2001 [39], and 2002 [40].

Descriptive characteristics of the available evidence

This scoping review identified 70 cross-sectional studies, 7 longitudinal studies, and 2 interventions. Out of all cross-sectional studies including school-aged participants, 18 studies focused on children, 54
| First author and year of publication | Characteristics of study sample | Methods | Primary outcome(s) | Main finding(s) |
|--------------------------------------|--------------------------------|---------|-------------------|-----------------|
| Baďura et al., 2018 [90]             | n = 6 935<sup>d</sup>  
51% girls  
13–15 years  
Czech Republic | Self-reported (HBSC questionnaire) | PA (OLTA (team sports, individual sports and other activities)) | 79% of respondents engaged in at least one OLTA per week. 34% of respondents engaged in overall unstructured activities daily or at least twice a week. The selected unstructured activities were strongly associated with an increased occurrence of adolescents’ health-risk behaviors and low academic achievement. |
| Baďura et al., 2017 [91]             | n = 10 279<sup>d</sup>  
51% girls  
11–15 years  
Czech Republic | Self-reported (HBSC questionnaire) | PA (OLTA (team sports, individual sports and other activities)) | 48% of boys and 52% of girls participated in OLTA. With increasing age, participation in OLTA decreases. OLTA participation was associated with lower occurrence of repeated substance use and truancy and inversely with higher odds for physical fights and injuries. Girls, in general, were at lower risk when participating in OLTA than boys. |
| Baďura et al., 2016 [92]             | n = 10 483<sup>d</sup>  
51% girls  
11–15 years  
Czech Republic | Self-reported (HBSC questionnaire) | PA (OLTA (team sports, individual sports and other activities)) | Youth involvement in OLTA was linked to general better school performance and attachment to school. Adolescents participating in more activities at the same time had the best school performance. |
| Baďura et al., 2015 [93]             | n = 10 503<sup>d</sup>  
51% girls  
11–15 years  
Czech Republic | Self-reported (HBSC questionnaire) | PA (OLTA (team sports, individual sports and other activities)) | 81% of respondents participated in one or more OLTA. Participation in OLTA was associated with better physical and mental health in adolescents. The association varies by pattern of activity participation and was partly gender- and age-specific. |
| Bešič et al., 2016 [48]              | n = 174  
48% girls  
9–11 years  
Olomouc region | Device-measured (accelerometer ActiGraph GT3X and GT3X+, hip-worn, 7 consecutive days, >10 valid hours per day) | PA (total, LPA, MPA, VPA) | Boys had higher BMI, spent more time in VPA and showed better results in health-related physical fitness than girls. Children who spent more time in VPA were more likely to had better cardiorespiratory fitness. |
at least 4 weekday and 1 weekend day, CoP by Freedson 2005)

| Study                                      | Sample Size | Gender | Age | Region                  | Methodology                        | PA (steps/day) | Boys achieved more steps/day (by 1 000 steps) than girls. Weekday steps/day were significantly higher than weekend steps/day. |
|--------------------------------------------|-------------|--------|-----|-------------------------|------------------------------------|----------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Bláha et al., 2019 [57]                    | n = 639     | 46%    | 11–16 years | North-western Bohemia region | Device-measured (pedometer Digi-walker Yamax SW-200 and SW-700, at least 5–6 weekdays and 1 weekend day) | PA (steps/day) |                                                                                                                                 |

| Study                                      | Sample Size | Gender | Age | Region                  | Methodology                        | PA (leisure-time PA, PI) | The participation in leisure-time PA was on average by 8% higher in boys than girls on all days of the week and was decreasing with age, particularly in girls. Boys had 6% higher ST than girls in all days of the week. |
|--------------------------------------------|-------------|--------|-----|-------------------------|------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Bláha et al., 2010 [58]                    | n = 1 185   | 59%    | 11–16 years | North-western Bohemia region | Self-reported (PA and SB questionnaire) | PA (leisure-time PA, PI) |                                                                                                                                 |

| Study                                      | Sample Size | Gender | Age | Region                  | Methodology                        | PA (MVPA) | SB (ST) | Meeting MVPA recommendation was reported by 21.5% of Czech adolescents. Low (less than 3.5 h/school day), middle (3.5—7) and high (more than 7) ST reported 30.7 %, 35 % and 34.4 % of Czech adolescents, respectively. Social and environmental correlates differed for MVPA ad ST of adolescents. |
|--------------------------------------------|-------------|--------|-----|-------------------------|------------------------------------|------------|---------|-------------------------------------------------------------------------------------------------------------------------------------|
| Bucksch et al., 2019 [20]                  | n = 5 082\textsuperscript{d} | 52%    | 11–15 years | Czech Republic\textsuperscript{b} | Self-reported (HBSC questionnaire) | PA (MVPA) | SB (ST) |                                                                                                                                 |

| Study                                      | Sample Size | Gender | Age | Region                  | Methodology                        | PA (total, up to 7 hour/week or \( \geq 7 \) hour/week) | SB (ST) | 60% of respondents performed PA during the week. Boys were more physically active, watched more television and used the computer more often than did girls. Watching TV more than 7 h a week was positively associated with being overweight/obese in 15–18-year-old girls and was found to be negatively associated in boys of the same age group. |
|--------------------------------------------|-------------|--------|-----|-------------------------|------------------------------------|----------------|---------|-------------------------------------------------------------------------------------------------------------------------------------|
| de Gouw et al., 2010 [45]                  | n = 30 966\textsuperscript{d} | 56%    | 10–18 years | Czech Republic          | Self-reported (questionnaire) | PA (total, up to 7 hour/week or \( \geq 7 \) hour/week) | SB (ST) |                                                                                                                                 |

| Study                                      | Sample Size | Methodology                        | PA (AT – commuting) | A decrease in the proportion of commuting between boys and girls |                                                                 |                                                                 |                                                                                                                                 |
|--------------------------------------------|-------------|------------------------------------|---------------------|----------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Dygrýn et al., 2015 [39]                   | n = 6 236   | Self-reported (national 2011)      | PA (AT – commuting) | A decrease in the proportion active commuting between boys and girls |                                                                 |                                                                 |                                                                                                                                 |
### Olomouc and Hradec Králové region

50% girls 12–17 years

Czech Census of Population and Housing) to/from school)

2001 and 2011 to school was observed in 47% respondents. Between 2001 and 2011, the proportion of adolescents actively commuting to school decreased by 47%, from an absolute rate of 49.1% to 26%. The proportion of active commuters fell in low walkable areas by 61% and in high walkable areas by 39%. The adolescents in 2011 were 2.7 times less likely to actively commute than in 2001.

### Frömel et al., 2020a [21]

Frömel et al.,
2020a [21]

| n = 1 462 | Self-reported (IPAQ-LF) | PA (total, VPA, MVPA, AT) |
|---|---|---|
| 64% girls | | |
| 15–19 years | | A higher rate of AT was only significantly associated with higher well-being in girls. AT accounted for 22.5% and 24.9% of weekly PA of Czech boys and girls, respectively. |

### Frömel et al., 2020b [76]

Frömel et al.,
2020b [76]

| n = 596 | Device-measured (pedometer Digi-walker Yamax SW-700) | PA (steps/day) |
|---|---|---|
| 62% girls | | The stronger negative associations between depressive symptoms and PA (especially recreational PA) were confirmed. The girls who reported the fewest depressive symptoms had 2.12 times greater odds of meeting the 11,000 steps/day recommendation than did the girls with the most depressive symptoms. |
| 15–19 years | | |
| Czech Republic | | |

### Frömel et al., 2018 [30]

Frömel et al.,
2018 [30]

| n = 1 117 | Self-reported (IPAQ-LF) | PA (total, VPA, MPA, LPA, MVPA) |
|---|---|---|
| 60% girls | | Girls were found to be less active than boys at high PA intensities. The recommendations for vigorous PA were met by 46% of Czech boys and 33% of girls. |
| 15–17 years | | |
| Czech Republic | | |

### Frömel et al., 2017 [31]

Frömel et al.,
2017 [31]

| n = 6 371 | Device-measured (pedometer Digi-walker Yamax SW-700, at least 3 weekdays and 1 weekend day) | PA (total, VPA, MVPA, PA preferences, steps/day) |
|---|---|---|
| 60% girls | | The agreement between preferred and PA actually undertaken was associated with higher odds for meeting the weekly PA recommendations and higher levels of well-being both in boys and girls. |
| 15–17 years | | |
| Czech Republic | | |
Frömel et al., 2016a [70] | n = 641 | 68% girls | Mean age: 16.6 years | Czech Republic | Device-measured (accelerometer ActiTrainer, hip-worn, 3 school days; pedometer Digi-walker Yamax SW-700; heart rate sensor Polar) PA (school, MVPA during PE lessons and recess, steps/hour, steps/day) | Both boys and girls participating in a PE lessons reported significantly better results compared with nonparticipating individuals regarding all indicators of volume and intensity of school PA. An increase in school PA and an improved lifestyle in adolescents on school days were significantly supported more by PE lessons than by longer recess time.

Frömel et al., 2016b [32] | n = 236 | 70% girls | Mean age: 16.0 years | Czech Republic | Device-measured (accelerometer ActiTrainer, hip-worn, at least 1 school and 1 weekend day, 15 s epoch; heart rate sensor Polar) PA (total and school steps/hour, PI) | Boys and girls participated in more PA at lower intensities on the weekends compared with school days. Sitting (lying) at a computer was 60 min/day longer in boys than in girls.

Frömel et al., 2007 [72] | n = 440 | 53% girls | Mean age: 15–20 years | Czech Republic | Self-reported (IPAQ-LF) PA (total and school, VPA, participation in organized PA and sport) | Boys were more active than girls. Increasing age was associated with lower leisure-time PA, AT and school or work PA in boys, and lower leisure-time and higher PA in household and at school or work in girls.

Gába et al., 2020a [81] | n = 659 | 58% girls | Mean age: 8–18 years | Czech Republic | Device-measured (accelerometer ActiGraph GT9X Link or wGT3X-BT, non-dominant wrist, 7 consecutive days, >16 valid hours per day, at least 4 weekday and 1 weekend day) PA (multi-day 24-h data; LPA, MVPA) SB (total sedentary time) | Children had by 26 min/day more LPA and by 19 min/day more MVPA than adolescents. Adolescents had by 111 min/day more SB than children. In children, being a short sleeper was associated with higher SB by 95 min/day and lower MVPA by 16 min/day. In adolescents, being a short sleeper was associated with a higher amount of time spent in SB by 67 min/day and lower LPA by 2 min/day.

Gába et al., 2020b [81] | n = 425 | Device-measured (accelerometer ActiGraph GT9X Link or wGT3X-BT, non-dominant wrist, 7 consecutive days, >16 valid hours per day, at least 4 weekday and 1 weekend day) PA (total, LPA, MVPA) SB (total sedentary time) | The children spent 87% of their time sedentary.
2020b [55]  |  58% girls  |  7–12 years  |  Moravia region  |  measured (accelerometer ActiGraph GT3X, hip-worn, 7 consecutive days, 60 s epoch, >10 valid hours per day, at least 4 weekday and 1 weekend day, CoP by Evenson)  |  LPA, MVPA  |  total SB time in sedentary bouts that were shorter than 30 min. Boys spent on average 9.9 min/day less in short sedentary bouts and 7.5 min/day more in long sedentary bouts compared with girls. Adiposity status could be improved by increasing MVPA at the expense of time spent in middle sedentary bouts. Some benefits for adiposity were found for replacing middle sedentary bouts with short sedentary bouts.

Gába et al., 2017 [56]  |  n = 365  |  57% girls  |  7–12 years  |  Moravia region  |  Device-measured (accelerometer ActiGraph GT3X, hip-worn, 7 consecutive days, 60 s epoch, >10 valid hours per day, at least 3 weekday and 1 weekend day, CoP by Evenson)  |  PA (total, LPA, MVPA, VPA, steps/day)  |  SB (total sedentary time)  |  In terms of the overall PA, boys were more active than girls. No associations were found between LPA and all body fatness indicators. MVPA was negatively associated with all body fatness indicators only in girls. In contrast, vigorous PA was strongly negatively associated with body fatness indicators only in boys.

Groffik et al., 2020 [33]  |  n = 629  |  66% girls  |  Mean age: 16.2 years  |  Czech Republic  |  Device-measured (accelerometer ActiTrainer, hip-worn, 4 consecutive days, at least 1–3 days, 15 s epoch; pedometer Digi-walker Yamax SW-700; heart rate sensor Polar)  |  PA (total and school, MVPA, steps/hour)  |  Participation in PE lessons was associated with a higher rate of meeting school PA recommendations. Compared with the Czech Republic, more PE lessons in the Polish education system were associated with increased daily VPA and a greater portion of school PA in daily PA.

Hamřík et al., 2015 [34]  |  n = 4 404  |  52% girls  |  11–15 years  |  Self-reported (HBSC questionnaire)  |  PA (total, VPA)  |  VPA was positively associated with healthy development of adolescents. Screen-based behavior showed an inverse relationship with adolescents’ healthy development,
| Study | Sample Size | Gender Distribution | Age | Setting | Data Collection Method | Physical Activity (PA) | Summary |
|-------|-------------|---------------------|-----|---------|------------------------|------------------------|---------|
| Hamřík et al., 2014 [80] | n = 4365d | 52% girls | 11–15 years | Czech Republic | Self-reported (HBSC questionnaire) | SB (ST) | The prevalence of SB rises with growing age, with the most visible increase in prevalence between ages 11 and age 13. SB was significantly more prevalent among adolescent boys compared with adolescent girls. Czech adolescents were more likely to not meet the recommendation of 2 hours for watching TV at weekends compared to weekdays. Playing computer games was more common among boys contrary to chatting online, which was more common among girls. |
| Hamřík et al., 2012 [83] | n = 4425d | 52% girls | 11–15 years | Czech Republic | Self-reported (HBSC questionnaire) | SB (ST) | More than 55% of girls and 60% of boys spent more than 2 hours a day in front of a TV, DVD or video screen in the working week. With age, the proportion of children who spent 2 or more hours a day using computer increases. |
| Hollein et al., 2018 [87] | n = 4404 | 52% girls | 11–15 years | Czech Republic | Self-reported (HBSC questionnaire) | PA (AT – commuting to/from school) | 58% of children used AT for commuting to and from school. Children actively commuted more often in schools which had formally processed health promotion objectives than in school without these goals. In addition, children who had a school in the same village or city had a higher chance for AT than children who had a school elsewhere than in the place of residence. |
| Hollein et al., 2017 [88] | n = 1522 | 52% girls | 15 years | Czech Republic | Self-reported (HBSC questionnaire) | PA (AT – commuting to/from school) | School policies and programs promoting AT to and from schools in the Czech Republic contributed to the use of AT. The association between school policies and programs and AT was stronger in boys compared to girls. |
| Jakubec et al., 2020 [60] | n = 679 | 57% girls | 8–18 years | | Device-measured (accelerometer ActiGraph GT9X Link or LPA) | PA (multi-day 24-h data; LPA, MVPA) | No associations were found between meeting all three recommendations (≥60 min/day of MVPA, < 2 h/day of recreational ST, and |
Czech Republic  wGT3X-BT, non-dominant wrist, 7 consecutive days, >16 valid hours per day, at least 3 weekday and 1 weekend day)  SB (ST)  uninterrupted sleep for 9–11 h/day (for children) or 8–10 h/day (for adolescents) within the 24-hour movement guidelines and adiposity indicators. However, meeting ST only recommendation and the combination of the ST and sleep recommendations was associated with a reduced risk of excess adiposity.

| Study                          | Sample Size   | Year | Country | Measures | PA (Activity) | Findings                                                                 |
|-------------------------------|---------------|------|---------|----------|--------------|--------------------------------------------------------------------------|
| Kalman et al., 2015a [61]     | n = 4 385d    | 2015 | Czech   | Self-reported (HBSC questionnaire) | PA (total, MVPA, VPA, motives for PA) | A substantial part of boys and girls were not participating in MVPA and VPA as recommended. MVPA and VPA among girls significantly decreased from age 11 to age 15. Boys compared to girls reported significantly more MVPA and VPA in all age groups, except 11 years old adolescents where the level of MVPA among girls and boys did not differ. Girls appear to be more influenced by social motives. Importance of these motives became higher with increasing age. Achievement motivation for PA was more important for boys and it also was increasing with age. |
| Kalman et al., 2015b [35]     | n = n/a d,e   | 2015 | Czech   | Self-reported (HBSC questionnaire) | PA (total, MVPA) | In Czech adolescents, there was a decrease in meeting MVPA recommendation at least 60 min daily (4% and 3% for boys and girls, respectively) between 2002 and 2010. |
| Kleszczewska et al., 2020 [36]| n = 11 553    | 2020 | Czech   | Self-reported (HBSC questionnaire) | PA (AT – commuting to/from school) | In Czech sample, passive means of transport, walking and biking were found in 35, 62.1 and 2.9 % of adolescents, respectively. Biking to school was protective against reports of health complaints. Adolescents actively commuting to school were less likely to report especially psychological symptoms. |
| Kokko et al.,                 | n = 10 501d   |      |         | Self-reported | PA (total,     | Sixty-two % Czech children and                                           |



| Year | Age | Country | Methodology | PA Outcomes | Findings |
|------|-----|---------|-------------|-------------|----------|
| 2018 [37] | 11–15 years | Czech Republic | (HBSC questionnaire) | VPA, participation in sports club | Adolescents (boys: 70%; girls: 55%; 11-, 13-, and 15-year-old: 66, 64, and 57%, respectively) took part in sports club activities. Sports club participants were more likely to meet the overall PA recommendations and VPA recommendation than non-participants. |
| Kopčáková et al., 2017 [22] | n = 3 481 | Czech Republic | Self-reported (HBSC questionnaire) | PA (total, MVPA) | An environment perceived as activity-friendly was associated with higher odds that adolescents met recommendations for PA and lower odds for excessive screen-based activities. |
| Kudláček et al., 2020 [23] | n = 2 334 | Czech Republic | Device-measured (pedometer Digi-walker Yamax SW-700) | PA (steps/day, VPA, MVPA, preferences for fitness PA) | The preference for fitness PA in boys was highly stable over the 8-year study period, with fitness PA third ranked after team and individual PA. For girls, an increasing trend was observed in the preference for fitness PA at the expense of dance and outdoor PA. In boys and girls, those who preferred fitness PA were more likely to achieve the recommended weekly PA level than those who did not prefer fitness PA. |
| Kudláček, 2015 [49] | n = 238 | Olomouc and Hradec Králové region | Self-reported (IPAQ-LF; questionnaire - Sport Preferences) | PA (total, MPA, VPA, walking, leisure-time PA, school PA, PA preferences) | The students from Vrchlabí showed a significantly higher level of leisure-time PA as opposed to the students from Olomouc, who report a significantly higher level of school-based PA. |
| Maliňáková et al., 2018 [106] | n = 4 182 | Czech Republic | Self-reported (HBSC questionnaire) | PA (OLTA) | Both, spirituality and religious attendance of adolescents decreased the likelihood of excessive watching TV and playing computer games. Adolescent religious attendance and spirituality were associated with a more active way of spending leisure-time (sporting and non-sporting activities and regular reading books or playing a musical instrument). |
| Study | Sample Size | Gender | Age | Measurement Method | Physical Activity (PA) | Findings |
|-------|-------------|--------|-----|--------------------|------------------------|----------|
| Mikláňková et al., 2013 [107] | n = 124 | | 6–11 years | Device-measured (accelerometer Caltrac, pedometer Digi-walker Yamax SW-200, hip-worn, 7 consecutive days) | PA (steps/day, active energy expenditure) | High level of PA was found in all segments of the day and week (except of weekend days) in 10–11-year-old children compared to 6–9-year-old children. |
| Mitáš et al., 2020 [62] | n = 1,908 | 59% girls | 15–19 years | Device-measured (pedometer Digi-walker Yamax SW-700; heart rate sensor Polar) | PA (steps/day, MVPA) | Considering average steps/day and an achievement of 11,000 steps/day, continuous significant decrease was found between 2010 and 2017 in adolescent girls (by 18%) and boys (by 28%). The estimates of meeting the recommended weekly PA expressed as MET-min/week were not so convincing about the decrease. Given the lowest amount of PA on Sunday, the combination of weekend days with Monday represents a great risk for youths in terms of health. |
| Mitáš et al., 2009 [71] | n = 302 | 54% girls | 14–15 years | Self-reported (IPAQ-LF) | PA (total, MPA, VPA, walking) | Girls were significantly more likely to be sitting than boys. Children living in a middle-sized to large-sized community, and living in an apartment, were significantly more likely to be sitting. |
| Ng et al., 2020 [24] | n = 4,809d | 52% girls | 11–15 years | Self-reported (HBSC questionnaire) | PA (MVPA) | Czech girls had better perceived school performance than boys, yet more boys participated in daily MVPA than girls. The associations between perceived school performance and MVPA were inverted U shaped. The strongest association for very good perceived school performance was among young adolescents who reported 5 to 6 days MVPA after controlling for family affluence scale. |
| Nováková Lokvencová et al., 2011 [25] | n = 383 | 53% girls | | Device-measured (pedometer Digi-walker) | PA (total, steps/day) | Czech boys and girls showed a significantly higher number of steps on school days than on weekend days. The differences |
| Study | Year | n | Gender | Region | Data Collection Method | PA Variable | Description |
|-------|------|---|--------|--------|------------------------|-------------|-------------|
| Pavelka et al., 2017 [86] | 2017 | 12,273 | 51% girls | Czech Republic | Self-reported (HBSC questionnaire) | PA (AT – commuting to/from school) | AT to school decreased sharply among Czech children of school age from 2006 to 2014 (by 21.7% in boys and by 23% in girls). Walking was the most frequently used mode of AT. The boys were significantly more likely to cycle to school compared to the girls. |
| Pavelka et al., 2016 [26] | 2016 | 418 | 54% girls | Olomouc region | Self-reported (HBSC questionnaire) | SB (ST) | Two-thirds of the respondents watched television or used a computer for at least two hours a day. The older children spent excessive amounts of time watching television. |
| Pavelka et al., 2012 [63] | 2012 | 4,425 | 52% girls | Czech Republic | Self-reported (HBSC questionnaire) | PA (AT – commuting to/from school) | AT to and from school was opted for in the Czech Republic by approximately two-thirds of children aged 11 to 15. Differences between genders were not significant; most children opting for AT were aged 11 (69%). An important factor increasing the probability of AT as much as 16 times was whether a child's place of residence was in the same municipality as the school. |
| Pelclová et al., 2010a [50] | 2010a | 13 | 85% girls | Olomouc region | Device-measured (pedometer Omron HJ-105, waist, 10 months, >10 valid hours per day) | PA (steps/day, organized after-school PA) | Regardless of the day, month and season, high-school pupils participating in regular organized after-school PA achieved approximately 4,000 more mean step counts/day than the pupils not participating in after-school PA. |
| Pelclová et al., 2010b [51] | 2010b | 12 | 83% girls | Olomouc region | Device-measured (pedometer Omron HJ-105, hip-worn, 10 months, >10) | PA (steps/day, school PA) | Across all months and seasons, high-school pupils achieved notably more steps on weekdays than on weekends, and on PE days than on non-PE days. The total |
| Study Details | Sample Size | Gender | Age | Region | Activity Measure | PA Categories | SB Categories | Results |
|---------------|-------------|--------|-----|--------|-----------------|---------------|---------------|---------|
| Roubalová et al., 2018a [41] | n = 22 | 100% girls | 6–11 years | Moravia region | Device-measured (accelerometer ActiGraph GT3X+, hip-worn, 7 consecutive days, 60 s epoch, >10 valid hours per day, at least 3 weekday and 1 weekend day, CoP by Evenson) | PA (total, LPA, MVPA) | SB (total sedentary time) | Seasonal differences were found in volume of PA (LPA, MVPA) and SB in younger school-age girls. The highest values of SB were found in autumn (November). The lowest values of SB and the highest values of LPA and MVPA were found in spring (May). Younger girls reported lower values of SB and higher values of PA in all monitored season, then older girls. |
| Rubín et al., 2020 [64] | n = 679 | 56% girls | 8–18 years | Czech Republic | Device-measured (accelerometer ActiGraph GT9X Link or wGT3X-BT, non-dominant wrist, 7 consecutive days, >16 valid hours per day, at least 4 weekday and 1 weekend day) | PA (multi-day 24-h data; LPA, MVPA) | SB (ST) | Approximately 6.5% of children and 2.2% of adolescents met all recommendations of the combined 24-h movement guidelines and several correlates related to family were identified. In children, girls and participants with overweight or obese fathers had significantly lower odds of adherence to the combined movement guidelines. |
| Sigmund et al., 2020a [77] | n = 796 | 4–16 years | Mean age: 10.0 years | Czech Republic | Device-measured (pedometer Digi-walker Yamax SW-200, 8 consecutive days, >6 valid hours per day) | PA (steps/day, OLTA) | SB (ST) | The mother's overweight/obesity significantly increases her children's odds of overweight/obesity. Concerning fathers, active participation in OLTA and reaching 10,000 steps per day significantly reduce the odds of overweight/obesity in their children and adolescent offspring. |
| Sigmund et al., 2020b [82] | n = 1 114d | 51% girls | 6–16 years | Czech Republic | Device-measured (pedometer Digi-walker Yamax SW-200, hip-worn, 8 consecutive days) | PA (steps/day, OLTA) | | Regardless of parents' overweight/obesity, the children who participated in OLTA ≥ three times a week had a lower prevalence of obesity than the children without |
| Study                         | Sample Size | Gender | Age Range | Activity Measure                  | Main Findings                                                                                                                                 |
|-------------------------------|-------------|--------|-----------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| Sigmund et al., 2018a [78]    | n = 649d    | 51%    | 9.3 years | Device-measured (pedometer        | The mother’s PA (achievement of at least 10 000 steps/day) was associated with the achievement of recommended daily steps in overweight/obese preschool and school-aged children. |
|                              |             |        |           | Digi-walker Yamax SW-200, hip-worn, 8 consecutive days, >8 valid hours per day), at least 4 weekdays and 2 weekend days, OLTA               |                                                                                                                                               |
| Sigmund et al., 2018b [65]    | n = 18 250d | 51%    | 10.5–16.5 years | Self-reported (HBSC questionnaire) | A significant decrease was revealed in the rates of meeting the MVPA recommendation in low-family affluence boys (from 28.9 % in 2002 to 23.3 % in 2014) and girls (22.3 % in 2002 to 17.3 % in 2014). A significant trend-related increase in excessive ST was evident in adolescents regardless of gender and family affluence category. While in the high- family affluence boys category of adolescents, achieving 60 min of MVPA daily and the absence of excessive ST on weekdays significantly reduced their odds of being overweight/obese, in low- family affluence adolescents this was not the case. |
|                              |             |        |           | PA (MVPA)                         |                                                                                                                                               |
|                              |             |        |           | SB (ST)                           |                                                                                                                                               |
| Sigmund et al., 2015a [66]    | n = 19 940d | 51%    | 10.5–16.5 years | Self-reported (HBSC questionnaire) | Between the years 2002 and 2014, significant decreases in meeting MVPA recommendations were evident for both adolescent boys and girls. Moreover, increases in excessive ST on weekdays and weekends were found in boys. |
|                              |             |        |           | PA (MVPA, VPA)                    |                                                                                                                                               |
|                              |             |        |           | SB (ST)                           |                                                                                                                                               |
| Sigmund et al., 2015b [85]    | n = 485     |        |           | Device-measured                  | A quantifiable relationship between parent-child steps/day                                                                                   |
|                              |             |        |           | PA (total, steps/day)             |                                                                                                                                               |
| Study | Sample Size | % Girls | Age Range | Country | Device Measurement Details | PA Variables | Findings |
|-------|-------------|---------|-----------|---------|-----------------------------|--------------|---------|
| Sigmund et al., 2014 [67] | n = 338 | 51% | 9–12 years | Czech Republic | pedometer Digi-walker Yamax SW-200, 7 consecutive days, >10 valid hours per day, at least 4 weekdays and 2 weekend days | SB (ST) | Participation in PE lessons led to higher school and daily MVPA in the overweight/obese and normal-weight girls and boys. Participation in PE lessons also reduced school-time SB in the overweight/obese children and normal-weight girls. |
| Sigmund et al., 2013a [52] | n = 176<sup>a</sup> | 50% | 9–11 years | Czech Republic | Device-measured (accelerometer ActiTrainer, waist, 2 consecutive days, >12 valid hours per day, 15 s epoch) | PA (LPA, MVPA) | Participation in PE lessons led to higher school and daily MVPA in the overweight/obese and normal-weight girls and boys. Participation in PE lessons also reduced school-time SB in the overweight/obese children and normal-weight girls. |
| Sigmund et al., 2012c [53] | n = 176 | 48% | 6–9 years | Olomouc region | Device-measured (pedometer Digi-walker Yamax SW-200, hip-worn, 7 consecutive days, >12 valid hours per day) | PA (steps/day) | School-based PA (PE lessons, PA during short breaks and longer recesses, PA at after-school nursery) in compatible active environments (child-friendly gym and school playground, corridors with movement and playing around corners and for games) had a vital role in obesity and overweight reduction among younger pupils. |
| Sigmund et al., 2011c [54] | n = 176 | 48% | 6–8 years | Olomouc region | Device-measured (accelerometer Caltrac, pedometer Digi-walker Yamax SW-200, hip-worn, 7 consecutive days, >8 valid hours per day) | PA (steps/day) | Higher school PA significantly enhances the inhibition of the decline in daily PA and the increase of obesity in 6–8 year-old children. After two years of the intervention program, there |
| Country/Region | Year | Gender | Age | Measures | PA (steps/day) | Findings |
|---------------|------|--------|-----|----------|----------------|----------|
| Olomouc region | 2009a [108] | n = 176 | 48% girls | Device-measured (accelerometer Caltrac, pedometer Digi-walker Yamax SW-200; hip-worn, 7 consecutive days, >8 valid hours per day) | PA (steps/day) | First-grade school children had lower PA than preschool children on weekdays and at weekends. Decline in PA on weekdays was during time spent at school and not during after-school children's leisure-time. |
| Czech Republic | 2008 [46] | n = 193 | 44% girls | Self-reported (IPAQ-SF) | PA (total, organized PA, VPA, MPA, walking) | A longer duration of total PA in daughters, sons and their fathers and mothers was related to a shorter daily period of time spent sitting. A longer time spent daily in sitting in parents was associated with a longer time spent sitting in their children. Children, both daughters and sons, and their mothers, who participate in organized PA twice or more times a week, showed a significantly longer time spent performing VPA than children whose mothers are without any participation in organized PA. |
| Olomouc region | 2007 [47] | n = 67 | 48% girls | Device-measured (accelerometer Caltrac, pedometer Digi-walker Yamax SW-200, 7 consecutive days) | PA (steps/day) | More than 73% of participating children, who were physically active at weekend at least at the same level as at school days, met the health-related PA recommendations for this age category. The weekly number of steps for children who met the health recommendations was 6000 steps/day higher than for children who did not meet the health recommendations. |
| Czech Republic | 2020a [95] | n = 1795 | 4–16 years | Device-measured (pedometer Digi-walker Yamax SW-200; hip-worn, 7 consecutive days) | PA (steps/day) | A strong parent-child step counts relationship was found in children younger than eight years of age. In older children, the parent-child step counts association was gender-specific and dominated by the... |
| Study                                      | Participants | Location | Measurement Method | PA (steps/day) | SB (ST) | Description                                                                                                                                                                                                 |
|-------------------------------------------|--------------|----------|---------------------|----------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Sigmundová et al., 2020b [79]             | n = 1 284    | Czech Republic | Device-measured (pedometer Digi-walker Yamax SW-200, 8 consecutive days) | PA (steps/day) | SB (ST) | Despite the different mother-/father–child behavioral associations, daily step counts of parents were positively associated with daily step counts of their children. For both overweight/obese and non-overweight children, the odds of reaching the recommended daily step counts were increased by their regular participation (≥ twice per week) in OLTA and non-excessive entertainment ST (≤ 2 h per day) in the mother–child and nuclear family triads. |
| Sigmundová et al., 2018 [73]              | n = 649<sup>d</sup> | Czech Republic | Device-measured (pedometer Digi-walker Yamax SW-200; hip-worn, 8 consecutive days, >8 valid hours per day, at least 4 weekdays and 2 weekend days) | PA (steps/day) | SB (ST) | High levels of parents’ PA contributed to the achievement of the recommended daily PA in children on weekdays and at weekends. Excessive weekend ST of parents reduced their odds of their children achieving the recommended daily PA; however, the influence of parents’ PA on their children’s achieving the recommended daily PA was stronger than the inhibitory effect of ST. |
| Sigmundová et al., 2017 [84]              | n = 16 535<sup>d</sup> | Czech Republic | Self-reported (HBSC questionnaire) | SB (ST) | | The boys and girls surveyed in 2014 were up to two times more likely to meet the recommendations for watching television in comparison with groups of schoolchildren of the same age surveyed in 2002. In contrast, computer use by adolescents increased markedly between 2006 and 2014. Taking total ST into account, spending two hours per day or less on it decreased significantly among boys and girls between 2006 and 2014. |
| Sigmundová et al., 2014 [74]              | n = 485      | Czech Republic | Device-measured (pedometer Digi-walker Yamax SW-200; 7 consecutive days, >10 valid hours per day) | PA (steps/day) | SB (ST) | The children of fathers and mothers who met the weekend recommendation of 10 000 steps were 5.48 and 3.60 times, respectively more likely to achieve the weekend recommendation than the children of less active parents. The children of mothers who reached the weekday |
| Study                                      | Sample Size | Gender Distribution | Age Range | Country | Measurement Method | Physical Activity (PA) | Sedentary Behavior (SB) | Note                                                                 |
|-------------------------------------------|-------------|---------------------|-----------|---------|--------------------|------------------------|------------------------|----------------------------------------------------------------------|
| Sigmundová et al., 2013 [40]             | n = 14,219  | 51% girls           | 11–15 years | Czech Republic | Self-reported (HBSC questionnaire) | PA (MVPA)              | SB (ST)                | In comparison with 2002, increased sedentary time and a decline or stagnation of the proportion of children meeting recommendations for PA were found among Czech school-aged children in 2010. |
| Sigmundová et al., 2011 [38]             | n = 520     | 60% girls           | 14–18 years | Czech Republic | Device-measured (pedometer Digi-walker Yamax SW-701 or Omron HJ-105, hip-worn, 7 consecutive days, >10 valid hours per day) | PA (total, steps/day) | SB (total sedentary time) | A secular decrease in PA were found amongst adolescents between 1998–2000 and 2008–2010. The significant interaction effects (cohort × age; and cohort × gender) that this study found suggested that secular trends in PA differ by age and gender. |
| Šimůnek et al., 2017 [68]                | n = 701     | 60% girls           | Mean age: 17.0 years | Czech Republic | Self-reported (IPAQ-LF) | PA (total, AT, LPA, MVPA) | SB (sitting time) | The differences in the overall weekly PA between secondary school boys and girls and between university boys and girls were significant, when secondary school and university boys were more active than secondary school and university girls. |
| Šnoblová et al., 2015 [94]              | n = 169     | 50% girls           | 9–10 years | Czech Republic | Device-measured (accelerometer ActiTrainer; hip-worn, 2 days, >12 valid hours per day, 15 s epoch) | PA (total, steps/day, MVPA) | | Boys were more physically active than girls during their stay at school, both in terms of the step count (800 steps/day more than girls), and duration of MVPA. |
| Valach et al., 2017 [59]                  | n = 653     | 59% girls           | Mean age: 17.3 years | Plzeň region | Self-reported (IPAQ-LF, questionnaire - Sport Preferences Surve) | PA (total, MPA, VPA) | | The preference of fitness activities was associated with a higher level of PA in spare time of boys, and with VPA of boys and girls, compared to those, who did not prefer these activities. In addition, in case of boys, significant correlations |
were found between the preference of team sports and PA at school. Individual sports (swimming, cycling, and downhill skiing) are the main PA preferred by girls. These activities were followed by team sports, rhythmic and dance activities. In case of boys, team sports (football, floorball, and basketball), individual sports, and fitness activities appear at top positions.

| Study                                      | Participants | Measurement          | Variable               | Results                                                                 |
|--------------------------------------------|--------------|----------------------|------------------------|-------------------------------------------------------------------------|
| Valová et al., 2013 [42]                   | n = 55       | Device-measured (accelerometer ActiGraph GT3X, hip-worn, 7 consecutive days) | PA (total, coordination skills) | There wasn't difference in PA between girls from cities and villages. |
| Vašičková et al., 2013 [27]                | n = 786      | Device-measured (pedometer Digi-walker Yamax SW-700) | PA (steps/day)         | Young people on average recorded lower numbers of steps on weekends compared to schooldays with Sunday being the most critical day of the week. No significant differences between boys and girls were found in terms of average number of steps per day. |
| Vašičková et al., 2008 [43]                | n = 9        | Device-measured (pedometer Omron HJ-105, hip-worn, 10 months, >10 valid hours per day) | PA (steps/day)         | The variability in year-round PA was found across days and autumn, winter and spring months. Saturdays and Sundays were the days with the lower number of steps. The highest number of steps was obtained on days with PE lesson. The months with the lowest and highest average steps/day were February and June, respectively. |
| Vindiš et al., 2019 [44]                   | n = 27       | Device-measured (accelerometer ActiGraph GT3X+, hip-worn, 7) | PA (total, LPA, MPA, VPA) | The volume of SB and PA was different on the days with training, on the days without training and during the seasons. On the days with PE lessons, the girls had 27.6% |
### Czech Republic

- **CoP by Evenson:**
  - **SB (total sedentary time):**
    - More MPA, 37.7% more VPA and 8% fewer than on the days without PE lessons.

### Vorliček et al., 2020 [89]

| Study | n | Percentage | Age | Methodology | PA | Findings |
|-------|---|------------|-----|-------------|----|----------|
|       | 1586 | 48% girls | 11–15 years | Self-reported (HBSC questionnaire and IPEN Adolescent questionnaire) | PA (AT – commuting to/from school) | Most of the Czech adolescents misperceived the active commuting norms of their peers. 68% of the Czech adolescents in this study were daily active commuters (walking, cycling, or riding a scooter or skateboard). |

### Vorliček et al., 2019 [69]

| Study | n | Percentage | Age | Methodology | PA | Findings |
|-------|---|------------|-----|-------------|----|----------|
|       | 1586 | 48% girls | 11–15 years | Self-reported (Questionnaire od study SONIAA from Czech version questionnaire (Youth Activity Profile)) | PA (MVPA on Saturday) | The level of the real PA of an individual and perceived level of Saturday’s PA in peers significantly differed among Czech adolescents. Pupils believed that 41.9% of their classmates had had at least one hour of PA on Saturday. This estimation differs by 18 percentage points from the reported situation. |

### Vorliček et al., 2017 [75]

| Study | n | Percentage | Age | Methodology | PA | Findings |
|-------|---|------------|-----|-------------|----|----------|
|       | 1745 | 49% girls | 11–19 years | Device-measured (pedometer Digi-walker Yamax SW-700, 7 consecutive days) | PA (AT – commuting to/from school, steps/day) | A greater proportion of pupils, who met health recommendations for PA, occur in the group using the active forms of commuting to school, such as walking or riding a bike or skateboard. The majority (85%) of pupils, who commuted actively to school, lived within a 20-minute walking distance. |

### Weinberg et al., 2019 [28]

| Study | n | Percentage | Age | Methodology | PA | Findings |
|-------|---|------------|-----|-------------|----|----------|
|       | 4847 | 11–15 years | Czech Republic | Self-reported (HBSC questionnaire) | PA (MVPA, VPA) | Daily involvement in MVPA decreased with age (from 4.62 days with MVPA/week in 11-year-old adolescents to 3.99 days with MVPA/week in 15-year-old adolescents) while weekly VPA increased (from 1.99 hours/week in 11-year-old |
studies on adolescents, and 7 studies on both. The age of the study participants ranged between 6 and 19 years. The intervention studies employed only children aged 6–9 years. Girls represented more than 50% of the study sample in most of the studies and boys have not been included in 4 studies [41–44]. Out of all 79 studies, the randomly selected representative samples were identified in 28 studies.

In cross-sectional studies, the sample size varied from 55 [42] up to 30,966 participants [45]. Longitudinal studies employed samples with 9 to 176 participants.

This scoping review identified data on PA and SB of Czech children and adolescents in 18 international and 61 national studies. Some of the national studies narrowed their selection only to specific regions: 12 studies from the Olomouc region [26, 39, 43, 46–54], 2 studies from the Hradec Králové region [39, 49], three studies from the Moravia region [41, 55, 56], two studies from the North-western Bohemia region [57, 58], one study from the Plzeň [59] and Opava region [42].

All studies reported the measurement tool for PA or SB assessment (Table 1). The number of studies using self-reported (n = 39), device-measured (n = 32), and a combination of both (n = 8) assessments of PA and SB is shown in Figure 3. Out of 40 studies using device-based measurements, accelerometers (ActiGraph GT3X, GT3X+, GT9X Link, wGT3X-BT, Caltrac, and ActiTrainer) were used in 19 studies, while pedometers (Digi-walker Yamax SW-200, SW-700, SW-701, Omron HJ-105) were used in 28 studies. Studies using self-reported measurements used the HBSC questionnaire (n = 27), IPAQ-long form (n = 13), IPEN Adolescent questionnaires (n = 2), IPAQ-short form (n = 1) and other types of questionnaires (n = 9).

Of the 79 included studies (Figure 2), PA-only studies comprised the largest proportion (61%), followed by both PA and SB studies (34%) and SB-only studies (5%). PA was expressed as minutes, MET-minutes or steps on an average day (waking time or 24h) or a specific segment of the day (unorganized or organized leisure-time physical activity (OLTA), school PA in physical education (PE) lessons, or during recesses, active transport (AT). SB studies reported minutes of total SB, sitting time, or ST, which was defined as TV viewing, playing games on PC/console, chatting online, internet, emailing, etc.

**Main findings related to PA and SB**
Prevalence of sufficient/insufficient PA and SB

Thirty-seven studies (Supplementary file 3) also reported the prevalence of sufficient/insufficient PA, SB, or both. The prevalence of the adherence to the PA and ST recommendations ranges between 12.6–73% and 17.5–73.6%, respectively. However, the definition of sufficient PA level was different in the included studies, from meeting 60 minutes of moderate to vigorous physical activity (MVPA) daily or five times a week [20, 21, 23, 30, 31, 35, 37, 52, 56, 60–70], 20 minutes of VPA at least three times a week or 30 minutes of MPA or walking at least five times a week [21, 23, 30, 31, 37, 59, 61, 66, 68, 71, 72], daily step counts ranging between 11,000–14,000 for boys and 10,000–13,000 for girls [27, 31, 38, 47, 62, 70, 73–79]. Moreover, the recommendation for school PA (i.e., 500 steps/school time) was met by 39% Czech adolescents [33] and 83% of boys and 69% of girls in days with PE lesson [70]. Excess SB was mostly defined as ≥2 hours/day of ST [66, 73, 74, 80] and was accomplished by 40.4–80.7% of children and adolescents.

Higher likelihood of meeting recommended level of PA was associated with lower age [24, 28, 37, 40, 41, 60, 61, 64, 66, 69, 72, 81], an environment perceived as activity-friendly [22], participation in PE lessons or intervention programs [53, 67, 70], active transportation [21, 69], OLTA [78, 82] or more specifically in sports clubs [37], sufficient PA at weekend days [27, 74], preferences of fitness activities [23, 59], different kind of motives [31, 42, 48, 49, 61] and the agreement between preferred and PA actually undertaken [31].

The proportion of children and adolescents not meeting recommendation for SB or ST was positively associated with age [26, 60, 80, 83, 84] and more ST at weekend days compared to weekdays [32, 40, 58, 66, 74, 80, 84, 85]. Furthermore, longitudinal studies confirmed the variability of the achievement of sufficient PA and SB across seasons, months, and days of the week [41, 43, 44, 50, 51].

Studies investigating the trends of sufficient PA or SB found an increasing prevalence of sedentary time [40, 66], the decreasing prevalence of children and adolescents meeting PA guidelines [35, 38, 62, 66], and active commuting [86]. However, one study suggested that the way how children and adolescents spent their time being sedentary has shifted from watching TV to computer use during 2002 and 2014 [84].

Weekdays versus weekend days

In all studies, a greater PA level was found for weekdays compared to weekend days. Moreover, this was confirmed in longitudinal studies [43, 51] which revealed that across all months and seasons, children and adolescents achieved notably more minutes in MVPA or steps on weekdays than on weekends, with Sunday being the least active day [43, 50, 51, 62]. Conversely, weekend days seem to be the “risk time” for excessive ST and insufficient PA level [40, 62, 66, 74, 80, 85].

Active transport

Out of 11 studies examining AT, 9 studies focused on active commuting to and from school including walking, cycling, and riding a scooter or skateboard. The proportion of children and adolescents using actively commuting to school ranged between 22.5% and 74.3% across studies [29, 36, 39, 63, 75, 86–
Living within a 20-minute walking distance to school [75], a place of residence being in the same municipality as the school [63, 87], high walkable areas [39], and attending schools with policies and programs promoting AT [87, 88] were positively associated with active commuting to school. Based on one study [21], AT accounted for 22.5% and 24.9% of the weekly PA of Czech boys and girls, respectively. A long-term decrease in AT of Czech adolescents was found in two studies. One study [39] found a decrease in the proportion of active commuting in 47% of respondents and suggested 2.7 times decrease in likelihood to actively commute in 2011 than in 2001. The second study [86] showed an overall decrease in AT by 21.7% in boys and by 23% in girls between 2006 and 2014.

**PE lessons and organized leisure-time activities**

Participation in regular PE lessons contributed considerably to increment of the volume and intensity of school PA [33, 67, 70], steps/day [43, 51], daily MVPA [67] and decrease of school-time SB [67]. This was apparent across all months and seasons [43, 44, 51]. In intervention studies [52–54], PE lessons as a part of the school PA program performed in the compatible active environments were found to have a vital role in obesity and overweight reduction among younger pupils.

The proportion of children and adolescents who participated in OLTA ranged between 41–81% across studies [90–93] and was decreasing with age [58, 91]. More specifically, 62% of Czech children and adolescents took part in sports club activities [37]. Moreover, OLTA was positively associated with better physical and mental health [93], lower occurrence of repeated substance use and truancy, and inversely with higher odds for physical fights and injuries [91], higher school engagement, lower levels of school-related stress, and better academic achievement [92], and a lower prevalence of obesity [82]. Longitudinal engagement in OLTA increased daily PA, regardless of the month and season [50]. In contrast, 34–37% of Czech children and adolescents were not engaged in any OLTA [29, 90]. However, the involvement in peer-oriented unstructured activities was strongly associated with an increased risk of smoking, getting drunk, experience with sexual intercourse, and worse academic achievement in 34% of adolescents [90].

**Differences between boys and girls**

The majority of studies investigating PA in both sexes suggested that boys are more active than girls [56, 72, 94]. This was obvious particularly in total PA [32, 37, 72], MVPA [24, 30, 31, 35, 40, 55, 56, 61, 62, 65–67, 94], school-based PA [32, 33, 70], leisure-time PA [58, 72, 82, 90, 92, 93] and active transportation [21, 39, 86, 88]. Although the most studies found a higher daily number of steps in boys than in girls [25, 31, 33, 52–54, 56, 57, 62, 70, 73, 74, 79, 82, 85, 94, 95], four studies conversely suggested higher steps/day in girls compared to boys [32, 38, 76, 78]. Sex-specific patterns related to PA were found in several studies. For example, boys were more likely to cycle to school [86] and the association between school policies and programs and AT was stronger in boys compared to girls [80]. On the other hand, a higher rate of AT was significantly associated only with higher well-being in girls [21]. Girls had significantly lower odds of adherence to the combined movement guidelines [64], appeared to be more influenced by social motives [61] and their participation in leisure-time PA was decreasing with age more than in boys [58]. PA preference differed between boys and girls and was longitudinally more stable for boys than for girls [23].
In SB studies, the results related to sex differences were not so clear. In some device-based studies, girls were found to be more sedentary [38, 56, 67, 71], while in others, time spent in SB was higher in boys compared to girls [45, 58, 65, 80, 83]. Moreover, in self-reported studies, boys reported higher overall ST [58, 83], computer use [32, 45, 80], or TV watching [45] than girls. On the contrary, chatting online was more common among girls [80]. The sex-specific SB was found also in the device-based study [55], where boys spent on average 9.9 min/day less in short sedentary bouts and 7.5 min/day more in long sedentary bouts compared with girls. Also, longitudinal increases in excessive ST on weekdays and weekends were found only in boys [66].

**Parent-child PA**

The relationship between the parent’s and children's PA and SB was investigated in 8 studies [46, 73, 74, 78, 79, 82, 85, 95]. In conclusion, high levels of parents’ PA contributed to the achievement of the recommended daily PA in children [73, 74, 78, 79, 85, 95], and excessive ST of parents was associated with a longer time spent sitting in their children [46] and reduced likelihood of their children of achieving the recommended daily PA [73, 85]. The parent-child PA or SB relationship was found to be stronger for children younger than eight years of age [78, 95], on weekend days [73, 74, 85, 95], and in families participating in organized PA [46].

**24h time use**

In four studies, 24-h movement behaviours were considered including SB, PA, and sleep. Based on one self-reported study [29], 95% of Czech children slept for 9–11 hours per night. Approximately three-quarters of children (71 %) and adolescents (75.3 %) slept less than 9 and 8 hours, respectively [81]. In children, this shorter sleep duration was associated with higher SB by 95 min/day and lower MVPA by 16 min/day. In adolescents, a higher SB by 67 min/day and lower light intensity PA (LPA) by 2 min/day were found to be associated with a short sleep duration. [81]. Also, meeting combined 24h movement guidelines (≥ 60 min/day of MVPA, < 2 h/day of recreational ST, and uninterrupted sleep for 9–11 h/day for children or 8–10 h/day for adolescents) was investigated in two studies [60, 64]. All recommendations of the combined 24h movement guidelines were met by approximately 6.5% of children and 2.2% of adolescents [64]. While no associations were found between meeting all three (combined) recommendations and adiposity indicators, meeting ST only recommendation or the combined ST and sleep recommendations was found to be negatively (favorably) associated with adiposity [60]. Furthermore, significantly lower odds of adherence to the combined movement guidelines were in girls and participants with overweight or obese fathers [64].

**Discussion**

This scoping review examined 79 original articles related to PA or SB of Czech children and adolescents and summarized the descriptive characteristics and main conclusions of the available evidence. The majority of studies were cross-sectional (88.6%), approximately two-thirds of the studies (61%) examined only PA, and half of the studies (50.6%) employed device-based assessments. Approximately 47% of
studies reported the prevalence of sufficient/insufficient PA and 14%, 23%, and 10% of studies focused on AT, organized PA (including PE or OLTA), and parent-child PA, respectively.

Although we searched for the articles published in the past two decades, the articles included in this review have been not published until 2007. Since then, the number of PA and SB research has been on the rise with 79 papers being published till December 2020. This is in line with the gradual increase of Czech studies dealing with the PA of children and adolescents, often connected with international cooperation and participation in global studies, such as International Physical Activity and the Environment Network, Health Behaviour in School-Aged Children, or Childhood Obesity Surveillance Initiative. Although the first two papers were published in 2007, data from identified studies cover the whole 20-year period. This is mainly apparent in trend studies with the first round of assessments in 1998–2000 [38], 2001 [39], and 2002 [40].

In this review, we found a high proportion of cross-sectional studies and only nine studies with a longitudinal design. The follow-up period of longitudinal studies ranged between 10 to 24 months and revealed differences across days of the week, months, and seasons, and in one specific life transition (e.g., from kindergarten to school). However, these studies employed mainly very small convenience samples with limited possibility to generalize the results to the Czech school-aged population. Considering longitudinal studies as the way how to define the causality and determinants of PA and SB, more longitudinally designed studies with the random sample are needed in the Czech Republic. Additionally, these studies should consider the year-round movement behaviours concerning different life transitions.

This study critically reviewed only the PA and SB research in target populations, although the importance of sleep has been recognized and was included as an important health outcome when considering the impact of PA and SB [81]. This was done for two reasons. Firstly, the vast majority of Czech studies focused only on PA and/or SB, with exception of four studies [55, 60, 64, 81] published very recently which examined movement behaviours (i.e., PA, SB, and sleep) using 24-h wear time protocol. Secondly, this approach agrees with a recently published edition of "WHO Guidelines on Physical Activity and Sedentary Behavior" [1]. However, in recent years, the univariate paradigm in movement behaviour research has been substituted by a 24-h time-use paradigm that integrates all daily movement behaviours being analyzing relative to each other, rather than as individual entities [96]. This approach is apparent in world initiatives, such as developing time-use epidemiology [97] and in the creation of 24-h movement behaviour recommendations in several countries, such as Australia [98], Canada [99], Croatia [100], New Zealand [101] or Thailand [102]. Within this review, the lack of Czech studies focusing on health-related time-use patterns and covering all daily behaviours in children and adolescent populations has been recognized.

Consistent, understandable assessments of prevalence and trends in PA (ideally relative to other behaviours) are necessary to guide the development of policies and programs to increase activity levels and to reduce the burden of non-communicable diseases associated with physical inactivity and elevated
SB. In this review, 37 studies investigating the percentage of Czech children or adolescents who achieved PA or SB recommendations were cross-sectional with 62% not having a representative sample.

This review also identified several studies that examined trends in PA or SB or meeting recommendations for these behaviours. Such studies with randomly selected samples suggested the negative trends which were found in other countries [5], such as increased sedentary time, decreasing percentage of children and adolescents meeting PA guidelines, and using AT. However, these studies employed self-reported assessments of PA and SB that could be prone to both inaccurate reporting and reporting bias [103]. Moreover, accelerometers were found more accurate in the characterization of the entire activity pattern in school-aged children [104]. On the other hand, the domain and type-specific differences in PA and SB (e.g., AT, ST) advocate the importance of assessing movement behaviours using the combination of self-reported and device-based methods. Furthermore, the variety of tools used to assess PA and SB, the way how were the data processed (especially in accelerometers) as well as the different definition of sufficient level of PA and SB in the studies may explain the inconsistency of findings related to sex-specific PA and SB or prevalence of sufficient PA.

**Strengths and limitations of the study**

This is the first comprehensive study systematically reviewing available evidence related to PA and SB in Czech children and youth. Moreover, within this review, we provide suggestions for future directions of the national surveillance system on these behaviours.

Several limitations have to be mentioned. Firstly, the search strategy does not cover "grey literature". This could lead to publication bias as we might miss some valuable data published in conference proceedings, Master or Doctoral thesis, or reports. On the other hand, our search strategy ensured that all studies found for this review underwent a peer-review process and demonstrate at least satisfactory methodological quality standards. Last and not least, within this scoping review we described the study designs, samples, and methods of PA and SB assessments and the main findings of the selected studies. However, an assessment of methodological quality which could help in comparison of outcomes of the studies was not carried out.

**Conclusion And Recommendations**

This scoping review identified 79 studies related to PA and SB in Czech children and adolescents and revealed the increasing trend in a number of studies being published during the past two decades. The results of studies suggested an increase of the unhealthy sedentary time or its proxy-indicators and decreasing percentage of Czech children and adolescents meeting a sufficient amount of PA. Based on this review, organized PA including PE lessons as well as OLTA, increasing of weekend PA, family inclusion, and movement supporting environment might contribute to decrement of unhealthy time-use in Czech children and adolescents.
Although we reviewed 79 studies, the unified national surveillance was not recognized. This review identified limitations including the large proportion of cross-sectional studies, the limited sample size in longitudinal studies, the lack of studies using a mix of devised-based and self-reported methods, and focusing on health-related 24-h time-use patterns.

In agreement with global calls [11, 105], the result of this review advocates the necessity of the governmental-supported development of a national surveillance system that would incorporate a combination of standardized device-based measures, such as those derived from accelerometers, and self-reported domain and type-specific assessments. Such a national surveillance system on movement behaviours which would allow to systematically assess the recommended amount of these behaviours is needed to reduce decreasing of sufficient PA and hence, improve health or reduce the risk of different non-communicable diseases in Czech children and adolescents.

With respect to the "WHO Global action plan on physical activity 2018–2030" call [11] and based on this review of the best available evidence, we identified several issues which might serve as a recommendation for future directions in Czech research and policy and were inspiring for other Central European countries lacking a national surveillance system:

- We advocate the development of a national surveillance system on 24-h movement behaviours that would incorporate both device-based measures and self-reported domain and type-specific assessments.
- The national surveillance system should systematically monitor the prevalence of sufficient PA and 24-h time use of PA, SB, and sleep and their associations with health outcomes.
- Further evidence is needed to support national recommendations on PA, SB, and sleep and to enforce them in state and school policy and practice. Furthermore, longitudinally designed device-based studies employing randomly selected samples of Czech children and adolescents are needed.

**Abbreviations**

PA: physical activity

SB: sedentary behaviour

METs: metabolic equivalents

WHO: World Health Organization

OLTA: organized leisure-time physical activity

PE: physical education

AT: active transport
Declarations

Acknowledgments

We are thankful to the Palacký University Olomouc for providing us with essential resources to complete this review.

Authors' contributions

EM, JP and AG conceptualized the study. EM and JP wrote the manuscript. EM, JP and AG contributed to the abstract and full-text screening. AG creates the search strategy. AG and KF critically reviewed the manuscript and made revisions. All the authors approved the final draft.

Funding

The study was funded by the internal Palacký University Olomouc grant IGA_FTK_2018_007.

Availability of the data and materials

The data supporting the conclusion of this paper are available through the detailed reference list. No original datasets are presented since this was a review of previously existing literature. Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Ethics approval and consent to participate

This study is a systematic scoping review that relied solely on existing literature. Hence, ethical approval was not required since there were no human participants.

Consent for publication

Not applicable.

Competing interests

ST: screen time

MVPA: moderate-to-vigorous physical activity

LPA: light-intensity physical activity
The authors declared no competing interests.

References

1. World Health Organization. WHO guidelines on physical activity and sedentary behaviour. Geneva: World Health Organization. 2020.
2. World Health Organization. Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age. Geneva: World Health Organization. 2019.
3. Poitras VJ, Gray CE, Borghese MM, Carson V, Chaput JP, Janssen I, et al. Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. Appl Physiol Nutr Metab. 2016;41(6):197–239.
4. Guariguata L, Jeyaseelan S. Children and non-communicable disease: Global Burden Report 2019. NCD Child. 2019. Available from: www.ncdchild.org
5. Gordon-Larsen P, Nelson MC, Popkin BM. Longitudinal physical activity and sedentary behavior trends: adolescence to adulthood. Am J Prev Med. 2004;27(4):277–83.
6. Guthold R, Stevens GA, Riley LM, Bull FC. Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1·6 million participants. Lancet Child Adolesc Heal. 2020;4(1):23–35.
7. Marques A, Henriques-Neto D, Peralta M, Martins J, Demetriou Y, Schönbach DMI, et al. Prevalence of physical activity among adolescents from 105 low, middle, and high-income countries. Int J Environ Res Public Health. 2020;17(3145):1–11.
8. Parrish AM, Tremblay MS, Carson S, Veldman SLC, Cliff D, Vella S, et al. Comparing and assessing physical activity guidelines for children and adolescents: a systematic literature review and analysis. Int J Behav Nutr Phys Act. 2020;17(16):1–22.
9. Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act. 2017;14(75):1–17.
10. Tremblay MS, LeBlanc AG, Kho ME, Saunders TJ, Larouche R, Colley RC, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act. 2011;8(98):1–22.
11. World Health Organization. Global action plan on physical activity 2018-2030: more active people for a healthier world. Geneva: World Health Organization. 2018.
12. Ramírez Varela A, Cruz GIN, Hallal P, Blumenberg C, da Silva SG, Salvo D, et al. Global, regional, and national trends and patterns in physical activity research since 1950: a systematic review. Int J Behav Nutr Phys Act. 2021;18(5):1–15.
13. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169(7):467–73.
14. Frömel K, Šafář M, Jakubec L, Groffik D, Žatka R. Academic stress and physical activity in adolescents. Biomed Res Int. 2020;1–10.

15. Kudláček M, Frömel K, Jakubec L, Groffik D. Compensation for adolescents’ school mental load by physical activity on weekend days. Int J Environ Res Public Health. 2016;13(3).

16. Svozil Z, Frömel K, Chmelík F, Jakubec L, Groffik D, Šafář M. Mental load and its compensation by physical activity in adolescents at secondary schools. Cent Eur J Public Health. 2015;23:44–9.

17. Valach P, Vašíčková J, Frömel K, Jakubec L, Chmelík F, Svozil Z. Is academic achievement reflected in the level of physical activity among adolescents? J Phys Educ Sport. 2020;20(1):186–95.

18. Bobakova D, Hamrik Z, Badura P, Sigmundova D, Nalecz H, Kalman M. Test-retest reliability of selected physical activity and sedentary behaviour HBSC items in the Czech Republic, Slovakia and Poland. Int J Public Health. 2015;60:59–67.

19. Bosakova L, Kolarcik P, Bobakova D, Sulcova M, Van Dijk JP, Reijneveld SA, et al. Test–retest reliability of the scale of participation in organized activities among adolescents in the Czech Republic and Slovakia. Int J Public Health. 2015;61(3):329–36.

20. Bucksch J, Kopcakova J, Inchley J, Troped PJ, Sudeck G, Sigmundova D, et al. Associations between perceived social and physical environmental variables and physical activity and screen time among adolescents in four European countries. Int J Public Health. 2019;64(1):83–94.

21. Frömel K, Groffik D, Mitáš J, Dygrýn J, Valach P, Šafář M. Active travel of Czech and Polish adolescents in relation to their well-being: support for physical activity and health. Int J Environ Res Public Health. 2020;17(6):2001.

22. Kopcakova J, Dankulincova Veselska Z, Madarasova Geckova A, Bucksch J, Nalecz H, Sigmundova D, et al. Is a perceived activity-friendly environment associated with more physical activity and fewer screen-based activities in adolescents? Int J Environ Res Public Health. 2017;14(39):1–8.

23. Kudlacek M, Fromel K, Groffik D. Associations between adolescents’ preference for fitness activities and achieving the recommended weekly level of physical activity. J Exerc Sci Fit. 2020;18:31–9.

24. Ng KW, Sudeck G, Marques A, Borraccino A, Boberova Z, Vasickova J, et al. Associations between physical activity and perceived school performance of young adolescents in health behavior in school-aged children. J Phys Act Health. 2020;17:698–708.

25. Nováková Lokvencová P, Frömel K, Chmelík F, Groffik D, Bebčáková V. School and weekend physical activity of 15–16 year old Czech, Slovak and Polish adolescents. Acta Univ Palacki Olomuc Gymnica. 2011;41(3):39–45.

26. Pavelka J, Husarova D, Sevcikova A, Madarasova Geckova A. Country, age, and gender differences in the prevalence of screen-based behaviour and family-related factors among school-aged children. Acta Gymnica. 2016;46(3):143–51.

27. Vašíčkova J, Frömel K, Groffik D, Chmelík F. Decrease in weekend number of steps in adolescents. Acta Univ Palacki Olomuc Gymnica. 2013;43(1):49–55.

28. Weinberg D, Stevens GWJM, Bucksch J, Inchley J, De Looze M. Do country-level environmental factors explain cross-national variation in adolescent physical activity? A multilevel study in 29
29. Whiting S, Buoncristiano M, Gelius P, Abu-Omar K, Pattison M, Hyska J, et al. Physical activity, screen time, and sleep duration of children aged 6–9 years in 25 countries: an analysis within the WHO European childhood obesity surveillance initiative (COSI) 2015–2017. Obes Facts. 2020;1–13.

30. Frömel K, Grofik D, Chmelik F, Cocca A, Skalik K. Physical activity of 15–17 years old adolescents in different educational settings: a Polish-Czech study. Cent Eur J Public Health. 2018;26(2):137–43.

31. Fromel K, Kudlacek M, Grofik D, Svozil Z, Simunek A, Garbaciak W. Promoting healthy lifestyle and well-being in adolescents through outdoor physical activity. Int J Environ Res Public Health. 2017;14(533):1–15.

32. Frömel K, Kudlacek M, Grofik D, Chmelik F, Jakubec L. Differences in the intensity of physical activity during school days and weekends in Polish and Czech boys and girls. Ann Agric Environ Med. 2016;23(2):357–60.

33. Grofik D, Mitáš J, Jakubec L, Svozil Z, Frömel K. Adolescents’ physical activity in education systems varying in the number of weekly physical education lessons. Res Q Exerc Sport. 2020;91(4):551–61.

34. Hamřík Z, Bobáková D, Kalman M, Dankulincová Veselská Z, Klein D, Madarasová Gecková A. Physical activity and screen-based activity in healthy development of school-aged children. Cent Eur J Public Health. 2015;23:50–6.

35. Kalman M, Inchley J, Sigmundova D, Iannotti RJ, Tynjälä JA, Hamrik Z, et al. Secular trends in moderate-to-vigorous physical activity in 32 countries from 2002 to 2010: a cross-national perspective. Eur J Public Health. 2015;25(2):37–40.

36. Kleszczewska D, Mazur J, Bucksch J, Dzielska A, Brindley C, Michalska A. Active transport to school may reduce psychosomatic symptoms in school-aged children: data from nine countries. Int J Environ Res Public Health. 2020;17(8709):1–12.

37. Kokko S, Martin L, Geidne S, Van Hoye A, Lane A, Meganck J, et al. Does sports club participation contribute to physical activity among children and adolescents? A comparison across six European countries. Scand J Public Health. 2018;47(8):1–8.

38. Sigmundová D, El Ansari W, Sigmund E, Frömel K. Secular trends: a ten-year comparison of the amount and type of physical activity and inactivity of random samples of adolescents in the Czech Republic. BMC Public Health. 2011;11(731).

39. Dygrýn J, Mitáš J, Gába A, Rubín L, Frömel K. Changes in active commuting to school in Czech adolescents in different types of built environment across a 10-year period. Int J Environ Res Public Health. 2015;12:12988–98.

40. Sigmundová D, Sigmund E, Hamrik Z, Kalman M. Trends of overweight and obesity, physical activity and sedentary behaviour in Czech schoolchildren: HBSC study. Eur J Public Health. 2013;24(2):210–5.

41. Roubalová E, Pelclová J. Sezónní změny v pohybové aktivitě a sedavém chování u dívek ve věku 6–11 let. Tělesná Kult. 2018;41(1):42–7.
42. Valová M, Vala R, Fojtík I. Srovnání koordinačních schopností a množství pohybové aktivity dívek městských a vesnických základních škol. Stud Kinanthropologica. 2013;14(3):231–6.

43. Vašíčková J, Pelcová J, Frömel K, Chmelík F, Pelcl M. Pilotní studie ročního režimu pohybové aktivity gymnaziálních studentek. Tělesná Kult. 2008;31(2):102–8.

44. Vindiš J, Pelcová J, Pechová J. Přínos volnočasové organizované pohybové aktivity k celkové denní pohybové aktivitě v kontextu sezónnosti. Tělesná Kult. 2019;42(2):35–40.

45. de Gouw L, Klepp K-I, Vignerová J, Lien N, Steenhuis IHM, Wind M. Associations between diet and (in)activity behaviours with overweight and obesity among 10–18-year-old Czech Republic adolescents. Public Health Nutr. 2010;13(10A):1701–7.

46. Sigmund E, Turoňová K, Sigmundová D, Přidalová M. The effect of parents’ physical activity and inactivity on their children’s physical activity and sitting. Acta Univ Palacki Olomuc Gymnica. 2008;38(4):17–24.

47. Sigmund E, Lokvencová P, Mitáš J, Miklánková L, Vašíčková J, Frömel K. Ověření možnosti celotýdenního monitorování pohybové aktivity dětí mladšího školního věku pomocí akcelerometru a pedometru pro tvorbu a kontrolu pohybových programů. Česká kinantropologie. 2007;11(4):9–20.

48. Bešič D, Balaban V. Vztah mezi pohybovou aktivitou a komponentami zdravotně orientovanětělesné zdatnosti u dětí ve věku 9–11 let. Stud Kinanthropologica. 2016;17(3):203–12.

49. Kudláček M. Pohybová aktivita a sportovní preference adolescentů ve vazbě na prostředí – regionální komparativní studie. Tělesná Kult. 2015;38(1):47–67.

50. Pelcová J, El Ansari W, Vašíčková J. Is participation in after-school physical activity associated with increased total physical activity? A study of high school pupils in the Czech Republic. Int J Environ Res Public Health. 2010;7:2853–65.

51. Pelcová J, El Ansari W, Vašíčková J. Study of day, month and season pedometer-determined variability of physical activity of high school pupils in the Czech Republic. J Sport Sci Med. 2010;9:490–8.

52. Sigmund E, Sigmundová D. Longitudinal 2-year follow-up on the effect of a non-randomised school-based physical activity intervention on reducing overweight and obesity of Czech children aged 10–12 years. Int J Environ Res Public Health. 2013;10:3667–83.

53. Sigmund E, El Ansari W, Sigmundová D. Does school-based physical activity decrease overweight and obesity in children aged 6–9 years? A two-year non-randomized longitudinal intervention study in the Czech Republic. BMC Public Health. 2012;12(570):1–13.

54. Sigmund E, Sigmundová D, Šnoblová R, Miklánková L, Neuls F, El Ansari W. Pohybovou aktivitou ve školním prostředí ke zmírnění obezity 6–8 letých dětí: výsledky tříleté longitudinální studie v České republice. Česká kinantropologie. 2011;15(4):61–75.

55. Gába A, Pedišić Ž, Štefelová N, Dygrýn J, Hron K, Dumuid D, et al. Sedentary behavior patterns and adiposity in children: a study based on compositional data analysis. BMC Pediatr. 2020;20(147):1–11.
56. Gába A, Mitáš J, Jakubec L. Associations between accelerometer-measured physical activity and body fatness in school-aged children. Environ Health Prev Med. 2017;22(1):1–8.

57. Blaha L, Cihlar D. Determining differences among genders and days of the week in adolescent physical activity levels using pedometers in Northwestern Bohemia. Phys Act Rev. 2019;7:80–8.

58. Bláha L, Cihlář D. Uplatňování volnočasových pohybových aktivit a inaktivit u dětí na 2. stupni ZŠ. Česká kinantropologie. 2010;14(2):107–18.

59. Valach P, Frömel K, Jakubec L, Benešová D, Salcman V. Physical activity and sport preferences of West Bohemian adolescents. Tělesná Kult. 2017;40(1):45–53.

60. Jakubec L, Gába A, Dygrýn J, Rubín L, Šimůnek A, Sigmund E. Is adherence to the 24-hour movement guidelines associated with a reduced risk of adiposity among children and adolescents? BMC Public Health. 2020;20(1119):1–9.

61. Kalman M, Hamrik Z, Sigmund E, Sigmundová D, Salonna F. Physical activity of Czech adolescents: findings from the HBSC 2010 study. Acta Gymnica. 2015;45(1):3–11.

62. Mitáš J, Frömel K, Valach P, Suchomel A, Vorlíček M, Groffik D. Secular trends in the achievement of physical activity guidelines: indicator of sustainability of healthy lifestyle in Czech adolescents. Sustainability. 2020;12(5183):1–14.

63. Pavelka J, Sigmundová D, Hamřík Z, Kalman M. Active transport among Czech school-aged children. Acta Univ Palacki Olomuc Gymnica. 2012;42(3):17–26.

64. Rubín L, Gába A, Dygrýn J, Jakubec L, Materová E, Vencálek O. Prevalence and correlates of adherence to the combined movement guidelines among Czech children and adolescents. BMC Public Health. 2020;20(1692):1–11.

65. Sigmund E, Badura P, Sigmundová D, Voráčová J, Zacpal J, Kalman M, et al. Trends and correlates of overweight/obesity in Czech adolescents in relation to family socioeconomic status over a 12-year study period (2002–2014). BMC Public Health. 2018;18(122):1–11.

66. Sigmund E, Sigmundová D, Badura P, Kalman M, Hamrík Z, Pavelka J. Temporal trends in overweight and obesity, physical activity and screen time among Czech adolescents from 2002 to 2014: a national health behaviour in school-aged children study. Int J Environ Res Public Health. 2015;12:11848–68.

67. Sigmund E, Sigmundová D, Hamrík Z, Madarássová Gecková A. Does participation in physical education reduce sedentary behaviour in school and throughout the day among normal-weight and overweight-to-obese Czech children aged 9–11 years? Int J Environ Res Public Health. 2014;11:1076–93.

68. Šimůnek A, Frömel K, Salonna F, Bergier J, Junger J, Ács P. Sedávě chování a vybrané aspekty pohybové aktivity SŠ a VŠ studentů. Tělesná Kult. 2017;40(2):105–11.

69. Vorlíček M, Baďura P, Mitáš J, Rubín L, Banátová K, Kolarčík P, et al. Čeští adolescenti si vytváří zkreslené sociální normy v kontextu sobotní pohybové aktivity. Tělesná Kult. 2019;42(2):48–54.

70. Frömel K, Svozil Z, Chmelík F, Jakubec L, Groffik D. The role of physical education lessons and recesses in school lifestyle of adolescents. J Sch Health. 2016;86:143–51.
71. Mitáš J, Nykodým J, Frömel K. Physical activity and sedentary behavior in 14–15 year old students with regard to location of school. Acta Univ Palacki Olomuc Gymnica. 2009;39(3):7–11.

72. Frömel K, Chmelík F, Bláha L, Feltlová D. Pohybová aktivita české mládeže: koreláty intenzivní pohybové aktivity. Česká kinantropologie. 2007;11(4):49–55.

73. Sigmundová D, Badura P, Sigmund E, BUCKSCH J. Weekday–weekend variations in mother-/father–child physical activity and screen time relationship: a cross-sectional study in a random sample of Czech families with 5- to 12-year-old children. Eur J Sport Sci. 2018;18(8):1158–67.

74. Sigmundová D, Sigmund E, Vokáčová J, Kopčáková J. Parent-child associations in pedometer-determined physical activity and sedentary behaviour on weekdays and weekends in random samples of families in the Czech Republic. Int J Environ Res Public Health. 2014;11:7163–81.

75. Vorlíček M, Rubín L, Dygrýn J, Mitáš J. Pomáhá aktivní docházka/dojíždě českým adolescentům plnit zdravotní doporučení pro pohybovou aktivitu? Tělesná Kult. 2017;40(2):112–6.

76. Frömel K, Jakubec L, Groffk D, Chmelík F, SVOZIL Z, ŠAfář M. Physical activity of secondary school adolescents at risk of depressive symptoms. J Sch Health. 2020;90(8):641–50.

77. Sigmund E, Sigmundová D, Badura P. Excessive body weight of children and adolescents in the spotlight of their parents’ overweight and obesity, physical activity, and screen time. Int J Public Health. 2020;65:1309–17.

78. Sigmund E, Badura P, Vokáčová J, Sigmundová D. Vztah pohybové aktivity rodičů a jejich dětí v českých rodinách s dětmi s normální tělesnou hmotností a dětmi s nadváhou/obezitou. Prakt lékař. 2018;98(2):73–80.

79. Sigmundová D, Badura P, Sigmund E. Parent–child dyads and nuclear family association in pedometer-assessed physical activity: a cross-sectional study of 4-to-16-year-old Czech children. Eur J Sport Sci. 2020;1–12.

80. Hamřík Z, Kalman M, Sigmundová D, Pavelka J, Salonna F. Screen-based behaviour in Czech adolescents is more prevalent at weekends. Acta Gymnica. 2014;44(4):203–9.

81. Gába A, Dygrýn J, Štefelová N, Rubín L, Hron K, Jakubec L, et al. How do short sleepers use extra waking hours? A compositional analysis of 24-h time-use patterns among children and adolescents. Int J Behav Nutr Phys Act. 2020;17(104):1–12.

82. Sigmund E, Sigmundová D. The relationship between obesity and physical activity of children in the spotlight of their parents’ excessive body weight. Int J Environ Res Public Health. 2020;17(8737):1–14.

83. Hamřík Z, Kalman M, Bobáková D, Sigmund E. Sedavý životní styl a pasivní trávení volného času českých školáků. Tělesná Kult. 2012;35(1):28–39.

84. Sigmundová D, Sigmund E, BUCKSCH J, Badura P, Kalman M, Hamřík Z. Trends in screen time behaviours in Czech schoolchildren between 2002 and 2014: HBSC study. Cent Eur J Public Health. 2017;25:15–20.

85. Sigmund E, Sigmundová D, Badura P, Voráčová J. Relationship between Czech parent and child pedometer-assessed weekday and weekend physical activity and screen time. Cent Eur J Public
86. Pavelka J, Sigmundová D, Hamřík Z, Kalman M, Sigmund E, Mathisen F. Trends in active commuting to school among Czech schoolchildren from 2006 to 2014. Cent Eur J Public Health. 2017;25:21–5.

87. Hollein T, Pavelka J, Sigmundová D. Aktivní transport českých školáků v kontextu školních opatření. Tělesná Kult. 2018;41(2):49–55.

88. Hollein T, Vašíčková J, Bucksch J, Kalman M, Sigmundová D, van Dijk JP. School physical activity policies and active transport to school among pupils in the Czech Republic. J Transp Heal. 2017;6:306–12.

89. Vorlíček M, Baďura P, Mitáš J, Kolarčík P, Rubín L, Vašíčková J, et al. How Czech adolescents perceive active commuting to school: a cross-sectional study. Int J Environ Res Public Health. 2020;17(5562):1–10.

90. Badura P, Madarasova Geckova A, Sigmundova D, Sigmund E, van Dijk JP, Reijneveld SA. Can organized leisure-time activities buffer the negative outcomes of unstructured activities for adolescents’ health? Int J Public Health. 2018;63(6):743–51.

91. Badura P, Sigmundová D, Sigmund E, Madarasova Geckova A, van Dijk JP, Reijneveld SA. Participation in organized leisure-time activities and risk behaviors in Czech adolescents. Int J Public Health. 2017;62:387–96.

92. Badura P, Sigmund E, Madarasova Geckova A, Sigmundova D, Sirucek J, van Dijk JP, et al. Is participation in organized leisure-time activities associated with school performance in adolescence? PLoS One. 2016;11(4):1–14.

93. Badura P, Madarasova Geckova A, Sigmundova D, van Dijk JP, Reijneveld SA. When children play, they feel better: organized activity participation and health in adolescents. BMC Public Health. 2015;15(1090):1–9.

94. Šnoblová R, Jakubec L, Sigmund E, Sigmundová D. Srovnání školní a celodenní pohybové aktivity 9–10letých děvčat a chlapců. Tělesná Kult. 2015;38(1):92–106.

95. Sigmundová D, Sigmund E, Badura P, Hollein T. Parent-child physical activity association in families with 4-to 16-year-old children. Int J Environ Res Public Health. 2020;17(4015):1–12.

96. Dumuid D, Pedišić Ž, Palarea-Albaladejo J, Martín-Fernández JA, Hron K, Olds T. Compositional data analysis in time-use epidemiology: what, why, how. Int J Environ Res Public Health. 2020;17(2220):1–17.

97. Pedišić Ž, Dumuid D, Olds TS. Integrating sleep, sedentary behaviour, and physical activity research in the emerging field of time-use epidemiology: definitions, concepts, statistical methods, theoretical framework, and future directions. Kinesiology. 2017;49:252–69.

98. Department of Health. Australian 24-hour movement guidelines for children and young people (5 to 17 years). 2019. Available from: https://www1.health.gov.au

99. Tremblay MS, Carson V, Chaput J-P. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2016;41(6):311–27.
100. Jurakić D, Pedišić Ž. Croatian 24-hour guidelines for physical activity, sedentary behaviour, and sleep: a proposal based on a systematic review of literature. Phys Act as Med. 2019;28(2):143–53.

101. New Zealand Government. Sit less, move more, sleep well: physical activity guidelines for children and young people. 2017. Available from: https://www.health.govt.nz/

102. Khamput T, Phuangkrampun M, Sangsumritpol W, Thongbo T, Sianglee S, Kaeyai T. Thailand recommendations on physical activity, non-sedentary lifestyles, and sleeping. Ministry of Public Health. 2017.

103. Ainsworth BE, Caspersen CJ, Matthews CE, Mâsse LC, Baranowski T, Zhu W. Recommendations to improve the accuracy of estimates of physical activity derived from self report. J Phys Act Heal. 2012;9(1):76–84.

104. Sprengeler O, Wirsik N, Hebestreit A, Herrmann D, Ahrens W. Domain-specific self-reported and objectively measured physical activity in children. Int J Environ Res Public Health. 2017;14(242):1–12.

105. Ding D. Surveillance of global physical activity: progress, evidence, and future directions. Lancet Glob Heal. 2018;6(10):1046–7.

106. Malinakova K, Madarasova Geckova A, van Dijk JP, Kalman M, Tavel P, Reijneveld SA. Adolescent religious attendance and spirituality - Are they associated with leisure-time choices? PLoS One. 2018;13(6):1–14.

107. Miklánková L, Elfmark M, Sigmund E. Specifika pohybové aktivity dětí raného a středního školního věku. Stud Sport. 2013;1:7–14.

108. Sigmund E, Sigmundová D, El Ansari W. Changes in physical activity in pre-schoolers and first-grade children: longitudinal study in the Czech Republic. Child Care Health Dev. 2009;35(3):376–82.

Figures
Figure 1

The flow of information through the different phases of the review.
Figure 2

The overview of included studies considering their year of publication and primary outcomes. Note. PA = Physical activity; SB = Sedentary behaviour.
Figure 3

The overview of included studies considering their year of publication and the assessment tools.

**Supplementary Files**

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryfile1.pdf
- Supplementaryfile2.pdf
- Supplementaryfile3.pdf