

# Physical activity and BMI before and after the situation caused by COVID-19 in upper primary school pupils in Czech Republic

Jana Pyšná<sup>1,\*</sup>, Jiří Suchý<sup>2</sup>, Ladislav Pyšný<sup>1</sup>, David Cihlář<sup>1</sup>, Dominika Petřů<sup>1</sup>, Lenka Hajer-Müllerová<sup>3</sup> and Luděk Čtvrtečka<sup>1</sup>

<sup>1</sup> Jan Evangelista Purkyně University in Ústí nad Labem, Faculty of Education, Department of Physical Education and Sport, České mládeže 8, Ústí nad Labem, Czech Republic; jana.pysna@ujep.cz

<sup>2</sup> Charles University in Prague, Faculty of Physical Education and Sport, Department of Didactics, José Matího 31, Praha 6, Czech Republic; [email@jirisuchy.cz](mailto:email@jirisuchy.cz)

<sup>3</sup> West Bohemia University in Plzeň, Faculty of Education, Department of Pedagogy, Chodské náměstí 1, Plzeň, Czech Republic; hajerova@kpg.zcu.cz

\* Correspondence: jana.pysna@ujep.cz; Tel.: +420 606 545 623

**Abstract:** Regular physical activity is a very important factor in the healthy development of an individual and an essential part of a healthy lifestyle. However, today's population still suffers from insufficient amount of exercise caused mainly by technical progress and often inappropriate conditions for practicing sports. In relation to this, we are grappling with a steady increase in obesity. During the COVID-19 pandemic, conditions for regular physical activity became even more unfavourable, with the declaration of a state of emergency and anti-pandemic measures leading to the closure of sports grounds and sporting competitions. In our research survey, we attempted to determine whether there would be changes in physical activity and BMI before and after the situation caused by the COVID-19 disease in upper primary school pupils in the Czech Republic. Using a questionnaire survey of a sample of children (n=1456), we found that already before the pandemic, 69% of the observed sample had not met the recommended amount of physical activity and only 67% of the sample was of normal weight. After the end of the anti-pandemic measures, the observed values deteriorated even more. There was a significant decrease in children with normal weight (by 7.5%) and an increase in children with Class 1 obesity. At the same time, we saw a significant decrease in children doing sports.

**Keywords:** physical activity, Body Mass Index, COVID-19, pupils, health, lifestyle, sport, obesity

---

## 1. Introduction

According to Perič and Březina [1], exercise and sport are a fundamental part of every individual's life, an essential manifestation of a healthy lifestyle that is indispensable for the proper development of every individual [2]. According to the World Health Organization [3], physical activity includes any activity produced by skeletal muscles causing an increase in pulse and respiration rate. It includes habitual physical activity, controlled performance and competitive physical activity with the aim of best performance and leisure-time physical activity [4]. Sport and physical activity is a very important component of a healthy lifestyle and a vital factor that influences health. Spontaneous physical activity is the most significant component of exercise in children, where appropriate development of movement abilities and acquisition of movement skills occurs, thus contributing to the course of further development of the child and anchoring interest in physical education and sports activities [5].

School physical education is also an integral part of children's exercise, but it cannot cover the real exercise requirement. In particular, school physical education helps to break the stereotype of mostly sedentary teaching and creates important movement patterns in children. Undoubtedly, sports clubs can be included among pupils' common sports

---

---

activities, intended to mainly focus on performance [6-9]. The formation of positive relationship and attitudes towards physical activity, as well as their lifelong application, occurs during childhood [10]. Recommendations for children and adolescents aged 7 to 15 years state the practice of moderate-intensity physical activity for at least 60 minutes per day. Under these conditions, physical activity accounts for about 30-50% of an individual's daily energy expenditure and is one of the factors contributing to a positive energy balance by means of decreasing energy and fat intake, and contributes to the prevention of civilization diseases [7, 10, 11-12]. The European College of Sports Medicine, the US National Institute of Health and the American College of Sports Medicine recommend a volume of physical activity with an energy expenditure of 4200kJ/week as sufficient for beneficial health effects [13-15]. Physical activity performed at moderate intensity with a duration of 150-250 minutes per week leads to moderate weight loss. Physical activity longer than 250 minutes per week leads to significant changes in weight loss. 250-300 minutes per week is sufficient to prevent weight gain, and 300 minutes per week in combination with a low-calorie diet is sufficient to maintain weight after previous weight loss [16-17].

Regular physical activity also increases physical fitness, lowers cholesterol levels, appears to be the most effective factor in preventing civilisation diseases, contributes to mental freshness, increases the sense of resistance to stress, helps to improve blood circulation and oxygenation of the brain, muscle pain, the development of functional musculoskeletal disorders and is also a prevention of chronic non-infectious diseases [18-20]. In the context of the prevention of civilization diseases, sport leads to the prevention of the development of serious cardiovascular, metabolic, and cancer diseases, and at the same time improves the quality of life. For example, if physical activity is indicated in an appropriate volume, it contributes to weight reduction and weight maintenance, while also improving metabolic complications that significantly accompany obesity [21-22].

In the development of an individual from childhood to adulthood, there is currently a significant decline in the amount of physical activity, mainly due to sedentary lifestyle. In this context, it is necessary to remember that the human organism, as a result of evolution, is set up to be exposed to relatively intense physical stimulation for the natural and healthy development of the individual [14]. In early childhood, sedentary lifestyle is only minimally prevalent, in approximately 8% of girls and 6% of boys, and is preferred by 25% of women and 22% of men by the age of 20. In developed countries, this is mainly due to a change in leisure time use in favour of less physically demanding activities. This can lead to physical inactivity over time [17, 23-24]. Bunc [25] reports that energy intake has been stagnating or decreasing over recent decades in the Czech Republic and Central European countries. However, on the other hand, energy expenditure is also decreasing significantly.

According to Rychtecký and Tilinger [26], the older school-age period is characterised by risk behaviour manifesting by the reduction in the amount of physical activity. The changes characteristic of adolescence (e.g., psychological, hormonal, behavioural changes) with the persistent trend of decreasing the amount of physical activity, which has arisen due to the modernization of society and the constant advancement of information technology, may negatively affect the lifestyle of adolescents [14]. The result, for example, is the above-mentioned ever-increasing prevalence of obesity, which poses a serious problem for our society, with the representation of overweight and obese people approaching sixty percent [27]. Children and young people are also at risk. The assessment of the development in the second half of the twentieth century already showed a long-term positive trend of increase in body weight of children and youth [5, 28-31]. Therefore, we are talking about childhood obesity, which is conditioned by a change in the lifestyle of children with a characteristically significant limitation of their spontaneous physical activity. Thus, at the same time, obesity becomes a large-scale, not just economic, problem for the entire healthcare system [32-33].

The most important manifestation of insufficient physical activity in children and young people is the above-mentioned obesity, which is described as a chronic, multifactorial disease resulting from a positive energy balance, especially in people with

---

a polygenic predisposition to fat accumulation. In terms of aetiopathogenesis, common obesity is the most widespread, accounting for more than 90% of the prevalence [34-36]. In this type of obesity, more than 600 genes, markers and chromosomal regions are currently known to underlie the development of this type of obesity and at the same time influence, in particular, the regulation of food intake, including feelings of hunger or satiety, eating behaviour with preference for certain foods, absorption, processing, burning and storage of ingested nutrients, as well as the amount of hormones that regulate energy balance [34]. The development of overweight and obesity is mostly influenced by the high proportion of fat in the diet due to its high energy density, taste appeal, low satiety and postprandial thermogenesis [37-38]. In addition, more than 80 factors are highly implicated in the development of obesity, which include intrauterine programming, prenatal and postnatal epigenetic factors, targeted mate selection, short sleep duration, and poor dietary strategies [34, 39-43].

The cause of the most widespread simple obesity is an imbalance between energy intake and energy expenditure. It is certainly also influenced by some of the genetic predispositions already mentioned, but adverse epigenetic influences are crucial. If they affect the child from the early stages of development, a rather unfavourable programming of the organism is created, and if it is further promoted by unfavourably increased energy intake or inappropriate food composition, it subsequently leads to excessive fat tissue deposition already in childhood [44].

As mentioned above, obesity and overweight are accompanied or complicated by a number of serious diseases that subsequently increase the risk of developing a range of severe clinical symptoms, such as coronary heart disease, myocardial infarction and stroke Gupta et al. and Pischon et al. [45-46]. In addition, obesity promotes the development of other major health complications, such as musculoskeletal and respiratory diseases, or certain cancers. Not only does the high weight of an individual place a tremendous burden on the musculoskeletal system, but the adverse metabolic changes that occur alone affect the structure of bone tissue. The result is bone loss and remodelling with a decrease in strength [47]. At the same time, the increased weight places a significant mechanical load on each joint of the obese individual, where osteoarthritis develops [48]. Obesity also adversely affects the ventilatory functions of the respiratory system, which are mainly caused by reduced elasticity of the chest wall and impaired contractile force of the respiratory muscles. Thus, in obese individuals we often find not only exertional but also resting dyspnea. The latter can, in some cases, lead to the development of obstructive sleep apnoea [49-50].

Adipose tissue dysfunction is also likely to adversely affect the development of some tumours [51-52]. In addition to the aforementioned health risks of insufficient amounts of physical activity in adolescent children, impulsivity, irritability, reduced ability to concentrate, self-control and aggression are also common. The former experience of adventure in a variety of children's physical games and activities is nowadays replaced by a virtual experience with simultaneous minimal physical activity [53-54]. All of these health risks increase proportionally with BMI values [21-22]. In relation to the issue investigated, BMI is one of the basic indicators of body weight in connection to overweight and obesity. It is a globally recognized index, applicable to all age categories. Weight ranges, together with the resulting health risks, are provided for the respective age groups [16, 55].

A number of experts point out the ongoing need for the development of appropriate physical activity intervention programmes that promote regular physical activity in children and adolescents, which, especially during childhood, significantly affects physical and mental health [14, 56-57]. Moreover, these patterns and exercise habits are carried on by the child into adulthood. Physical activity is recommended by experts not only in the Czech Republic but also worldwide as an important component in the fight against the increasing prevalence of obesity, and its promotion has become a national health priority. The findings of a number of studies show that a large proportion of older children do not participate in the recommended daily sixty minutes of moderate to vigorous intensity physical activity, so it is necessary to intervene and change their behaviour [15, 29, 53, 58].

---

Experts emphasize that appropriate physical activity interventions can potentially increase children's level of physical activity, and moreover, can be included in school health programs. The focus on youth physical activity has led to the development of guidelines and recommendations specific to adolescents, children and infants [14, 59].

Exercise intervention should take, into account a range of indicators, such as health status, exercise history, current level of fitness, and physical ability. The actual design of physical activity should include the form, intensity, duration, frequency, instructions and checking of the effect [20, 60]. It is important to respect the child's developmental stage i.e. anatomical, physiological, psychological and training specificities. In the first stage of the indication of exercise regimes, it is necessary to focus on the cultivation of movement activities. The load should not last more than 40 minutes with pulse rate (PR) values of 80-90% of the maximum PR. Exercise programmes should primarily load large muscle groups and should include compensatory exercises. Under these conditions, exercise has been shown to improve health, positively promote a healthy lifestyle and contribute to a higher quality of life in various ways. It improves psychological well-being in the course of life, improves self-image and also brings pleasurable emotional experiences [26].

In the spring of 12 March 2020, the Government of the Czech Republic declared a state of emergency due to the health threat by from the rapid spread of the SARS-CoV-2 coronavirus, which lasted until 30 June 2020 [61-62]. Under the declaration of a state of emergency, certain human rights and freedoms may be restricted pursuant to Crisis Act No. 240/2000 Coll. On the basis of the declaration of a state of emergency, new government measures were imposed concerning, among others, the prohibition of sporting events, school attendance and educational events, as well as the free movement of the population; the state of emergency thus affected, among others, the area of education, organised sport and leisure-time physical activities [63]. As of 1 September 2020, a state of emergency was again declared by the Government of the Czech Republic, which lasted until 14 February 2021 [64].

The Ministry of Health first established basic hygiene rules for schools and other facilities. In the spring, from 12 March 2020 - 30 June 2020, the Government announced new measures on school attendance and educational events, banning pupils and students from school facilities, extracurricular activities and competitions. Regulations were still in force that further restricted the operation of school facilities, in particular physical education, organized sports activities and sports competitions [65]. As of 2 November 2020, a government resolution newly prohibited the presence of pupils and students at classes and sports activities [66]. From 30 November 2020 until June 2020, the regulations that further restricted the operation of school facilities, in particular physical education, organized sports activities and sports competitions, were again in force [67, 68]. The government measures restricted, among other things, the free movement of persons, education, organized physical activity and competitions worldwide.

The aforementioned summary of government measures in the Czech Republic shows that since its inception, the COVID-19 pandemic has spread globally, and the various bans and restrictions resulting from efforts to limit the spread of the disease have also had a significant impact on children's physical activity. The closure of schools with gymnasiums, sports halls, swimming pools, public parks and playgrounds, and a range of other sports venues was associated with a very significant reduction in school-based physical education, organized sports and leisure-time physical activity for children. All this has resulted in an increased amount of time spent at home without the standard opportunity for regular sporting activity beyond the home or natural environment. During the harshest government measures, movement outside one's own home was even restricted [58].

According to Bates et al. [69] and Yang et al. [70], the impact of anti-pandemic measures has thus caused a reduction in social contact that has had far-reaching adverse effects on the mental and physical health of children and adolescents, exacerbated the current problem of low levels of physical activity, and increased the prevalence of sedentary lifestyles. In their study, Dubuc et. Al [71], Moore et al. [72] and Velde et al. [73] found a negative impact of government measures on the exercise and play behaviours of

---

Canadian, Dutch and other children and adolescents, specifically that during the initial coronavirus crisis period, these individuals were less active, played outdoors less, spent more time in sedentary activities instead, increased their interest in PC or television, and also slept more compared to the period before the restrictions. Similar results reporting a decrease in physical activity when the emergency was declared among children in Shanghai were found by Xiang et al. [74], the authors also reported a significant increase in the prevalence of physically inactive students and an increase in the average weekly time spent in front of a television screen. Another cross-sectional study conducted among adolescents in two European countries (Italy and Spain) and three Latin American countries (Brazil, Chile, and Colombia) reported changes in the amount of physical activity and in the consumption of industrially processed foods among adolescents. Decreases in physical activity and increases in consumption of industrially processed foods were observed in the probands, with more pronounced changes found in Latin American adolescents Ruíz-Roso et al. [75]. The impact of reduced physical activity on psychosocial factors in adolescents has been investigated by Slimani et al. [76]. In their research, they found impaired behaviour, poorer mood, a decline in psychological fitness or socialization problems.

## 2. Materials and Methods

The research survey was conducted following the approval of the Ethics Committee of the Faculty of Education UJEP (1/2019/01) in 15 primary schools with the consent of school principals and the informed consent of parents. The survey was carried out in two stages. The first stage was conducted before the outbreak of the pandemic COVID-19 in April 2019 to February 2020 (1133 pupils) in 15 primary schools in North Bohemia in Czech Republic. The second stage took place after the end of the stringent anti-pandemic measures associated with pandemic COVID-19 in September 2020 to January 2021 (323 pupils) at 5 of the original 15 primary schools on the day of the survey, with pupils present whose parents provided their written consent to participate in the research. Between the different stages of data collection, anti-pandemic measures were adopted in the Czech Republic, which, among other things, severely limited children's sport and physical activity. The research survey attempted to determine whether there would be changes in physical activity and BMI before and after the situation caused by COVID-19 disease in upper primary school pupils in North Bohemia.

The sample monitored consisted of 1,456 pupils (mean age 12.9 years) of primary schools in North Bohemia. Of these, 681 were girls and 775 were boys. The average age of the girls was 12.7 years and the average age of the boys was 13.1 years. The sample consisted of upper primary school pupils from 15 schools in North Bohemia. The schools were selected using a group selection with the definition of the strata characterizing stratified selection. These schools meet the requirements for the stratification of schools in terms of location in the region and at the same time meet the characteristics of the environment of North Bohemia. For the entire sample of 1,456 pupils, the level of lifestyle was ascertained using a questionnaire survey, anthropometric data and body composition assessed by BMI. Since no statistically significant difference was found between girls and boys in the indicators studied, we present the population without gender distribution.

**Table 1.** Distribution of boys and girls in the group according to the school year

The methods used include somatometry to measure basic anthropometric indices (age, body weight and height). To assess body composition, we used the Body Mass Index and to ascertain the level of lifestyle we used the questionnaire method using the CAV (National anthropological research) 2001 questionnaire for children and adolescents [77]. For the purpose of this research, we used questions within Set I, II and III.

---

The measurement of basic anthropometric indicators (body weight and height): Calibrated scale with accuracy to one decimal place, measurement values are given in kilograms (kg); calibrated measuring device with accuracy to two decimal places; body height values are given in centimetres (cm).

Method of assessing body composition: From the body height and weight data observed, we used the calculation of the ratio of weight in kilograms to height in m<sup>2</sup>. To evaluate the observed results, we rely on the BMI-for-age evaluation [78].

Lifestyle level questionnaire: The CAV (National anthropological research) 2001 standardised questionnaire for children and youth Vignerová and Bláha [77] contains a total of 15 closed questions in 5 sets. Set I - identification questions - age, sex, height, weight, nationality; Set II - physical activity /"Where do you do sports most often?", "How many hours a week do you do sports outside PE at school?", "Do you own a bicycle and use it as a means of transport or for sports?"; Set III - leisure time /"How many hours a week do you watch TV? ", the question "How many hours a week do you work on a computer, play computer games or Play Station games?", "How many hours a week do you spend on your mobile phone or communicating on social networks?"/; Set IV - eating and drinking habits /"Do you eat breakfast in the morning? ", "Do you eat snacks at school?", "Do you have a hot meal at school?", "Do you eat snacks in the afternoon?", "Do you have dinner?", "Do you eat fruit and vegetables regularly?"/; Set V - taking care of the body habitus /weight tracking, dieting/.

Statistical methods of data processing: In evaluating the data, we used descriptive statistics, significance tests (chi-square test of independence). We used statistical significance tests to demonstrate the relationships under study. Null hypotheses are rejected with less than 5% probability of error, i.e., when our p-value (probability of error in rejecting the null hypothesis) fell below 0.05 [79].

### 3. Results

The results presented in Table 2 show a statistically significant difference in BMI values between the study groups. When BMI is evaluated, it is evident that after the measures associated with the COVID-19 pandemic (the second stage of the research), there was a decrease in children in the normal weight category and an increase in children in the underweight and Class 1 obesity category.

**Table 2.** Breakdown of pupils into categories by BMI before and after COVID-19 situation

Table 3 presents the distribution of pupils according to the answers to the question "Where do you do sports most often?" before and after the situation caused by the COVID-19 pandemic. It is clear from these answers that most children after the measures caused by COVID-19 stopped doing sports in sports clubs with competitive training; subsequently, there was an increase in the number of children exempt from physical education, and at the same time there was an increase in the number of children who stated that they did sports only in school clubs without competitive training. There was a relatively large increase in the number of children doing sports at school, with friends and with family after the COVID-19 measures. The difference between the groups in the indicator of participation in physical activity at the first and second data collection is statistically significant.

**Table 3.** Pupils' answers to the question "Where do you do sports most often?" before and after the situation caused by COVID-19

Table 4 presents the number of hours spent doing sports in the study sample before and after the situation caused by the COVID-19 pandemic. The amount of recommended

---

minimum sports activity is based on the recommendations of doctors, who say that sports activity in children should take at least 1 hour a day. Based on this, we divided the children into two groups. The group doing sports are children who meet the recommended amount of sports activity (at least 7 hours per week); the group not doing sports are children who do not meet this recommendation (less than 7 hours per week). The results of the comparison of the observed indicator at the first and second stage of data collection are not statistically significant, yet we can observe a change which represents the decline in sporting children after the situation caused by COVID-19.

**Table 4.** Pupils' answers to the question "How many hours a week do you do sports outside PE at school?" before and after situation caused by COVID-19

Table 5 shows the results of children's answers to the question "Do you own a bicycle and use it as a means of transport or for sport?" When comparing the results, we can see that fewer children report using a bicycle as a means of transport and for cycling after the situation caused by COVID-19. This result is statistically significant.

**Table 5.** Pupils' responses to the question "Do you own a bicycle and use it as a means of transport or for sport?" before and after situation caused by COVID-19

Table 6 shows the results of pupils' responses to the question "How many hours a week do you watch TV?" before and after the situation caused by COVID-19. It can be seen from these values that the number of probands watching TV increased only for the interval 4-7 hours per week after the situation caused by COVID-19. In other intervals of the periods of watching TV, the numbers of children fell. The comparisons of the results of the responses between the groups at the first and second stages of the research are not statistically significant.

**Table 6.** Pupils' responses to the question "How many hours a week do you watch TV?" before and after situation caused by COVID-19

Table 7 shows an evaluation of the probands' answers to the question "How many hours a week do you work on a computer, play computer games or Play Station games?" The results show significantly higher numbers of children who spend time on the PC more than 4 hours per week after the situation caused by COVID-19. The highest increase in time on the PC is in the interval of 14+ hours. These results, which compare probands' responses before and after the situation caused by COVID-19, are statistically significant.

**Table 7.** Pupils' responses to the question "How many hours a week do you work on the computer, play computer games or Play Station games?" before and after the situation caused by COVID-19

Table 8 shows the results of spending time on the mobile phone or communicating on social networks. After the situation caused by COVID-19, there was a significant decrease in the time interval of 0-3 hours per week and 4-7 hours per week in the study sample, and in contrast, there was a significant increase in the number of hours spent on the mobile phone and social media communication in the remaining two time intervals studied. The highest increase, more than double, is for the time interval of 14+ hours per week. These results are statistically significant.

**Table 8.** Pupils' responses to the question "How many hours a week do you spend on your mobile phone or communicating on social media?" before and after situation caused by COVID-1

---

#### 4. Discussion

The entire study sample of upper primary school children in North Bohemia in Czech Republic (n=1456) was surveyed using a questionnaire to obtain information on leisure activities and BMI. We attempted to ascertain what areas the pupils' extracurricular physical activity is concentrated in and what average time the pupils devote to it per week. For further elaboration, the variable of out-of-school sports activity was categorised (doing sports and not doing sports) and an alternative was created showing pupils reporting at least 7 hours of physical activity per week, which corresponds to the condition "at least one hour per day on average", and pupils reporting less than 7 hours per week. Here, we relied on expert claims that cite 7 hours of sports activity per week as the optimal amount [25, 80]. We also investigated the amount of time pupils spend watching television or using the computer, and the amount of time they spend on social media. In particular, we focused on comparing these indicators ascertained in the first and second stages of data collection, i.e. before and after the announcement of anti-pandemic measures that closed sports venues and sports competitions for half a year during the COVID-19 disease pandemic.

In the first stage of the research, we found that 69% of pupils did not meet the recommended amount of sporting activity in their leisure time. In the second stage of data collection, these figures increased by 5%. Thus, we confirm the claims of Sigmundová and Sigmund [4], who state that the physical activities of children and adolescents have changed significantly over the last 10 to 20 years. Extracurricular activities of young people have been reduced to watching television, communicating via the Internet and gathering in groups which, unfortunately, do not always have an appropriate focus. There are fewer young people playing sports who are willing to exert more physical effort and overcome obstacles of various types. We draw on the results of the research Jíra [81], where young people reported watching television as their favourite leisure activity. It is also interesting to note the results of the STEM/MARK (a full-service agency specializing in market research) survey, which brought information that children spend an average of 11 hours a week in front of the television, 5 hours and 20 minutes on the computer, 5 hours in unorganised activities and only 2 hours in after-school clubs [82]. At the same time, with regard to the above-mentioned issue, it is necessary to support the opinion of the National Health Institute In Prague [83] stating that sport in schools is the most widely available resource for promoting sport activity among young people and it is therefore worth considering to increase the amount of sport activity by expanding the hourly allocation of sport subjects in schools.

The decline in the amount of sports activities is also related to the period of puberty itself. This can be explained by the assumption of a group identity, where it is the group that provides support, shares interests and concerns. In contrast, the parent, who has often been the main supporter of the child in sport, thus takes a back seat as a role model. The child often prefers other interests, such as the conformity associated with the style of speech, dressing or behaviour in exchange for time spent playing sports. It is therefore very important to further shape, encourage and motivate the relationship with physical activity at this age [84]. Thus, it is important to use the influence of the family in creating a positive relationship with physical activity, especially in the pre-school period. Subsequently, the school and the influence of teachers should certainly be added during the school attendance period. Both entities have a clear and full responsibility for the formation of a positive attitude towards sport and a healthy lifestyle. These results confirm the negative impact of the six months of isolation of children from sporting activities associated with an increase in the number of hours spent on personal computers and social networks [85].

Alarming results were observed in the evaluation of the results in the second stage of data collection. i.e. after the situation caused by the COVID-19 disease, when there was a significant decrease in the number of children doing sports in clubs with competitive training and an increase in the number of children who are exempt from school physical



---

education and at the same time an increase in the number of children who stated that they play sports only in school clubs without competitive training. A relatively large increase in the second stage of the research occurred in the number of children who have played sports with friends and family after the situation caused by COVID-19. Our results confirm the claims of [84], who cites the age of the children as a possible factor influencing the increasing number of children playing sports with friends or family. It is likely that there was also a transfer of habits from the period when sports venues and sports competitions were closed and the family had the opportunity to spend more free time together and actively. The significant reduction in the number of children playing sports in clubs with competitive training during the second data collection after the period of anti-pandemic measures was probably amplified by the influence of risky behaviour of children during adolescence. According to [86] puberty is considered the most dynamic transformation in an individual's life, affecting all components of an individual's personality. Pubescent show increased excitability, moodiness, absent-mindedness and affective reactions. They strive for independence and increasing criticalness is the reason pupils are no longer willing to perform their duties without objection and very often display defiance and negativity, including in the sporting environment, which they very often leave for the reasons mentioned above or move to after-school clubs without competitive sports training.

In our further research we focused in particular on comparing the time pupils spend watching TV or using a personal computer, and how much time they spend on social media. In the results of the time spent watching television, we found that after the situation caused by COVID-19, i.e. during the second stage of the research, there was a decrease in the hours spent watching television, but on the contrary, there was a significant increase in the hours spent on PCs and social networks. The highest increase was seen in children who spend 14 hours or more per week on social media. These results are generally due to a preference for interests during adolescence, and at the same time there is certainly a negative impact of six months of sporting isolation and spending time at home during online learning. According to [87], girls are more likely to spend their free time with friends or in hobby groups, but unfortunately without sufficient physical activity, and boys have a closer inclination towards gaming technology and PC work. According to Pyšná et al. [58], it is evident that with increasing age there is an increase in the time spent communicating on social networks, with social networks influencing many areas of people's lives. The impact of virtual environments is being researched and discussed by experts across scientific disciplines. Given that social networking is part of the contemporary modern life of adolescents, we believe it is appropriate to share posts related to healthy lifestyle. According to the results, which confirmed that pupils use Instagram as a source of information, it can also be recommended that professionals start actively using social networks and more accounts with verified professional information are created. For example, content on Instagram could be rated by doctors and nutritionists so that a young person can distinguish between true and nonsensical information according to the tags assigned.

When evaluating the BMI in our research survey, we can confirm that there has been a steady increase in overweight and obesity in our children. This trend follows a number of Czech and international studies. e.g. Pyšná et al. [20], Kunešová et al. [29], World Health Organization [78], National Institutes of Health in Prague [83], Caldeira et al. [88], Flegal et al. [89], Canadian Community Health Survey [99] and Kubínová et al. [91]. In assessing the trend, it should be noted that already during the first stage of the research we observed a relatively high proportion of children (33%) with other than normal weight. During the second stage of data collection, i.e. after the measures associated with the COVID-19 pandemic, the number of children in the normal weight category decreased and the number of children in the underweight and Class 1 obesity category increased. The difference between the groups in the BMI indicator during the first and second data collection is statistically significant. During the first data collection, we observed 67% of children with optimal weight. These values decreased, i.e. there were fewer children in the normal BMI

---

category after the anti-pandemic measures. Although these values are more favourable in comparison with the results of the study by Pyšná et al. [20], it can be assumed in the context of the increasing number of obese children in our research that changing our children's lifestyles will lead to further serious health problems, such as metabolic changes in the body associated especially with increasing overweight and obesity, which will significantly reduce their future quality of life. This problem needs to be addressed by putting emphasis on not only the family, but also the school and the school environment. All possibilities must be activated here that will encourage, above all, the physical stimulation of the body. In this case, we are not just talking about school physical education, but all extracurricular physical activities.

The limitation of this study was certainly the number of probands observed during the second stage of data collection, which could be increased during future mapping. An issue associated with this fact involves the considerable problems caused to us by the General Data Protection Regulation (GDPR), where school principals were unable to give consent to the conduct of a research survey. The reason was the negative attitude of a number of parents, probably because of fears of breaching the GDPR, despite it being clear that the research would be anonymous.

In our research survey we used the BMI method of assessing overweight and obesity, which is advantageous when examining a larger sample of respondents due to the speed of the survey. BMI is a globally accepted index, applicable to all age categories [16, 55]. Indices calculated from anthropometric parameters, including BMI, should be assessed on the basis of national percentile charts and track the dynamics of their values over time. We are aware that the disadvantage of BMI is an inaccurate result for persons with a non-standard proportion of some body tissue, such as an above-average proportion of muscle tissue. Such individuals were not represented in the survey. For a more accurate assessment of body composition and, of course, obesity, it would be advantageous to use more accurate but more time-consuming methods. i.e. not only for example caliperation or bio-electrical impedance analysis method [87].

## 5. Conclusions

In the research survey of a sample of 1,456 upper primary school pupils in North Bohemia in Czech Republic, we looked at physical activity and BMI before and after the COVID-19 disease. In the assessment of sports activity, we found a significant decrease by 5% in children doing sports for at least 7 hours per week, a decrease by 8.74% in children in clubs with competitive training, and a significant increase by 5.4% in inactive time spent by children on PCs (in children spending more than 14 hours per week on PCs) and by 18.65 % on social networks (in probands spending 8-14 hours per week on social networks and by 18.56 % in pupils spending more than 14 hours per week on social networks). At the same time, we saw a significant decrease by 7.5% in normal-weight children and an increase by 1.87 % in children with Class 1 obesity and by 6.24 % in underweight children.

It is clear from the results that the observed indicators of physical activity and BMI deteriorated further and significantly after the COVID 19 situation. It should be pointed out that even before the adoption of anti-pandemic measures, i.e. during the collection of data in the first stage of the research, the children showed unsatisfactory results; 69% of the sample did not meet the recommended amount of sports activity and only 67% of the sample had a normal weight. Our research survey has shown that following the cessation of the anti-pandemic measures, the observed values worsened even further in upper primary school children in North Bohemia.

Given that physical activity is an essential part of the health of every individual, there needs to be a greater focus on changing social tolerance as part of healthy lifestyle education. Conditions need to be created for sports and physical activities of young people, especially in their leisure time. The most important thing we see is to combine the interest

of the family, school and society with the interests and preferences of youth. In everyday activities and educating young people about sport and physical activity as one of the delimiting factors of healthy lifestyle, this is about, among other things, finding an active way to spend leisure time that curbs the negative effects of the social environment, the influence of modern technology, media and inappropriate advertising aimed at promoting young people's fashionable lifestyles.

**Supplementary Materials:** Table S1: Distribution of boys and girls in the group according to the school year, Table S2: Breakdown of pupils into categories by BMI before and after COVID-19 situation, Table S3. Pupils' answers to the question "Where do you do sports most often?" before and after the situation caused by COVID-19, Table S4. Pupils' answers to the question "How many hours a week do you do sports outside PE at school?" before and after situation caused by COVID-19, Table S5. Pupils' responses to the question "Do you own a bicycle and use it as a means of transport or for sport?" before and after situation caused by COVID-19, Table S6. Pupils' responses to the question "How many hours a week do you watch TV?" before and after situation caused by COVID-19, Table S7. Pupils' responses to the question "How many hours a week do you work on the computer, play computer games or Play Station games?" before and after the situation caused by COVID-19, Table S8. Pupils' responses to the question "How many hours a week do you spend on your mobile phone or communicating on social media?" before and after situation caused by COVID-19, Table S9.

**Author Contributions:** Conceptualization, J.P., L.P.; D.C., J.S.; Methodology and Study Design, J.P. D.C.; Data Collection, J.P., D.P., J.S., L.Č.; Data analysis, D.C., J.S.; Data Interpretation, J.P. and L.P.; Writing-Original Draft Preparation, J.P. and L.P.; Writing – Review & Editing, J.P., D.C, D.P., J.S. L.H.M.; Visualization, J.P., L.M., D.C.; Project administration, J.P.; Supervision, L.P., L.H.M.; All authors have read and agreed to the published version of the manuscript.

**Acknowledgments:** This research was funded by creative activity support grant of Charles University, Faculty of Physical Education and Sport, grant Progress Q41 and SVV Movement activities and active lifestyle of the current society.

**Conflicts of Interest:** The authors declare no conflict of interest.

## Appendix - Tables

**Table 1.** Distribution of boys and girls in the group according to the school year

	<i>6th grade</i>	<i>7th grade</i>	<i>8th grade</i>	<i>9th grade</i>	<i>Total</i>
<i>Boys</i>	219	195	179	182	775
<i>%</i>	29.42	25.22	22.42	22.94	
<i>Girls</i>	190	199	158	134	681
<i>%</i>	29.08	30.68	22.51	17.73	
<i>Total</i>	409	394	337	316	1456

**Table 2.** Breakdown of pupils into categories by BMI before and after COVID-19 situation

	<i>Underweight</i>	<i>Normal weight</i>	<i>Overweight</i>	<i>Class 1 obesity</i>	<i>Class 2 obesity</i>	<i>Total</i>
<i>1<sup>st</sup> stage</i>	217	761	131	22	2	1133
<i>%</i>	19.15	67.17	11.56	1.94	0.18	
<i>2<sup>nd</sup> stage</i>	82	193	36	12	0	323

%	25.39	59.75	11.15	3.72	0.00	
<b>Total</b>	299	954	167	34	2	1456

Pearson Chi-square: 10.8593, p=0.028198

**Table 3.** Pupils' answers to the question "Where do you do sports most often?" before and after the situation caused by COVID-19

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>Total</b>
<b>1<sup>st</sup> stage</b>	12	108	347	152	232	851
<b>%</b>	1.41	12.69	40.78	17.86	27.26	
<b>2<sup>nd</sup> stage</b>	11	51	150	52	60	324
<b>%</b>	3.40	15.74	46.30	16.05	18.52	
<b>Total</b>	23	159	497	204	292	1175

Pearson Chi-square: 15.6897. p=0.003467

Legend: A - exempt from PE, B - I play sports only at school, C - at school and exercise with friends, C - with family, D - at school and club - hobby club without competitive training, E - at school and competitive sports training

**Table 4.** Pupils' answers to the question "How many hours a week do you do sports outside PE at school?" before and after situation caused by COVID-19

	<b>Doing sports</b>	<b>Not doing sports</b>	<b>Total</b>
<b>1<sup>st</sup> stage</b>	257	582	839
<b>%</b>	30.63	69.37	
<b>2<sup>nd</sup> stage</b>	83	240	323
<b>%</b>	25.70	74.30	
<b>Total</b>	340	822	1162

Pearson Chi-square: 2.74419. p=0.097612

**Table 5.** Pupils' responses to the question "Do you own a bicycle and use it as a means of transport or for sport?" before and after situation caused by COVID-19

	<b>Yes</b>	<b>No</b>	<b>Total</b>
<b>1<sup>st</sup> stage</b>	765	86	851
<b>%</b>	89.89	10.11	
<b>2<sup>nd</sup> stage</b>	277	47	324
<b>%</b>	85.49	14.51	
<b>Total</b>	1042	133	1175

Pearson Chi-square: 4.52669. p=0.033373

**Table 6.** Pupils' responses to the question "How many hours a week do you watch TV?" before and after situation caused by COVID-19

	<b>0 to 3 hrs</b>	<b>4 to 7 hrs</b>	<b>8 to 14 hrs</b>	<b>14 + hrs</b>	<b>Total</b>
<b>1<sup>st</sup> stage</b>	476	242	104	28	850
<b>%</b>	56.00	28.47	12.24	3.29	
<b>2<sup>nd</sup> stage</b>	180	99	37	8	324
<b>%</b>	55.56	30.56	11.42	2.47	
<b>Total</b>	656	341	141	36	1174

Pearson Chi-square: 1.00994. p=0.798847

**Table 7.** Pupils' responses to the question "How many hours a week do you work on the computer, play computer games or Play Station games?" before and after the situation caused by COVID-19

	<b>0 to 3 hrs</b>	<b>4 to 7 hrs</b>	<b>8 to 14 hrs</b>	<b>14 + hrs</b>	<b>Total</b>
<b>1<sup>st</sup> stage</b>	448	205	117	80	850
<b>%</b>	52.71	24.12	13.76	9.41	
<b>2<sup>nd</sup> stage</b>	136	87	53	48	324
<b>%</b>	41.98	26.85	16.36	14.81	
<b>Total</b>	584	292	170	128	1174

Pearson Chi-square: 13.5056. p=0.003663

**Table 8.** Pupils' responses to the question "How many hours a week do you spend on your mobile phone or communicating on social media?" before and after situation caused by COVID-19

	<b>0 to 3 hrs</b>	<b>4 to 7 hrs</b>	<b>8 to 14 hrs</b>	<b>14 + hrs</b>	<b>Total</b>
<b>1<sup>st</sup> stage</b>	197	303	193	157	850
<b>%</b>	23.18	35.65	22.71	18.47	
<b>2<sup>nd</sup> stage</b>	15	54	134	121	324
<b>%</b>	4.63	16.67	41.36	37.35	
<b>Total</b>	212	357	327	278	1174

Pearson Chi-square: 137.071. p=0.0000001

## References

1. Perič, T.; Březina, T. *Jak nalézt a rozvíjet sportovní talent*, 1st ed.; Grada Publishing: Praha, Czech Republic, 2019.
2. Dvořáková, H. *Pohybem a hrou rozvíjíme osobnost dítěte*, 1st ed.; Portál: Praha, Czech Republic, 2002.
3. World Health Organization. *Health21: The health for all policy frameworks for the WHO European region*. Available online: [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0010/98398/wa540ga199heeng.pdf](http://www.euro.who.int/__data/assets/pdf_file/0010/98398/wa540ga199heeng.pdf). (accessed on 29. November 2021).
4. Sigmundová, D.; Sigmund, E. *Trendy v pohybovém chování českých dětí a adolescentů*, 1st ed.; Univerzita Palackého: Olomouc, Czech Republic, 2015.
5. Kunešová, M.; Vignerová, J.; Stefllová, J.; Parizkova, J.; Lajka, J. Obesity in Czech children and adolescents: reaction to parental obesity and socioeconomic factors. *J. Public Health* **2007**, *15*, 163-170.
6. Görner, K.; Boraczyński, T.; Štihec, J. Physical activity, body mass, body composition and the level of aerobic capacity among young, adult women and men. *Sport Sci. Pract. Aspects* **2009**, *6*, 7-14.
7. Salvy, S.J.; de la Haye, K.; Galama, T.; Goran, M.I. Home visitation programs: An untapped opportunity for the delivery of early childhood obesity prevention. *Obes. Rev.* **2017**, *18*, 149-163.
8. Sattar, A.; Josephson, R.; Moore, S.M. Impact of obesity and other chronic conditions on lifestyle exercise during the year after completion of cardiac rehabilitation. *J. Cardiopulm. Rehabil. Prev.* **2018**, *37*, 262-267.

9. Wilkie, H.; Standage, M.; Gillison, F.B.; Cumming, S.P.; Katzmarzyk, P.T. Correlates of intensity-specific physical activity in children aged 9-11 years: a multilevel analysis of UK data from the international study of childhood obesity, lifestyle and the environment. *BMJ Open* **2018**, *8*, 1-11.
10. Roberto, C.H.A.; Swinburn, B.; Hawkes, C.; Huang, T.T.K.; Costa, S.A.; Ashe, M.; Zwicker, L.; Cawley, J.H.; Brownell, K.D. Patchy progress on obesity prevention: emerging examples, entrenched barriers, and new thinking. *Lancet* **2015**, *385*, 2400-2409.
11. Erben, K. *Homocystein, civilizační choroby a biochemické zdraví*, 1st ed.; Bondy: Praha, Czech Republic, 2015.
12. Lobstein, T.; Jackson-Leach, R.; Moodie, M.L.; Hall, K.D.; Gortmaker, S.L.; Swinburn, B.A.; James, P.T.; Wang, Y.; McPherson, K. Child and adolescent obesity: part of a bigger picture. *Lancet* **2015**, *385*, 2510-2520.
13. Davis, R.A.H.; Halbrooks, J.E.; Watkins, E.E.; Fischer, G.; Hunter, G.R.; Nagy, T.R.; Plaisance, E.P. High-intensity interval training and calorie restriction promote remodeling of glucose and lipid metabolism in diet-induced obesity. *Int. J. Behav. Nutr. Phys. Act.* **2017**, *13*, 243-256.
14. Jago, R.; Salwy, R.; Collison, L.E.; Sebire, S.J.; Thompson, J.L.; Lawlor, D.A. Association of BMI category with change in children's physical activity between ages 6 and 11 years: a longitudinal study. *Int. J. Obes.* **2020**, *44*, 104-113.
15. Bagchi, D. *Global perspectives on childhood obesity*, 1st ed.; Academic Press: San Diego, United States, 2019.
16. Kunešová, M. *Klasifikace a diagnostika obezity-základy obezitologie*, 2nd ed.; Galén: Praha, Czech Republic, 2016.
17. Svačina, Š.; Bretšnajdrová, A. *Dietologický slovník*, 1st ed.; Triton: Praha, Czech Republic, 2008.
18. Cooper A.R.; Goodman, A.; Page, A.S.; Sherar L.B.; Esliger, D.W.; Sluijs, E.M.F.; Andersen, L.B.; Anderssen, S.; Cardon, G.; Davey, R.; Froberg, K.; Hallal, P.; Janz, K.F.; Kordas, K.; Kreimler, S.; Pate, R.R.; Puder, J.J.; Reilly, J.J.; Salmon, J.; Sardinha, L.B.; Timperio, A.; Ekelund, U. Objectively measured physical activity and sedentary time in youth: the International children's accelerometry database (ICAD). *Int. J. Behav. Nutr. Phys. Act.* **2015**, *12*, 113.
19. Machová, J.; Kubátová, D. *Výchova ke zdraví*, 1st ed.; Grada Publishing: Praha, Czech Republic, 2015.
20. Pyšná, J.; Pyšný, L.; Petrů, D.; Cihlář, D. *Obezita u žáků druhého stupně základních škol Ústeckého kraje*, 1st ed.; Univerzita J. E. Purkyně v Ústí nad Labem, Ústí nad Labem, Czech Republic, 2019.
21. Haluzík, M.; Mráz, M.; Lacinová, Z. Jak tuková tkáň přispívá ke vzniku metabolických komplikací obezity? *Diabetologie-metabolismu-endokrinologie-výživa: časopis pro postgraduální vzdělávání* **2014**, *17*, 64-70.
22. Lavie, C.J.; Laddu, D.; Arena, R.; Ortega F.B.; Alpert, M.A.; Kushner, R.F. Healthy weight and obesity prevention: JACC health promotion series. *J. Am. Coll. Cardiol.* **2018**, *72*, 1506-1531.
23. Hochberg, Z. An evolutionary perspective on the obesity epidemic. *Trends Endocrinol. Metab.* **2018**, *29*, 819-826.
24. Kasalová-Daňková, Š.; Holub, J.; Láčková, J. *Evropské výběrové šetření o zdraví v České republice European Health Interview Survey 2008*, 1st ed.; Ústav zdravotnických informací a statistiky České republiky: Praha, Czech Republic, 2011.
25. Bunc, V. *Dětská hypokinéza-příčiny a možnosti nápravy*, 1st ed.; Pedagogická fakulta Univerzity v Hradci Králové: Hradec Králové, Czech Republic, 2015.
26. Rychtecký, A.; Tilinger, A. *Životní styl české mládeže: Pohybová aktivita, standardy a normy motorické výkonnosti*, 1st ed.; Karolinum: Praha, Czech Republic, 2017.
27. Matoulek, M.; Svačina, Š.; Lajka, J. Výskyt obezity a jejích komplikací v České republice. *Vnitř. Lek.* **2010**, *56*, 1019-1027.
28. Bláha, P.; Vignerová, J.; Riedlová, J.; Kobzová, J.; Krejčovský, L. VI. celostátní antropologický výzkum dětí a mládeže 2001. *Česlov. Pediat.* **2003**, *58*, 766-770.
29. Kunešová, M.; Vignerová, J.; Pařízková, J.; Procházková, B.; Braunerová, R.; Riedlová, J.; Zamrazilová, H.; Hill, M.; Bláha, P.; Stefllová, A. Long-term changes in prevalence of overweight and obesity in Czech 7 year old children: evaluation of different cut-off criteria of childhood obesity. *Obes. Rev.* **2011**, *12*, 483-491.
30. Prokopec, M. *Forty years of monitoring child growth in the Czech Republic: methodologies, outcomes and comparisons*, 1st ed.; Human Biology Budapest Sciencis: Budapest, Hungary, 2018.
31. Vignerová, J.; Riedlová, J.; Bláha, P.; Kobzová, J.; Krejčovský, L.; Brabec, M.; Hrušková, M. *Šestý celostátní antropologický výzkum dětí a mládeže 2001, Česká republika, souhrnné výsledky*, 1st ed.; Přírodovědecká fakulta Univerzity Karlovy v Praze a Státní zdravotnický ústav: Praha, Czech Republic, 2006.
32. Ipsen, D.H.; Tveden-Nyborg, P.; Lykkesfeldt, J. Dyslipidemia: obese or not obese-that is not the question. *Curr. Obes. Rep.* **2016**, *5*, 405-412.
33. Vekic, J.; Zeljkovic, A.; Stefanovic, Z.; Jelic-Ivanovic. Obesity and dyslipidemia. *Metabolism.* **2019**, *92*, 71-81.
34. Hainer, V. *Etiopatogeneze obezity-základy obezitologie*, 2nd ed.; Galén: Praha: Czech Republic, 2016.
35. Hainer, V.; Bendlová, B. *Etiopatogeneze obezity-základy klinické obezitologie*, 2nd ed.; Galén: Praha: Czech Republic, 2011.
36. Pygeyre, M.; Meyre, D. *Monogenetic obesity-pediatric obesity: Etiology, pathogenesis and treatment*, 1st ed.; Bern: Springer International Publishing, Switzerland, 2018.
37. Dixon, J.B.; Dixon, M.E.; O'Brien, P.E. Alcohol consumption in the severely obese subjects: Relationship with the metabolic syndrome. *Obes. Rev.* **2002**, *10*, 245-252.
38. Kunešová, M.; Hlavatá, K. *Nutriční faktory v etiologii a patogenezi dětské obezity-obezita v dětství a dospívání, terapie a prevence*, 2nd ed.; Galén: Praha, Czech Republic, 2007.
39. Duffey, K.J.; Gordon-Larsen, P.; Jacobs, D.R.; Williams, O.D.; Popkin, B.M.; Differential association of fast food and restaurant food consumption with 3 years change in body mass index: The Coronary Artery Risk Development in Young Adults Study. *Am. J. Clin. Nutr.* **2007**, *85*, 201-208.
40. Hollenrieder, V. Therapy of diabetes and obesity. *MMW Fortschr. Med.* **2018**, *160*, 64-67.

- 
41. Kocazeybek, B.; Dinc, H.O.; Ergin, S.; Saribas, S.; Ozcabi, B.T.; Cizmecigil, U.; Altan, E.; Atalik, K.; Yüksel, P.; Zeynep, Z.; Karakullukcu, A.; Sirekbasan, S.; Turan, N.; Cagatay, P.; Imamova, N.; Evliyaoglu, O.; Yilmaz, H. Evaluation of Adenovirus-36 (Ad-36) antibody seropositivity and adipokine levels in obese children. *Microb. Pathog.* **2017**, *108*, 27-31.
  42. Parr, E.B.; Coffey, V.G.; Cato, L.E.; Phillips, S.M.; Burke, L.M.; Hawley, J.A. A randomized trial of high-dairy-protein, variable-carbohydrate diets and exercise on body composition in adults with obesity. *Obesity (Silver Spring)* **2016**, *24*, 1035-1045.
  43. Sevinçer, G.M.; Sayar, G.H. Sleep related eating disorder: Importance of prebariatric evaluation-A case report. *Obes. Res. Clin. Pract.* **2017**, *11*, 360-363.
  44. Yousefi, R.; Mottaghi, A.; Saidpour, A. Spirulina platensis effectively ameliorates anthropometric measurements and obesity-related metabolic disorders in obese or overweight healthy individuals: A randomized controlled trial. *Complement. Ther. Med.* **2018**, *40*, 106-112.
  45. Gupta, P.P.; Fonarow, G.C.; Horwich, T.B. Obesity and the obesity paradox in hearth failure. *Can. J. Cardiol.* **2015**, *31*, 195-202.
  46. Pischon, T.; Boeing, H.; Hoffman, K.; Bergmann, M.; Schulze, M.B.; Overvad, K.; van der Schouw, Y.T.; Spencer, E.; Moons, K.G.M.; May, A.M. General and abdominal adiposity and risk of death in Europe. *N. Engl. J. Med.* **2008**, *359*, 2105-2120.
  47. Cao, J.J. Effects of obesity on bone metabolism. *J. Orthop. Sur. Res.* **2011**, *6*, 30.
  48. Loures, F.B.; de Araújo Góes, F.; Labronici, P.J.; Barretto, J.M.; Olej, B. Evaluation of body mass index as a prognostic factor in osteoarthritis of the knee. *Rev. Bras. Ortoped.* **2016**, *51*, 400-404.
  49. de Melo, C.M.; del Re, M.P.; Quaresma, M.V.L.D.S.; Antunes, H.K.M.; Togeiro, S.M.; Ribeiro, S.M.L.; Tufik, S.; de Mello, M.T. Relationship of evening meal with sleep quality in obese individuals with obstructive sleep apnea. *Clin. Nutr. ESPEN* **2019**, *29*, 231-236.
  50. Sucharda, P. *Zdravotní rizika obezity a nemoci komplikující obezitu-základy obezitologie*, 2nd ed.; Galén: Praha, Czech Republic, 2016.
  51. Avgerinos, K.I.; Spyrou, N.; Mantzoros, S.CH.; Dalamaga, M. Obesity and cancer risk: Emerging biological mechanisms and perspectives. *Metabolism* **2019**, *92*, 121-135.
  52. Weihrauch-Blüher, S.; Schwarz, P.; Klusmann, J.H. Childhood obesity: increased risk for cardiometabolic disease and cancer in adulthood. *Metabolism* **2019**, *92*, 147-152.
  53. Hainerová, I.A.; Zamrazilová, H. Zdravotní a psychosociální komplikace obezity u dětí a dospívajících. *Pediatr. Praxi.* **2015**, *16*, 150-153.
  54. Řehulka, E. *Škola a zdraví pro 21. století, výchova ke zdraví: mezinárodní zkušenosti*, 1st ed.; Brno: Masarykova Univerzita, Czech Republic, 2011.
  55. Bergman, R.N.; Stefanovski, D.; Buchanan, T.A.; Sumner, A.E.; Reynolds, J.C.; Sebring, N.G.; Xiang, A.H.; Watanabe, R.M. A better index of body adiposity. *Obesity (Silver Spring)* **2011**, *19*, 1083-1089.
  56. Geserick M.; Vogel, M.; Gausche, R.; Lipek, T.; Spielau, U.; Keller, E.; Pfäffle, R.; Kiess, W.; Körner, A. Acceleration of BMI in early childhood and risk of sustained obesity. *N. Engl. J. Med.* **2018**, *379*, 1303-1312.
  57. Hrubá, D.; Kunzová, Š. Chování a zdraví I - Životní styl a komplexní choroby. *Hygiena* **2015**, *58*, 3-28.
  58. Pyšná, J.; Bláha, L.; Pyšný, L.; Cihlár, D.; Petru, D.; Škopek, M. *Vybrané aspekty životního stylu u žáků druhého stupně základních škol Ústeckého kraje*, 1st ed.; Univerzita Jana Evangelisty Purkyně v Ústí nad Labem: Ústí nad Labem, Czech Republic; 2021.
  59. Pangrazi, R.P.; Baighle, A.; Vehige, T.; Vack, C. Impact of Promoting Lifestyle Activity for Youth (PLAY) on Children's Physical Activity. *J. Sch. Health* **2013**, *73*, 317-321.
  60. Pysny L.; Petru, D.; Pysna, J.; Cihlar, D. *The use of new experience in preventing and tackling child obesity as a part of teaching university students, the future primary and secondary school teachers*. In IATED Academy (Ed.) ICERI2019 Proceedings, 2019.
  61. Vláda České republiky. *Usnesení vlády České republiky: Nouzový stav*. Available online: <https://apps.odok.cz/attachment/-/down/IHOABMNHPBSV>. (accessed on 28. November 2021).
  62. Vláda České republiky. *Výsledky jednání vlády 15. března 2020*. Available online: <https://www.vlada.cz/cz/media-centrum/tiskovezpravy/vysledky-jednani-vlady-15-brezna-2020-180378/>. (accessed on 16. March 2021).
  63. Vláda České republiky. *Vládní usnesení a odůvodnění související s bojem proti epidemii*. Available online: <https://www.vlada.cz/cz/epidemie-koronaviru/dulezite-informace/prehledvladnich-usneseni-od-vyhlaseni-nouzoveho-stavu-180608/#brezen>. (accessed on 31. March 2021).
  64. Vláda České republiky. *Nouzový stav*. Available online: <https://apps.odok.cz/attachment/-/down/IHOABMNHPBSV>. (accessed on 31. March 2021).
  65. Vláda České republiky. *Usnesení vlády České republiky: O přijetí krizového opatření*. Available online: <https://apps.odok.cz/attachment/-/down/IHOABMNHPTS8>. (accessed on 1. November 2021).
  66. Vláda České republiky. *Usnesení vlády České republiky: O přijetí krizového opatření ze dne 8. října 2020*. Available online: <https://apps.odok.cz/attachment/-/down/IHOABU7M585P>. (accessed on 23. March 2021).
  67. Vláda České republiky. *Usnesení vlády České republiky: O přijetí krizového opatření*. Available online: <https://www.vlada.cz/assets/mediacentrum/aktualne/skoly-1112.pdf>. (accessed on 26. March 2021).
  68. Vláda České republiky. *Usnesení vlády České republiky: O přijetí krizového opatření ze dne 20. listopadu 2020*. Available online: <https://www.vlada.cz/assets/media-centrum/aktualne/Omezeni-skol-od-30-listopadu-1199.pdf>. (accessed on 28. March 2021).
  69. Bates, L. C.; Zieff, G.; Stanford, K.; Moore, J.B.; Kerr, Z.Y.; Hanson, E.D.; Gibbs, B.B.; Stoner, L. COVID-19 Impact on behaviors across the 24-hour day in children and adolescents: physical activity, sedentary behavior, and sleep. *Children* **2020**, *7*, 138.
  70. Yang, Y.; Koenigstorfer, J. Determinants of physical activity maintenance during the COVID-19 Pandemic: A focus on fitness apps. *Transl. Behav. Med.* **2021**, *10*, 835-842.

- 
71. Dubuc, M.M.; Bergian, F.; Goudreault, M.; Beaudoin, S.; Turcotte, S. COVID-19 Impact on Adolescent 24 h Movement Behaviors. *Int. J. Environ. Res. Public Health*. **2021**, *18*, 9256.
  72. Moore, S. A.; Faulkner, G.; Rhodes, R.E.; Brussoni, M.; Chulak-Bozzer, T.; Ferguson, L.J.; Mitra, R.; O'Reilly, N.; Spence, J.C.; Vanderloo, L.M.; Tremblay, M.S. Impact of the COVID-19 virus outbreak on movement and play behaviours of Canadian children and youth: a national survey. *Int. J. Behav. Nutr. Phys. Act.* **2020**, *17*, 123-136.
  73. Velde, G.T.; Lubrecht, J.; Arayess, L.; van Loo, CH.; Hesselink, M.; Raijnders, D.; Vreugdenhil, A. Physical activity behaviour and screen time in Dutch children during the COVID-19 pandemic: Pre-, during-and post-school closures. *Pediatr. Obes.* **2021**, *16*, 1-7.
  74. Xiang, M.; Zhang, Z.; Kuwahara, K. Impact of COVID-19 pandemic on children and adolescents' lifestyle behavior larger than expected. *Prog. Cardiovasc. Dis.* **2020**, *63*, 531-532.
  75. Ruíz-Roso, M. B.; de Carvalho Padilha, P.; Matilla-Escalante, D.C.; Brun, P.; Ulloa, N.; Acevedo-Correa, D.; Peres, WAF.; Martorell, M.; Carrilho, T.B.R.; Cardoso, L.O.; Carrasco-Marín, F.; Paternina-Sierra, K.; de las Hazas, M.C.L.; Rodriguez-Meza, J.E.; Villalba-Montero, L.F.; Bernabè, G.; Pauletto, A.; Taci, X.; Cárcamo-Regla, M.; Martínez, A.; Dávalos, A.; Changes of Physical Activity and Ultra-Processed Food Consumption in Adolescents from Different Countries during Covid-19 Pandemic: An Observational Study. *Nutrients* **2020**, *12*, 1-13.
  76. Slimani M.; Paravlic, A.; Mbarek, F.; Bragazzi, N.I.; Tod D. The Relationship Between Physical Activity and Quality of Life During the Confinement Induced by COVID-19 Outbreak: A Pilot Study in Tunisia. *Front. Psychol.* **2020**, *11*, 1-5.
  77. Vignerová, J.; Bláha, L. *Sledování růstu českých dětí a dospívajících. Norma, vyhublost, obezita, 1st ed.*; Státní zdravotní ústav: Praha, Czech Republic, 2001.
  78. World Health Organization. *Obesity and overweight*. Available online: <<http://www.who.int/mediacentre/factsheets/fs311/en/>>. (accessed on 21. May 2021).
  79. Chytrý, V.; Kroufek, R.; Janovec, J.; Nováková, A. *Moderní přístupy pedagogického výzkumu a analýzy dat*, 1st ed.; Univerzita Jana Evangelisty Purkyně Ústí nad Labem: Ústí nad Labem, Czech Republic, 2019.
  80. Mítáš, J.; Frömel, K. *Pohybová aktivita české dospělé populace v kontextu podmínek prostředí*, 1st ed.; Univerzita Palackého v Olomouci, Czech Republic, 2013.
  81. Jíra, O. *Děti, mládež a volný čas (Vybrané aspekty problému). Výsledky studie, 1997*, 1st ed.; Institut dětí a mládeže MŠMT ČR: Praha, Czech Republic, 2020.
  82. Kunešová, M. *Životní styl a obezita v ČR-longitudinální epidemiologická studie prevalence obezity v ČR. Závěrečná zpráva z výzkumu pro MZ ČR a Českou obezitologickou společnost. STEM/MARK: Praha, Czech Republic, 2006.*
  83. Státní zdravotnický ústav Praha. *Výskyt nadváhy a obezity*. Available online: <[https://www.szu.cz/uploads/documents/chzp/info.../Vyskyt\\_nadvahy\\_a\\_obezity\\_2012.pdf](https://www.szu.cz/uploads/documents/chzp/info.../Vyskyt_nadvahy_a_obezity_2012.pdf)>. (accessed on 1. September 2021).
  84. Kunešová, M.; Vignerová, J.; Pařízková, J.; Procházka, B.; Braunerová, R.; Riedlová, J.; Zamrazilová, H.; Hill, M.; Bláha, P.; Steřlová, A. Long-term changes in prevalence of overweight and obesity in Czech 7-year-old children: evaluation of different cut-off criteria of childhood obesity. *Obes. Rev.* **2011**, *12*, 483-491.
  85. Bláha, L. *Výuka tělesné výchovy a její odraz v aktivitách dětí a mládeže v regionu Severozápadních Čech*, 1st ed.; Univerzita Jana Evangelisty Purkyně v Ústí nad Labem: Ústí nad Labem, Czech Republic, 2019.
  86. Pyšná J.; Pyšný, L.; Cihlák, D.; Petřů, D.; Škopek, M. Effect of Physical Activity on Obesity in Second Stage Pupils of Elementary Schools in Northwest Bohemia. *Sustainability* **2020**, *12*, 1-14.
  87. Forýtková, L.; Bourek, A. *Standardy léčebných postupů a kvalita ve zdravotní péči*, 1st ed.; Verlag Dashöfer: Praha, Czech Republic, 2015.
  88. Caldeira, R.S.; Panissa, V.L.G.; Inoue, D.S.; Campos, E.Z.; Monteiro, P.A.; Giglio, B.M.; Pimentel, G.D.; Hofmann, P.; Lira, F.S. Impact to short-term high intensity intermittent training on different storages of body fat, leptin and soluble leptin receptor levels in physically active non-obese men: A pilot investigation. *Clin. Nutr. ESPEN* **2018**, *28*, 186-192.
  89. Flegal, K.M.; Carroll, M.D.; Kit, B.K.; Ogden, C.L. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *JAMA* **2012**, *307*, 491-497.
  90. Canadian Community Health Survey. *Overweight and Obese Adults*. Available online: <https://www150.statcan.gc.ca/n1/en/pub/82-625-x/2019001/article/00005-eng.pdf%3Fst%3DOBRuwojR>. (accessed on 3. September 2021).
  91. Kubínová, R. *Zdravotní stav české populace. Výsledky studie European Health Examination Survey 2014*, 1st ed.; Státní zdravotní ústav: Praha, Czech Republic, 2016.