PŮVODNÍ PRÁCE

STATISTICAL COMPARISON OF CHILDREN'S MOTOR SKILLS FROM THE PERIOD BEFORE AND AFTER THE COVID-19 PANDEMIC

Štatistické porovnanie pohybových schopností detí z obdobia pred a po pandémii COVID-19

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Abstract

The COVID-19 pandemic affected the whole world, including Slovakia. The pandemic has limited children's opportunities to develop fundamental motor skills and potentially harming their physical and mental health. The paper focuses on a comparison of children's motor skills from the period before (year 2019) and after (year 2022) the COVID-19 pandemic. The evaluated data were measured by physical education teachers. We conducted a statistical analysis of matching pairs of datasets. Using exploratory data analysis (EDA) and both parametric and nonparametric two-sample tests, we visualized and analysed the data. Our statistical methodology included descriptive statistics tables, test evaluation tables, and relevant statistical graphs. While restrictions on sports during the pandemic might suggest a decline in children's motor skills, our statistical analysis did not confirm this hypothesis at all. We discuss potential reasons for this in the Conclusions."

Keywords: *testing of motor skills, hypothesis testing, goodness-of -fit test, two-sample test.*

Introduction

During the COVID-19 pandemic, Slovakia was one of the countries in which schools were closed for the longest time. The transition to distance learning caused a drop in education level. A KPMG Business Institute survey (KPMG Business Institute, 2020) conducted in April 2020 on 330 Slovak teachers states that half of the interviewed teachers taught less than two hours a day on average, and a third of teachers taught 3 to 4 hours a day. This was particularly evident in children of marginalized backgrounds who, despite the provision of technical support, rarely joined online classes (Barnová, Hlásna - Krásna, Gabrhelová, & Barna, 2021). Measures ensuring social distancing also caused negative psychological aspects. The incidence of depression has increased and an increase in physical and psychological violence has been confirmed in almost all countries (Campbell, 2020).

This article is devoted to exploring how the COVID-19 pandemic has affected children's motor skills. In addition to schools, sports fields, and all leisure facilities where children were grouped were also closed. Isolation often led to an increase in online spending time and, for some, to a decrease in physical activity. Sport is an excellent means to maintain a healthy body and mind. Hypokinesis (absence of significant physical movement) in connection with an inappropriate lifestyle and a number of stressful situations contributes to the deterioration of the state of health and physical fitness of the current population (Buková, 2010).

Aim

The aim of this paper is to analyse and compare datasets that contain the results of the measurement of children's motor skills. Values were measured by physical education teachers in 2019 (pre-covid) and in 2022 (post-covid).

Methodology

Using the software R (Grolemund, & Wickam, 2017, Versani 2014), we analysed the measuring datasets for boys 5.-9. grades of elementary school (hockey and general classes) and for girls of the first year class of grammar school. The elementary school datasets contain the results for the disciplines: shuttle run 4 × 10 m, standing long jump, sit-up 30s and bent arm hang. The only exception was the 8th grade, where datasets from the two last ones were missing. The data files from the grammar school contain the measurement results for the disciplines: standing long jump, sit-up 30s and medicine ball throw.

Graphical analysis consists of depicting and analysing basic statistical graphs. It provides a graphical overview of the data, gives an idea of the data distribution, and helps with the assumption of testing. The analysis allows identify statistical peculiarities of the data – symmetry, local concentration of the data, detect and image outliers. In the case of comparing two or more datasets give a quick sight of the similarity or dissimilarity the data. If the data are measured in time, it can be displayed in the form of a time series.

The graphic analysis shows that 15.8% of the elementary school datasets and 50% of the measurement grammar school datasets contain outliers. There are various methods of detection of outliers, in our case it is the outlier value outside the interval (1), where q_1, q_3 are the lower and upper quartile of the dataset.

$$(q_1 - 1{,}5(q_3 - q_1),\ q_3 + 1{,}5(q_3 - q_1)) \qquad (1)$$

The purpose of the two-sample tests is to determine whether the difference between these two datasets (2019, 2022) is statistically significant. This is our primary goal. The secondary goal is to compare the performance of hockey and general classes and find statistically significant differences. The analysis begins with the calculation and comparison statistical values of location and dispersion (average, median, standard deviation). Each dataset is tested with an appropriate goodness-of-fit test (Shapiro, & Wilk, 1965) to validate conformity with a normal distribution

The significance level for all goodness-of-fit test is $\alpha = 0.05$. If each component of a pair of datasets (relevant discipline and class, data before and after covid) is normally distributed, we test with a suitable independent samples t-test. The choice of the two-sample test depends on the equality and inequality of the dispersion of the files.

The null hypothesis and the alternative hypothesis (depending on the discipline) are in the form

$$H_0: mean_{before} = (\leq)\ mean_{after} \quad H_1: mean_{before} > mean_{after} \qquad (2.1)$$
$$H_0: mean_{before} = (\geq)\ mean_{after} \quad H_1: mean_{before} < mean_{after} \qquad (2.2)$$

where $mean_{before}$, $mean_{after}$ is mean for the relevant dataset before, respectively, after covid. If data do not have normal distribution, we test with a suitable nonparametric test (two-sample Wilcoxon rank sum test, two-sample Kolmogorov Smirnov test). The null

hypothesis is the hypothesis that there is no statistically significant difference between the datasets. The null hypothesis and the alternative hypothesis (depending on the discipline) are in the form

$$H_0: median_{before} = (\leq)\ median_{after} \quad H_1: median_{before} > median_{after} \quad (3.1)$$
$$H_0: median_{before} = (\geq)\ median_{after} \quad H_1: median_{before} < median_{after} \quad (3.2)$$

Results

In Figure 1 is the Box Whisker chart for the shuttle run 4 × 10 m discipline for general classes before and after covid and in Figure 2 is the Box Whisker chart for hockey classes. In Figure 1, we can observe three datasets with outliers and a strong asymmetry of the data for the 6th, 7th and 9th grade before and after covid. Also, we can remark (visually) enhancement of the results for 7th, 8th, 9th grade (2022). In the second figure, we can see 3 datasets with outliers and data asymmetries for the 9th grades (year 2019) and grades 6 and 9 (year 2022). The data asymmetry predicts that the data will not be normally distributed and non-parametric methods must be used for data analysis.

The choice of how to deal with an outlier should depend on the cause. If a data point is excluded from the data analysis, this should be clearly stated in the report. Datasets include correctly measured data (repeated measurements with the best value selection). From this reason and with regard to the goals of the analysis, we decided to keep them in the data files.

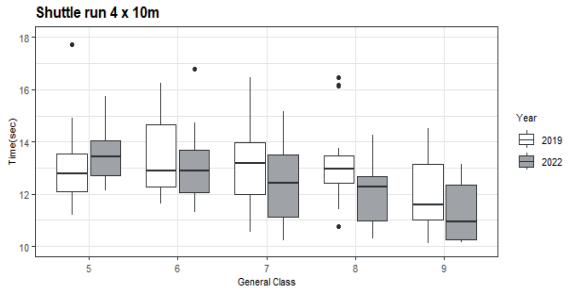

Figure 1 *Box Whisker chart's for the shuttle run 4 × 10 m discipline, General classes (before and after covid)*

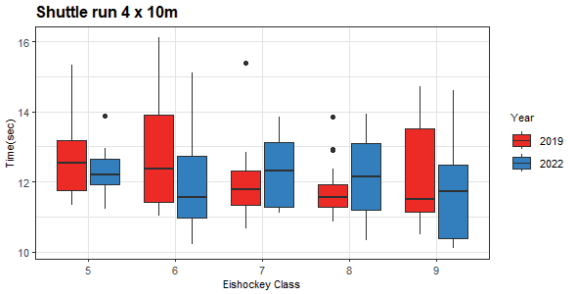

Figure 2 *Box Whisker chart's for the shuttle run 4 × 10 m discipline, ice hockey classes (before and after covid)*

Similar information of the data distribution for the long jump discipline standing (without outliers) is also provided by the distribution chart in Figures 3 and 4.

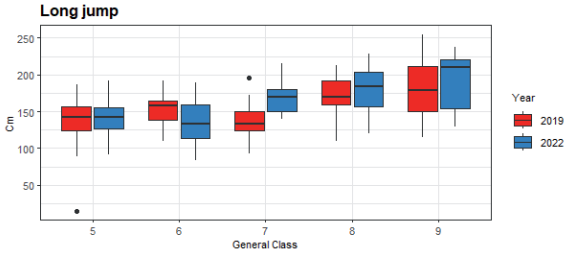

Figure 3 *Box Whisker chart's for the long jump discipline, General classes (before and after covid)*

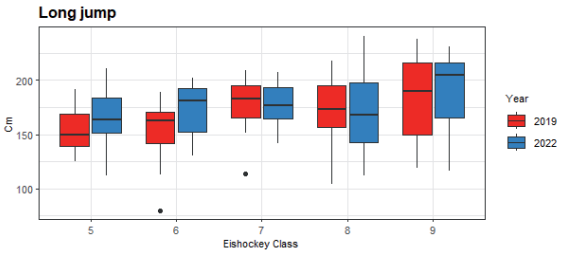

Figure 4 *Box Whisker chart's for the long jump discipline, ice hockey classes (before and after covid)*

The aim of our analysis is to compare datasets of measurements before and after covid. For comparing similarities and differences between two datasets, a combined graph is suitable, which includes a histogram and empirical density. The statistical characteristics of the location (average, median, mode) are often displayed in the graph. Figure 5 represents three combined graphs with median (solid line) and average (dashed line) as location characteristics for 3 disciplines and ice hockey class 5 only. We will use the relevant unpaired two -sample test to determine whether the differences are statistically significant.

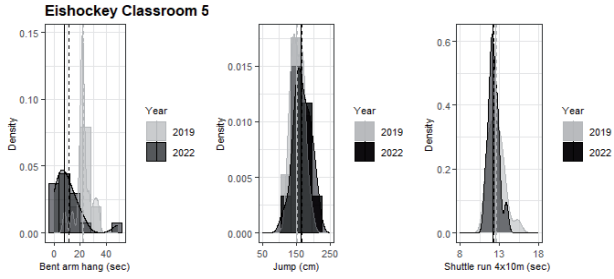

Figure 5 *Year 2019 and 2022 combined graph with histogram, empirical density, median (solid line) and average (dashed line)*

Median values of performances achieved in a given discipline and grade before and after covid, can also be shown as a time series, where "time" is the class (ascending). The curves should have an increasing or decreasing trend depending on the discipline represented. Figure 6 shows the median values for the jump discipline across the general and hockey classes in the form of a time series.

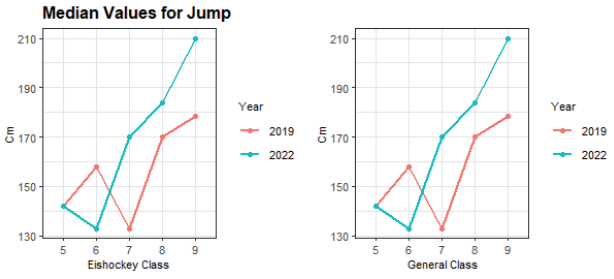

Figure 6 Median values time series for the long jump discipline across the general and hockey classes

We give conclusions for the significance level only. Some of the results can be seen in the Tab. 1. and 2.

Table 1 *Statistical values of location and dispersion, selected test and test conclusion for ice hockey grade and general class 7.*

Ice hockey Grade 7.	Shuttle run		Jump		Sit-Up		Bent arm hang	
	2019	2022	2019	2022	2019	2022	2019	2022
Mean	11.52	12.28	179.10	175.70	28.00	26.33	14.66	11.64
Median	11.34	12.30	183.00	177.00	29.00	27.00	9.70	8.24
St. deviation	0.82	0.98	23.48	19.76	4.71	2.87	15.12	10.06
Test	Parametric (2.1)		Parametric (2.2)		Nonparametric (3.2)		Nonparametric (3.2)	
Conclusion	Do not reject		Do not reject		Do not reject		Do not reject	

General Grade 7.	Shuttle run		Jump		Sit-Up		Bent arm hang	
	2019	2022	2019	2022	2019	2022	2019	2022
Mean	12.79	11.10	137.80	170.00	21.94	25.58	5.86	23.58
Median	12.96	11.12	133.00	170.00	20.00	25.60	0.00	28.00
St. deviation	1.27	1.17	25.49	21.31	4.46	3.50	13.31	14.04
Test	Parametric (2.1)		Parametric (2.2)		Nonparametric (3.2)		Nonparametric (3.2)	
Conclusion	Reject		Reject		Reject		Reject	

Table 2 *Statistical values of location and dispersion, selected test and test conclusion*

Grammar School (girls only)	Jump		Medicine Ball throw		Sit-Up	
	2019	2022	2019	2022	2019	2022
Mean	161.30	165.10	635.20	601.50	23.94	22.21
Median	165.00	160.00	620.00	590.00	24.00	22.00
St. deviation	23.13	20.98	124.26	98.83	3.55	3.36
Test	Parametric		Nonparametric		Parametric	
Conclusion	Do not reject (2.2)		Do not reject (3.2)		Do not reject (3.2)	

In all we performed 41 (100%) two sample tests (18 parametric and 23 non-parametric). We do not reject the null hypothesis (for significance level $\alpha = 0.05$) in 33 cases (80.5%), statistically significant differences were confirmed for 8 tests, while in 4 tests (9.75%) the results improved after covid, in another 4 tests they got worse after covid (9.75%).

Overall, it is not possible to confirm a significant downgrade in children's physical fitness for our datasets. This is true for the general and sports classes of the elementary school and for the first class of the grammar school.

Sports classes are designed for athletically talented children. Children have been selected based on excellent results in sports tests. Compared to general classes, they have a larger number of hours of physical education, and it is assumed that the physical fitness of children in sports classes and the results in individual monitored tests are better than for children in general classes. The aim of this chapter is to statistically compare the results of children from both classes in the tested disciplines before and after covid and to verify the hypothesis that children from the sports class have better results.

We proceed with the same keys as in the previous chapter, i.e., if the datasets are normally distributed, we test Hypotheses 2.1, 2.2 depending on the discipline. If the data are not normally distributed, we test Hypotheses 3.1, 3.2 depending on the discipline. After the tests, it can be concluded that the hockey class students are successful with the same or better results. Worsened results were shown only by students of the seventh grade after covid (see Table 3) in shuttle runs and bent arm hang. In each grade, we measure performance in 4 monitored disciplines (100%), in the case of eighth graders only in two monitored disciplines (missing datasets). The table does not specify the disciplines, only the percentage of the same, better or worse results than the results of general classes.

Table 3 *Discipline comparison for ice hockey and general classes*

Ice hockey Class	Results Comparison				
	Grade 5.	Grade 6.	Grade 7.	Grade 8.	Grade 9.
2019 equal	50%	75%	0%	100%	100%
2019 better	50%	25%	100%	0%	0%
2019 worse	0%	0%	0%	0%	0%
2022 equal	25%	50%	50%	100%	100%
2022 better	75%	50%	0%	0%	0%
2022 worse	0%	0%	50%	0%	0%

In total, we evaluated 18 tests for 2019. Better results were confirmed for the hockey class in 38.7%. Other results were comparable. For the year 2022, we also evaluated 18 tests. Better results were confirmed in 27.2%. In this year, hockey classes achieved worse results with 22.2%.

Discussion

While COVID-19 restrictions on sports during the pandemic might suggest a decline in children's motor skills, our statistical analysis did not support the hypothesis of a decline in these skills.

Similar results have been obtained by researchers from other countries who have examined this topic. Pajek (2022) reported that the COVID-19 pandemic significantly affected the motor development of 11-year-old children in Slovenia with major deficits in the domains of cardiorespiratory endurance, skill-related fitness and core strength. In general, the effects of the pandemic were greater in rural areas compared to urban areas (Pajek, 2022).

Jarnig, Jaunig and van Poppel (2021) reported a significant decrease in a 6-minute running test in Austrian children aged 7-10 years and a significant increase in the proportion of overweight and obese children (Jarnig, Jaunig & Poppel, 2021).

Eberhardt, Bös and Niessner (2021) reported that in 2020, the mean values of endurance and speed decreased, demonstrating the negative impact that the COVID-19 pandemic had on physical activity levels in children in Germany (Eberhardt, Bös & Niessner, 2021).

Šípová (2021), who compared the results of movement skills of Czech children (ages 7-11) after the covid pandemic, states that in most disciplines the pupils achieved average results compared to the results of the Unifittest (6-60). Students achieved the weakest performance in endurance running for 12 minutes. It is a test of endurance skills, which improve the fastest, but it is necessary to train these skills and this was missing during the lockdown (Šípová, 2021).

Another Czech study reported that individual aspects of physical activity decreased primarily among respondents, but in some cases remained at their original values or even increased. Respondents played primarily sports before and during lockdown (Kolařík, 2022).

Prof. Marián Vanderka from the Faculty of Physical Education and Sport of the Comenius University in Bratislava stated that the drop in VO2max was very striking in the first weeks of the pandemic. In healthy individuals without movement, it was up to 20 to 30% in 4 to 6 weeks. However, it is positive that if an untrained person begins to focus on it, most can achieve an increase of 20 to 30% in those 6 weeks (Šport a olympizmus, 2021). This explains why post-covid outcomes are not significantly worse compared to pre-covid outcomes.

Conclusions

In conclusions, after using statistical analysis and performing relevant tests, we conclude that although, based on several factors, it seemed that closure of schools and sports grounds would cause a deterioration in children's motor skills, this negative prognosis was not statistically confirmed based on the datasets available to us. There are several explanations. Although physical education and sports training did not take place in gyms and sports grounds, they were done online in homes. Isolation in homes led many families to a greater stay (and also movement) in nature. Many online training sessions were posted on the Internet, and some children who had been passive in sports until then, under the influence of their parents, began to replace limited movement in isolation in this way. Post-covid results were measured approximately 9 months after the reopening of schools and sports grounds, and during that time the children regained their fitness, which had been reduced during isolation.

Súhrn

Po použití štatistickej analýzy a vykonaní relevantných testov sme dospeli k záveru, že hoci by sme sa mohli na základe viacerých faktorov domnievať, že zatvorenie škôl a športovísk spôsobí zhoršenie pohybových schopností detí, táto negatívna prognóza sa štatisticky nepotvrdila na datasetoch, ktoré sme analyzovali. Existuje niekoľko vysvetlení. Telesná výchova a športová príprava síce neprebiehali v telocvičniach a na športoviskách, ale prebiehali online v domácnostiach. Izolácia v domácnostiach viedla mnohé rodiny k väčšiemu pobytu (a aj pohybu) v prírode. Na internete bolo zverejnených veľa online tréningov a niektoré deti, ktoré dovtedy športovali pasívne, si pod vplyvom rodičov začali takto izolovane nahrádzať obmedzený pohyb. Post-covidové výsledky sa merali približne 9 mesiacov po znovuotvorení škôl a športovísk a za ten čas sa deťom vrátila kondícia, ktorá bola počas izolácie znížená.

Kľúčové slová: *testovanie pohybových schopností,, testovanie štatistických hypotéz, test dobrej zhody, dvojvýberový test.*

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