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Efficiency in Physical Fitness of Czech Youth: Does School Matter?

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Abstract

This article examines the physical fitness of young people in the Czech Republic. Unlike other studies addressing similar topics, it does not assess the individual components of physical abilities in isolation. Instead, an efficiency score is calculated using a multi-criteria model based on four variables: shuttle run, long jump, the W170/kg test, and handgrip strength. This model produces an efficiency score for each participant, reflecting their overall level of physical fitness. The second stage of the analysis investigates whether these scores differ statistically significantly according to the type of school attended at the time of measurement. The comparison covers both general secondary schools (gymnasia) and technical/vocational secondary schools. The analysis also includes one military secondary school, which is the only institution of its kind in the Czech Republic. Data collected from 1,116 young people indicate that the type of school plays a significant role in determining physical fitness scores. Students attending the military secondary school achieve demonstrably better physical fitness outcomes compared to those from, for example, general academic secondary schools (gymnasia).

KEY WORDS: *adolescents, classification of secondary schools, endurance and strength, multi-criteria DEA model, physical fitness.*

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1. Introduction

There are many reasons why experts agree that children and adolescents should engage in adequate physical activity. In addition to strengthening their health and immunity, regular activity also helps develop ambition and self-confidence [1]. Sport, particularly team sport, further contributes to the development of effective communication skills [2]. Last but not least, active participation in sport provides an important escape from the digital environment [3].

In the military context, physical fitness is one of the key characteristics monitored. The relationship between military service and physical fitness is very close: a high level of fitness is essential for performing military tasks, coping with combat stress, and reducing the risk of injury. For these reasons, physical fitness is regularly assessed not only among active service members but also among veterans [4,5]. Since compulsory military service has been abolished in the Czech Republic, the armed forces cannot rely on large-scale conscription data to assess the physical preparedness of future recruits. Consequently, information on the physical fitness of young people is now obtained primarily through educational institutions, which represent the most relevant and accessible source for evaluating the physical preparedness of the emerging generation.

This article builds on research conducted within the BODY project (*Physical Fitness of the Population as a Risk Factor for Ensuring the Defensive Capacity of the Czech Republic*). The BODY project (running from 2020 to 2023) aimed, among other things, to analyze the physical fitness of secondary school students. The project focused on measuring a wide range of physical and non-physical factors used to assess the abilities of young people in the Czech Republic. The collected data made it possible, for example, to identify key determinants that significantly influence the physical fitness of young individuals [6]. [7] provided a detailed analysis of physical fitness results, examining men and women separately and concentrating primarily on variables measuring endurance and strength. Beyond physical characteristics, additional elements such as mental health were also explored [8].

Similarly, to [7], the present article concentrates on the physical aspects of young people. However, unlike the aforementioned studies, it does not investigate individual factors in isolation. Instead, it develops a model that integrates all

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relevant factors simultaneously. This model generates an efficiency score for each individual, representing their overall level of physical fitness.

A subsidiary objective is to examine physical fitness in relation to the type of secondary school. Physical education as a subject has a firmly established framework within the Czech education system, typically comprising 2–3 hours per week. However, in practical subjects (such as workshop-based classes), a higher level of physical activity can be expected, which leads to the assumption that technically oriented schools may promote better physical activity among students [9].

The second stage of the analysis investigates whether the scores differ statistically significantly according to the type of school attended at the time of measurement. The comparison includes both general secondary schools (gymnasia) and technical or vocational secondary schools. The analysis also included one military secondary school, which is the only institution of its kind in the Czech Republic.

2. Data and Methods

The data used in the analysis originate from the BODY project. The empirical results are based on measurements collected from 1,116 subjects. Strength and physical fitness are represented in the model by four variables: shuttle run, long jump, handgrip strength, and performance in an exercise test recalculated according to body weight (the W170/kg test). The basic characteristics of these variables are presented in Table 1. To avoid the need to determine the dominant hand, the handgrip strength result is reported as the average of the left- and right-hand measurements.

Table 1.

Basic characteristics for variables used

Variable	Long jump	Shuttle run	W170/kg test	Handgrip strength
Min	107.00	8.50	0.56	11.75
Lower quartile	179.00	10.60	1.98	28.40
Average	203.99	11.38	2.40	37.07
Median	205.50	11.28	2.43	36.53
Upper quartile	231.00	12.00	2.83	44.63
Max	292.00	16.90	4.50	73.35

A total of 15 schools from different regions of the Czech Republic are included in the analysis in order to maximize the representativeness of the sample. The schools also differed in their focus, see Table 2.

Table 2.

Number of students by type of school

Type of school	Number of students
General academic	358
General academic and technical	42
Technical (military-focused)	299
Technical	293
Technical and vocational	44
Vocational	80

Given the nature of the variables, the shuttle run serves as the sole input variable (with a minimisation orientation), while the remaining three variables function as output variables (with a maximisation orientation). The multi-criteria model employed follows the conceptual foundations established by Farrell [10]. In line with studies such as [11] and [12], a non-oriented model is adopted, in which efficiency scores are measured in a non-radial manner using slack-based measurement under the assumption of constant returns to scale:

$$\begin{aligned} \min_{\lambda,s^-,s^+} \quad & \rho = \frac{1-\frac{1}{m}\sum_{i=1}^{m}\frac{s_i^-}{x_{io}}}{1+\frac{1}{s}\sum_{r=1}^{s}\frac{s_r^+}{y_{ro}}} \\ & x_o = X\lambda + s^- \\ & y_o = Y\lambda + s^+ \\ \lambda \geq 0, \quad & s^- \geq 0, \quad s^+ \geq 0, \end{aligned} \tag{1}$$

where x_o denote the inputs of DMU_o ($x_o \in \mathbb{R}^m$); y_o denote its outputs ($y_o \in \mathbb{R}^s$); $X \in \mathbb{R}^{m\times n}$ and $Y \in \mathbb{R}^{s\times n}$ are the corresponding data matrices; s^- represent the input slacks ($s^- \in \mathbb{R}^m$); s^+ represent the output slacks ($s^+ \in \mathbb{R}^s$). Detailed mathematical information on the selected model can be found in Cooper, Seiford, and Tone [13].

To determine whether school type constitutes a statistically significant factor for the calculated physical fitness efficiency scores, the non-parametric Kruskal-Wallis test is applied, as the nature of the model does not allow us to assume that the condition of normality is satisfied [14]. Subsequent pairwise comparisons are conducted using Dunn's test.

3. Results

Overall, the physical fitness results are at a good level. Although the lowest recorded score is 54%, 75% of students achieved a score of 88% or higher (see Table 3). When compared with the median and upper-quartile values, it can be concluded that the distribution of scores is strongly left-skewed. This shape of the distribution confirms that the physical fitness outcomes can be evaluated positively.

Table 3.

Basic characteristics for the efficiency score obtained

Characteristic	Score
Min	0.54
Lower quartile	0.88
Average	0.93
Median	0.94
Upper quartile	0.99
Max	1.00

A total of 220 participants (almost 20%) achieved the maximum score of 100% (see Table 4). Among them, students from the military secondary school were particularly prevalent. However, all 15 participating schools had at least a few students who reached the full score. Likewise, all types of schools were represented in this group. As the primary criterion in our analysis is the type of school, the frequencies in Table 4 are presented according to this classification. The table reports not only the absolute number of students who achieved a score of 100%, but also their proportion relative to the total number of students within each school type.

Table 4.

Absolute and relative number of students with effective physical fitness

	Students with efficient physical fitness	
Type of school	Absolute number	Percentage
General academic	65	18.16
General academic and technical	5	11.90
Technical (military-focused)	79	26.42
Technical	42	14.33
Technical and vocational	9	20.45
Vocational	20	25.00
Total	220	19.71

A more detailed overview of the results by school type is provided in Table 5. As already noted, the maximum values are identical across all school types. Differences can therefore be observed in the minimum values as well as in the quartiles. When all these characteristics are taken into consideration, military secondary schools appear to perform the best.

Table 5.

Number of students by type of school

Type of school	N	Min	Q1	Median	Q3	Max
General academic	358	0.62	0.87	0.93	0.98	1.00
General academic and technical	42	0.59	0.90	0.95	0.98	1.00
Technical (military-focused)	299	0.71	0.92	0.96	1.00	1.00
Technical	293	0.54	0.86	0.94	0.98	1.00
Technical and vocational	44	0.74	0.89	0.95	0.99	1.00
Vocational	80	0.71	0.91	0.95	1.00	1.00

The results of the Kruskal-Wallis test (p-value <0.001) indicate that statistically significant differences exist between the schools. However, subsequent analyses showed that not all pairwise comparisons yielded conclusive differences. When the schools are grouped according to their focus (i.e., by school type rather than by individual institution), the results reveal that the outcomes of students from the military secondary school differ significantly from those of students attending both *General academic* and *Technical* secondary schools (p-value <0.001). No statistically significant differences were observed for the remaining pairs. In the case of the *General academic and technical* and *Technical and vocational* types of schools, the results were also influenced by the relatively low number of representatives, which naturally limits the power of statistical testing.

According to the median values, the scores presented in Table 5 suggest that, overall, gymnasia (general academic schools) perform the worst, whereas the only military secondary school in the Czech Republic ranks highest based on the median score. These results therefore support the assumption that, when focusing on the physical fitness of young people, secondary schools influence this area through the nature of their educational orientation.

4. Discussion, Limitations, and Directions for Future Research

This article examines the physical fitness of students in the Czech Republic using a multi-criteria model. Analysing the physical fitness of young people – particularly its development over time – can be considered crucial for national governments, as it provides an initial indication of the potential quality of future recruits for military service. Moreover, monitoring physical fitness trends allows policymakers to assess broader societal changes related to lifestyle, health, and physical activity. In countries with professional or mixed military systems, such information is increasingly important for long-term personnel planning and for identifying potential areas where preventive or supportive measures may be needed.

Owing to the existence of a secondary school in the Czech Republic that specialises in preparing future soldiers, it is possible to compare "regular" schools (whether general academic or technical/vocationally oriented) with an institution where students are systematically trained to maintain a high level of physical fitness, as this is essential for their future profession. The empirical results show that students from this military school achieve demonstrably better physical fitness scores compared to those attending general academic and technical secondary schools. The school factor has therefore proven to be a significant determinant influencing the physical fitness of young people.

At first glance, these results appear to contrast with the findings reported in [9]. However, this discrepancy can be explained by differences in research methodology. Study [9] examined 15-year-old students in Croatia and included only general academic and technical secondary schools. Moreover, the set of variables used also differed, as [9] focused on monitoring physical activity, whereas the present study estimates physical fitness scores. Last but not least, [9] did not include any schools with a military focus in its dataset. When physical fitness is examined only among students from general academic and technical secondary schools, the results of this study are consistent with those of [9], as neither study identified statistically significant differences between these two school types.

The inclusion of results from a military secondary school represents an added value of this study. According to the median values obtained, students from the military secondary school achieved the highest scores. Based on Dunn's test, it can be concluded that students attending the military secondary school perform statistically significantly differently from those attending both technical and general academic schools.

Measuring physical fitness is a highly complex issue. In this article, the focus is placed solely on its physical dimension. However, it does not focus on the selection of appropriate variables as in [15], but only on the calculation of physical fitness scores. The analysis could be further enriched by incorporating additional non-physical parameters, such as parental encouragement to engage in sports or the individual's mental well-being.

As the study examines only young people in the Czech Republic, its findings cannot be generalised to other geographical contexts. A useful extension would be to compare physical fitness levels across broader entities, such as EU or NATO member states. A comparison with countries where compulsory basic military service is in place would be particularly valuable.

Further limitations arise from the methodological approach. The model employed in this study is deterministic and therefore incapable of distinguishing between true inefficiency and noise. Future research could present the results in a more generalised and robust manner by applying various bootstrapping methods.

5. Conclusions

This article focuses on assessing the physical fitness of young people in the Czech Republic. Unlike previous studies, it does not monitor individual indicators separately but constructs an overall physical fitness score using a multi-criteria model. The model incorporates the results of the standing long jump, shuttle run, handgrip strength test, and the W170/kg test. In addition to analysing the overall state of physical fitness, the study also examines differences between types of secondary schools. The analysis covers general academic secondary schools and technical/vocational secondary schools. Unlike other studies, it also includes the country's only military secondary school.

The empirical results show that physical fitness scores vary depending on the type of school attended. Based on these results, students from the military secondary school can be considered the highest performing. Although there is only one such institution in the Czech Republic, the relatively large number of its participants allows the findings to be regarded as reliable. The statistical tests further confirmed that the outcomes of students from the military secondary school differ significantly from those of students attending general academic (gymnasia) and technical secondary schools.

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