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Physical Fitness of University of Defence Students: Faculty Comparison and Temporal Trends

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Abstract

Physical fitness represents an essential component of military readiness and a key prerequisite for the successful completion of military training and future service. The aim of this study was to analyse and compare the annual physical fitness assessment results among University of Defence students in the Czech Republic from 2022 to 2025, with a focus on differences between faculties. The analysis was based on administrative data from standardized testing and combined both cross-sectional and longitudinal approaches. Endurance was assessed using the 12-minute run (Cooper test), while the strength component was evaluated by the maximum number of pull-ups for males and the flexed-arm hang for females. The results showed no statistically significant differences between faculties in endurance performance among either males or females. Statistically significant differences between faculties were found only among males in the strength discipline, with the highest values observed among students of the Military Faculty of Medicine. The longitudinal analysis revealed that physical performance development during the study is not linear and varies by sex, faculty, and discipline type. For males, a clear increase in strength performance was observed across all faculties, while endurance performance showed a less stable pattern, including a temporary decline in some groups. The transition between the first and second year of study proved to be a critical period, during which some students experienced a decrease in endurance performance alongside an improvement in strength abilities. The findings of this study may contribute to the optimization of physical training during military university education and to a better consideration of the specific characteristics of individual study programmes.

KEY WORDS: *annual physical fitness assessment; 12-minute run (Cooper test); pull-ups and flexed-arm hang; longitudinal analysis*

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1. Introduction

Physical fitness represents an integral component of the professional competence of armed forces personnel and is systematically evaluated over the long term through standardized physical fitness tests. It is understood as a complex set of aerobic and strength abilities, the importance of which varies depending on the nature of the tasks performed and cannot be reduced to a single performance indicator. In the context of modern armed forces, physical fitness is considered not only a prerequisite for performing combat and support activities, but also a factor influencing resilience to load, injury prevention, and the long-term sustainability of performance [1].

The importance of individual components of physical fitness may vary depending on the specific type of military activity. Endurance abilities are particularly crucial for prolonged load, movement, and operations in demanding terrain, whereas strength abilities are required for handling equipment, overcoming obstacles, or performing tasks requiring short-term maximal effort. Most military activities require a combination of these components, and their optimal development represents a fundamental prerequisite for operational readiness [1].

The annual physical fitness assessment in the Czech Armed Forces serves not only as a tool for verifying compliance with prescribed performance standards, but also as an indicator of the long-term development of physical condition. Soldiers are evaluated based on their performance in individual tests, with assessment criteria adjusted for sex and age. Its advantages

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include standardization and long-term continuity, enabling the monitoring of performance development over time and across different groups. However, it is also necessary to consider that norm-based evaluation may lead to a certain simplification of result interpretation, particularly when performance is not assessed in relation to individual potential or training history. The issue of physical fitness is also linked to broader population trends. Several studies have reported changes in physical fitness and body composition in the general population, which may also be reflected in the initial fitness levels of candidates for military service [2, 3, 4]. These trends are not uniform and vary by the specific fitness component considered–while some parameters show stagnation or decline, others remain stable or show slight improvement [3]. Similar tendencies have been observed within the Czech Armed Forces, where certain components of physical fitness show a slight decline, although the overall trend remains unclear [5].

The University of Defence combines study programmes with different professional orientations, which may be reflected in differences in the physical fitness profiles of students from individual faculties. These differences may arise not only from initial fitness levels, but also from the nature of the academic workload, the structure of instruction, and the degree of involvement in practical training. Nevertheless, all students are assessed according to identical annual physical fitness assessment standards, differentiated only by sex and age. The question remains whether the results of the annual assessments differ between faculties and whether such differences can be interpreted in relation to the specific characteristics of the academic workload and training.

In addition to between-group comparisons, it is also relevant to examine the temporal development of physical fitness during the study. Adaptation to the military and academic environment may be associated with both improvements and temporary declines in performance, depending on the combination of training stimuli, overall load, and individual motivation. A longitudinal approach, therefore, enables a better understanding of the dynamics of changes in physical fitness and the identification of critical periods that may be essential for intervention.

The aim of this study is to analyse and compare the results of the annual physical fitness assessment among students of the Faculty of Military Leadership (FML), the Faculty of Military Technologies (FMT), and the Military Faculty of Medicine (MFM) in the period 2022–2025, with a focus on endurance and strength components of physical fitness. The analysis is designed as a longitudinal study, allowing the assessment of both differences between faculties and the development of performance over the course of the study. Particular emphasis is placed on identifying potential differences between faculties across specific types of disciplines and on capturing the dynamics of changes between academic years.

Special attention is paid to the transition between the first and second year of study, which, based on preliminary analysis, appears to be a key period in terms of performance changes across the observed disciplines. This phase is associated with adaptation processes to new academic and training conditions and may be characterized by varying trends in endurance and strength abilities, including a possible temporary decline or improvement in performance depending on the individual response to load [2, 6]. Therefore, the study focuses not only on the comparison of absolute performance, but also on a detailed analysis of changes between individual years, with particular emphasis on the first two years of study. This approach allows for a better understanding of the mechanisms underlying the development of students' physical fitness and the identification of critical periods relevant for optimizing physical training.

2. Data and Methods

The analysis is based on data from annual physical fitness assessments of University of Defence students from three faculties (FML, FMT, MFM) conducted between 2022 and 2025. Only students with four repeated measurements were included to examine performance development across individual years of study. For a more detailed analysis of performance changes between the first and second year of study, repeated measurements, including all transitions of students from the first to the second year across the observed period, were used, regardless of the year of enrolment.

All valid data were included in the overall analysis, and all analyses were performed separately for males and females. The assessment consisted of a test battery comprising strength and endurance disciplines, with both males and females completing one strength and one endurance test. Endurance was evaluated using the 12-minute run (Cooper test), with distance covered (m) recorded, while the strength component was assessed by the maximum number of pull-ups (overhand grip) for males and the flexed-arm hang (overhand grip) for females (s).

The analysis combined descriptive and inferential approaches to identify basic trends and differences in physical fitness across the observed groups (faculties). Differences between faculties were assessed using the Kruskal-Wallis test. Given the longitudinal nature of part of the data, changes in performance over time were also analysed using repeated measurements, tracking the same individuals across the first four years of a five-year study programme.

Based on the results obtained, changes in performance between the first and second year were analysed in greater detail using repeated measurements. Due to the violation of normality assumptions, the non-parametric Wilcoxon signed-rank test was used to determine statistically significant differences. Transition diagrams were used to visualise changes in performance between the first and second year. In this study, the analysis was primarily conducted using raw measured values. Recoding into performance categories based on age-specific standards was applied only for the construction of transition diagrams illustrating changes in performance between the first and second year of study. The standards and assessment criteria used are presented in Table 1. The analysis included results of students in the age category up to 30 years for males and up to 25 years for females from three faculties: the Faculty of Military Leadership (FML; 853 males, 271 females), the Faculty of Military Technologies (FMT; 611 males, 96 females), and the Military Faculty of Medicine (MFM;

133 males, 117 females). Only records corresponding to assessment results obtained within the standardized testing process in accordance with the applicable regulations of the Ministry of Defence were included in the analysis [7].

Table 1.

Standards and Evaluation of the Annual Assessment

Males						
Test	Pull-ups (overhand grip)			12-minute run (Cooper test)		
Rating	1	2	3	1	2	3
Age Category	Repetitions			Meters		
up to 30 years	12	10	8	3000	2800	2600
Females						
Test	Flexed-arm hang (overhand grip)			12-minute run (Cooper test)		
Rating	1	2	3	1	2	3
Age Category	Minutes: seconds			Meters		
up to 25 years	0:50	0:30	0:10	2550	2300	2100

Legend: Rating scale: 1 – excellent, 2 – good, 3 – satisfactory.

3. Results

Descriptive statistics of performance in the 12-minute run (Cooper test), the maximum number of pull-ups (overhand grip) for males, and the flexed-arm hang (overhand grip) for females, by faculty and for the overall sample, are presented in Table 2. Comparison of performance between faculties using the Kruskal-Wallis test did not reveal statistically significant differences in running performance for either males ($\chi^2 = 4.84$; $p = 0.089$) or females ($\chi^2 = 5.68$; $p = 0.058$). A statistically significant difference between faculties was found only among males in the pull-ups discipline ($\chi^2 = 39.15$; $p < 0.001$). Post hoc analysis revealed differences between all pairs of faculties, with the highest values observed at the Military Faculty of Medicine (MFM), followed by the Faculty of Military Leadership (FML) and the Faculty of Military Technologies (FMT). For females, no statistically significant differences between faculties were found in the flexed-arm hang discipline ($\chi^2 = 4.72$; $p = 0.095$).

Table 2.

Descriptive statistics of running and muscular endurance performance by faculty and gender

	Faculty	N	Mean	Median	SD	SE	Min	Max
Cooper test (males)	FML	844	2822.1	2790	174.9	6	2250	3650
	FMT	607	2803.4	2765	168.9	6.9	2360	3490
	MFM	131	2834.9	2787.5	214.4	18.7	2400	3342.5
	Total	1582	2816	2780	176.5	4.4	2250	3650
Pull-ups (males)	FML	852	12.9	12.3	4.5	0.2	0	33
	FMT	607	11.7	11	4.2	0.2	2	25
	MFM	131	13.7	13.5	4.3	0.4	1	25
	Total	1590	12.5	12	4.4	0.1	0	33
Cooper test (females)	FML	264	2479.8	2450	160.3	9.9	1970	3080
	FMT	96	2441.9	2400	165.6	16.9	2000	3150
	MFM	116	2452.9	2437.5	207.5	19.3	2000	3125
	Total	476	2465.6	2437.5	174.3	8	1970	3150
Flexed-arm hang (females)	FML	269	29.5	27	12.3	0.7	5	69
	FMT	94	26.5	25	11	1.1	5	60
	MFM	112	31.3	30.3	15.9	1.5	6	63.5
	Total	475	29.3	27	13.1	0.6	5	69

Legend: FML – Faculty of Military Leadership, FMT – Faculty of Military Technologies, MFM – Military Faculty of Medicine; N – Sample size; SD – Standard deviation; SE – standard error

To provide a clearer understanding of how student performance changes during study, descriptive statistics were calculated for both disciplines for students with continuous measurements available from the first to the fourth year (Table 3). Mean values for each year are presented in Figure 1. The figure illustrates differences in the development of average performance across test type, sex, and faculty affiliation. In the endurance test (Cooper test), a slight decrease in performance can be observed among males in the second year, most pronounced at the Faculty of Military Leadership (FML), followed by a gradual improvement in the third and especially the fourth year. As a result, FML achieves the highest values overall. For the Faculty of Military Technologies (FMT), a gradual decline in average performance is evident until the third year,

followed by a slight improvement. The Military Faculty of Medicine (MFM) remains relatively stable. For females, the development in the Cooper test shows a different pattern. FML demonstrates a gradual but continuous increase in performance across all years. In contrast, FMT shows a marked decline in the second and third years, followed by a noticeable improvement in the fourth year. MFM reaches its highest value in the third year, but a decline is observed in the fourth year. In the strength discipline for males (pull-ups), a clear increase in average performance is observed across all faculties. This trend indicates a systematic development of strength abilities during study. For females, the flexed-arm hang test shows a very similar pattern for FML and FMT, with both faculties demonstrating a slightly increasing trend. Unfortunately, MFM cannot be evaluated due to missing data in the third and fourth years.

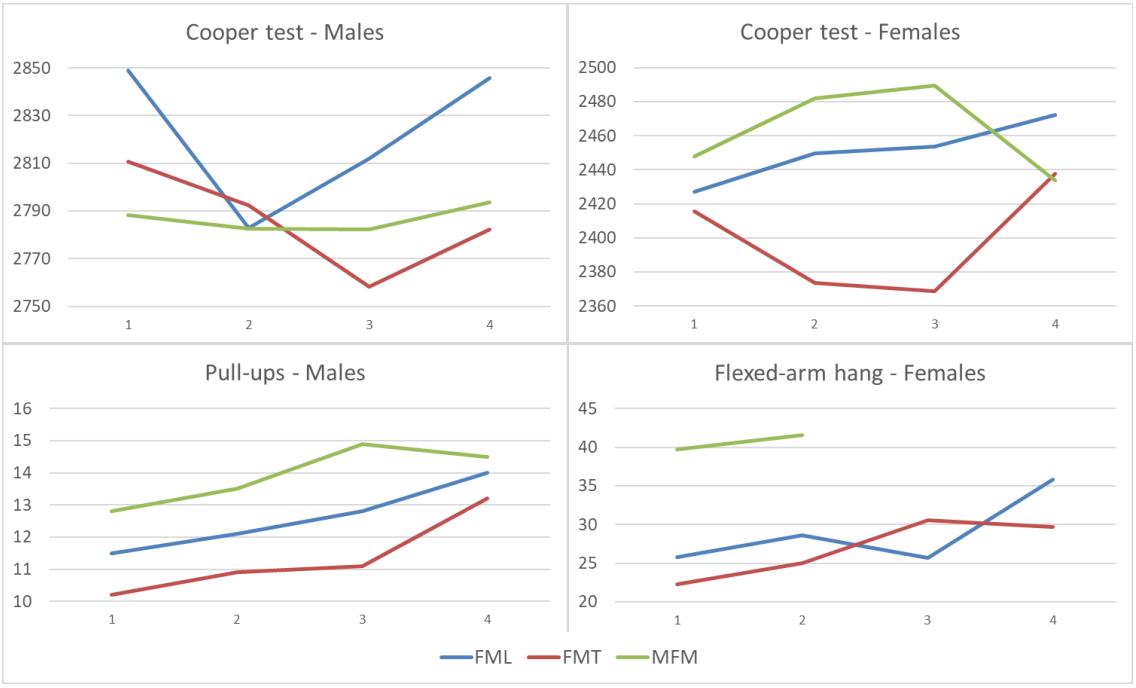

Fig. 1. Development of mean performance across the first four years of study for males and females in selected disciplines (12-minute run (Cooper test), pull-ups for males, flexed-arm hang for females) by faculty (FML, FMT, MFM). Data are presented as mean values calculated from annual physical fitness assessment results.

Table 3.

Descriptive statistics of running and muscular endurance performance by faculty, gender, and year of study.

		Males						Females					
		Cooper test			Pull-ups			Cooper test			Flexed-arm hang		
Faculty	Year	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD
FML	1	2849	2840	176.7	11.5	11	4.2	2427.1	2360	153.6	25.8	24.5	8.3
N=105; 24	2	2782.9	2770	148.1	12.1	11	3.9	2449.8	2400	165.9	28.6	25	11.3
	3	2812.1	2800	162.5	12.8	12	3.8	2453.8	2395	169.8	25.7	25	9.3
	4	2845.9	2830	167.2	14	14	4.3	2472.1	2400	220.1	35.8	32.6	12.9
FMT	1	2810.7	2800	156.3	10.2	10	3.4	2415.7	2400	94.5	22.3	20	10.2
N=53; 7	2	2792.3	2800	168.8	10.9	10	3.2	2373.6	2375	68.7	25	25	6.7
	3	2758.3	2725	152.8	11.1	10	3.8	2368.6	2350	78	30.6	30	9.8
	4	2782.4	2740	169.3	13.2	12	4.3	2437.9	2400	105.4	29.7	30	9.1
MFM	1	2788.3	2750	162.3	12.8	13	4.1	2447.9	2400	179.5	39.7	38.5	14.7
N=23; 14	2	2782.6	2800	207.6	13.5	14	4.1	2482.1	2475	143.6	41.6	40.5	16.2
	3	2782.4	2700	202.1	14.9	16	4	2489.3	2475	154.6	-	-	-
	4	2793.5	2700	201.9	14.5	16	4.3	2433.6	2400	170.5	-	-	-

Legend: FML – Faculty of Military Leadership, FMT – Faculty of Military Technologies, MFM – Military Faculty of Medicine; N – Sample size for males and females; SD – Standard deviation.

Further analysis focused on changes between the first and second year of study. The most pronounced changes in performance across the observed disciplines occur during this period. Graphical analysis suggests that the transition from the first to the second year is characterized by dynamic development, including both improvements and potential declines in performance. This phenomenon can be interpreted as a result of adaptation processes associated with entry into the university and military environment. Students face changes in daily routine, increased demands on time management, and regular

physical training. For some individuals, this transition results in rapid improvement, particularly in strength abilities, whereas others may experience a temporary decline, for example, due to overall load or changes in training conditions. Focusing the analysis on the first two years thus makes it possible to capture the most sensitive phase of performance changes while working with a relatively homogeneous group of students, in which more pronounced selection or differentiation due to specialization has not yet occurred. This approach also has practical relevance, as the identification of statistically significant changes in the early stage of study may serve as a basis for optimizing physical training and supporting student adaptation to the demands of military higher education.

The results of the Wilcoxon signed-rank test indicated only partial statistically significant changes between the first and second year. From the perspective of individual faculties, changes were observed primarily among males from FML (N = 388) and FMT (N = 205), where a statistically significant decrease in endurance performance was detected (FML: $z = 5.726$; $p < 0.001$; FMT: $z = 4.323$; $p < 0.001$), along with a statistically significant increase in strength performance measured by the number of pull-ups (FML: $z = -6.456$; $p < 0.001$; FMT: $z = -5.715$; $p < 0.001$). For females, statistically significant changes were observed in FML (N = 100) and MFM (N = 43). Specifically, an improvement in flexed-arm hang performance was found in FML ($z = -2.038$; $p = 0.042$) compared to the first year, as well as an improvement in the endurance discipline – the 12-minute run (Cooper test)—in MFM ($z = -2.479$; $p = 0.013$). For a more detailed assessment of changes in performance classification between the first and second year, transition diagrams were used, based on transition matrices of individual performance categories. These diagrams allow for a clear visualization of not only the overall trend of changes, but also the direction and frequency of transitions between individual categories (1 – excellent, 2 – good, 3 – satisfactory), including distinctions between improvement, decline, and stability of performance. For clarity and interpretability, only diagrams corresponding to cases with statistically significant changes between the first and second year are presented in this study. The results for males are shown in Figure 2.

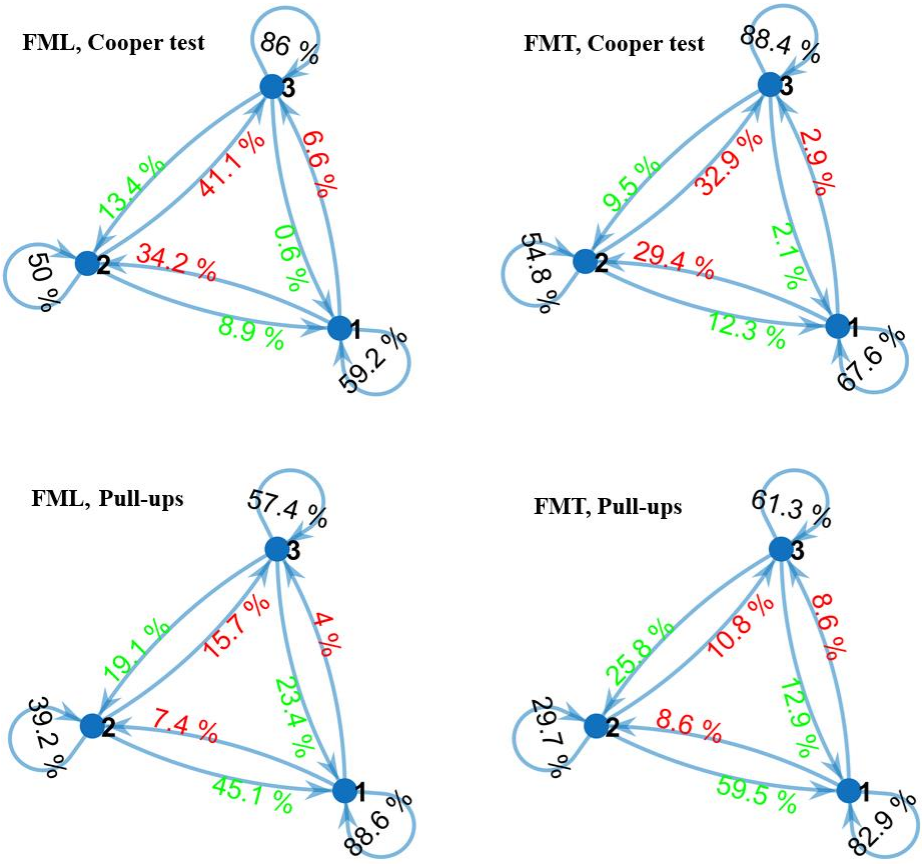

Fig. 2. Transition diagrams between performance rating categories (1 – excellent, 2 – good, 3 – satisfactory) for males from the first to the second year. Values on the arrows represent the relative proportion of transitions within the initial category (%); green arrows indicate improvements in performance, red arrows indicate declines, and loops represent stability within the same category.

Based on the transition matrices for males, the endurance discipline (12-minute run, Cooper test) shows a predominance of performance stability. The highest retention rates were observed in category 3 (FML: 86.0%; FMT: 88.4%). At the same time, transitions toward performance decline are more frequent than those toward improvement. This trend is particularly evident among students initially classified in category 2, where a substantial shift toward category 3 is

observed. Transitions from category 1 to lower categories are less frequent but also contribute to the overall declining trend. Overall, the transition diagrams confirm a tendency toward decreased endurance performance between the first and second year, consistently across both faculties. In contrast, the strength discipline shows a different pattern. Transition matrices indicate high stability in category 1 (FML: 88.6%; FMT: 82.9%), corresponding to a good level of strength performance. Notable shifts are also observed from category 2 to category 1 (FML: 45.1%; FMT: 59.5%), as well as from category 3 to categories 1 and 2. These results indicate an overall increase in strength performance between the first and second year, with improvements observed in both average and lower-performing students.

Transition matrices for females show that students from MFM in the endurance discipline (Cooper test) predominantly remain in category 1 (82.4%) and category 2 (55.0%). At the same time, transitions toward performance improvement are evident, particularly from category 3 to category 2 (66.7%) and from category 2 to category 1 (30%), while transitions toward decline are less frequent. Overall, these results suggest a slight improvement in endurance performance. In the strength discipline (flexed-arm hang) for FML females, high stability is observed, particularly in categories 3 (83.6%) and 2 (66.7%). However, transitions from category 2 are more often directed toward decline (26.7%) than toward improvement (6.7%), while transitions from category 3 to categories 2 and 1 are rare. This pattern indicates rather stagnation or a slight decline in performance in a subset of female students.

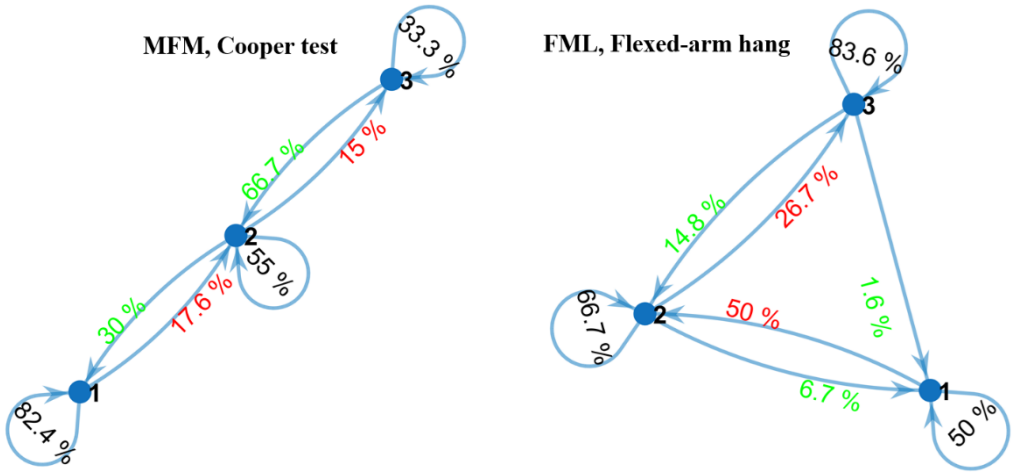

Fig. 3. Transition diagrams between performance rating categories (1 – excellent, 2 – good, 3 – satisfactory) for females from the first to the second year. Values on the arrows represent the relative proportion of transitions within the initial category (%); green arrows indicate improvements in performance, red arrows indicate declines, and loops represent stability within the same category.

4. Discussion and Conclusions

The results of the study indicate that the physical fitness of students at the University of Defence, as assessed through annual physical fitness assessments, does not differ significantly across faculties in the endurance component (Cooper test). Statistically significant differences between faculties were found only among males in the strength discipline (pull-ups). These findings suggest that the influence of study specialization and the nature of training may be more strongly reflected in the development of strength abilities than in aerobic performance. One possible explanation is the different sensitivity of individual components of physical fitness to training stimuli. While endurance abilities tend to be relatively stable and can be maintained even with lower-intensity or non-specific physical activity, the development of strength abilities is more dependent on targeted and sufficiently intense loading [8]. Even relatively small differences in training, availability of strength-oriented preparation, or individual approaches to conditioning may therefore be more pronounced in strength disciplines, which is consistent with the high variability of adaptive responses to training described in the literature [9]. Previous research in the military environment further indicates that standardized training and testing may lead to different adaptive responses depending on initial fitness level, with fitter individuals potentially experiencing stagnation or even a decline in performance [6]. The specific position of the Military Faculty of Medicine (MFM), which achieved the highest values in the strength discipline, may be related to a combination of several factors. One of these could be a selection effect, where students of this faculty may enter the programme with a different physical fitness profile or with higher intrinsic motivation for individual training.

The findings of the longitudinal analysis further indicate that the development of physical performance during the study is not linear and varies by discipline type, sex, and faculty affiliation. While strength performance for males shows a clearly increasing trend across all faculties, endurance performance develops less consistently and, in some cases, exhibits a temporary decline. This trend can also be interpreted in the context of current approaches to physical training, where strength-oriented training modalities represent dominant directions [10]. The greater availability and popularity of strength training may therefore contribute to more favourable development of strength abilities during study. At the same time, this development can be

interpreted considering the so-called concurrent training effect, which describes the interaction between the development of strength and endurance capacities. Although both components can be developed in parallel to some extent, a higher volume or intensity of endurance training may limit the development of muscle strength and hypertrophy, thereby modifying the resulting progression of physical performance [11]. For females, the development of strength abilities showed a slightly increasing trend in FML and FMT. The development of endurance performance for females also depends on faculty affiliation. At the Faculty of Military Leadership, a gradual but continuous increase in performance across all years is observed, indicating a stable adaptation process. In contrast, the Faculty of Military Technologies shows a decline in performance between the first and third year followed by improvement in the fourth year, which may indicate delayed adaptation or a temporary period of increased load. At the Military Faculty of Medicine, performance increases up to the third year followed by a decline in the fourth year, which may be related to increased academic and practical demands in the final stage of study. Overall, these findings confirm that the development of endurance performance for females is variable and strongly influenced by the specific characteristics of the study programme.

While the final stage of study is generally associated with increased time demands and psychological load, in some study programmes this phase may also be accompanied by higher levels of physical activity. In technically and military-oriented programmes (particularly FML and partly FMT), practical training in higher years includes field training, specialized courses, and internships, which are physically demanding and may contribute to the maintenance or further development of strength abilities. This factor is consistent with the observed trend, particularly among males, which involves a gradual improvement in performance in strength disciplines over the years, as well as a significant increase in endurance performance during the fourth year of study at the FML.

In contrast, in programmes with a predominance of clinical or professional practice (typically medical-oriented), the physical demands are of a different nature. Such practice may involve long shifts, prolonged standing, night duties, and overall fatigue, but without systematic loading leading to the development of physical fitness. This type of load may result more in the accumulation of fatigue than in a training effect. In such cases, stabilization or even a decline in physical performance can be expected, particularly if there is a concurrent reduction in opportunities for targeted physical training. This mechanism may also explain the greater variability in performance observed among MFM students.

Special attention in this study was paid to the transition between the first and second year, which proved to be a critical period in terms of performance changes. The results suggest that during this phase, some students experience a decline in endurance performance, while strength abilities may simultaneously improve. This phenomenon can be interpreted as a consequence of the adaptation process to new academic and training conditions, where increased overall load and changes in daily routine may temporarily negatively affect certain components of performance. Similar non-linear changes during training have been reported in previous studies [2,4]. One possible explanation may also lie in changes in motivational factors. Students of the Faculty of Military Leadership complete a common general foundation during the first three semesters, after which they are assigned to specializations based on academic performance and physical fitness level, which also includes the annual physical fitness assessment. Based on the results achieved, a ranking is created that subsequently influences the choice of specialization. The annual assessment is conducted predominantly in May and June, i.e., at a time when second-year students have only recently been assigned to their specialization.

From a practical perspective, the results of this study provide important insights for planning physical training during study. Identifying periods in which the most pronounced changes in performance occur allows for targeted adjustment of training load in order to minimize declines in the endurance component while simultaneously supporting a balanced development of individual abilities. The findings also highlight differences in the development of specific components of physical fitness, which may serve as a basis for modifying the structure and focus of physical training. In a broader context, these findings raise questions about the suitability of the assessment tools used. As some studies indicate, even commonly used strength tests may be subject to a certain degree of subjectivity and variability in evaluation, which can affect the interpretation of results [12]. Therefore, it is advisable to combine multiple types of tests when assessing physical fitness and to strive for the highest possible level of objectivity and standardization of measurement. However, the interpretation of the results should be considered in the context of the study's methodological limitations, which are discussed in more detail in a separate section.

Limitations. When interpreting the results, it is necessary to consider the limitations arising from the nature of the study, which is based on the analysis of administrative data from routine testing. The results may have been influenced by factors that could not be systematically monitored, particularly motivation, health status, training history, and performance strategy. Moreover, the norm-based nature of the annual physical fitness assessment may not fully reflect the maximum physical potential of individuals, especially among students with higher fitness levels. The study is also limited to selected test disciplines and does not provide a comprehensive assessment of physical fitness. Another limitation is the lack of detailed information on individual physical activity, training load, and lifestyle, as well as the inability to more precisely account for differences in academic and practical workload between faculties. An additional limitation is the unequal representation of the studied groups, particularly the lower number of students from the Military Faculty of Medicine (MFM) and the overall lower proportion of females within the University of Defence.

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