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Evaluating Trends in Cardiorespiratory Fitness Among Physiotherapy Students: A 15-Year Cross-Sectional Study (2007-2023)

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Background. Cardiorespiratory fitness (CRF) is a key health indicator, particularly for physiotherapy students who are expected to model healthy behaviors.

Objectives. The objective of the study was to analyze CRF trends among physiotherapy students over the period from 2007 to 2023 and to assess variations in maximal oxygen uptake (VO_2max) across gender and body mass index (BMI) categories.

Materials and Methods. Secondary data from 2007–2009 and 2010–2012 were compared with primary data collected in 2022–2023. CRF was measured using a submaximal Monark Ergomedic 839E cycle ergometer test in 242 students (aged 18–25 years). Statistical analyses included t-tests, ANOVA, and non-parametric tests ($p < 0.05$). The Kruskal-Wallis test was used for between-group comparisons and Spearman's correlation — to assess trends over time.

Results. Over half of male (52%) and female (63%) participants had CRF levels below the reference values. Female students showed a significant VO_2max decline in 2022–2023 compared to 2007–2009 (mean difference = 1.78 ml/min/kg, $p < 0.05$), while no trend was observed in males. Students with BMI > 25 kg/m² had significantly lower VO_2max than those with BMI ≤ 25 kg/m² ($p < 0.05$).

Conclusions. These findings highlight the need for targeted fitness programs for female students and those with elevated BMI. Future research should explore lifestyle factors and intervention strategies to improve CRF in students. This study provides foundational data for future research on the relationship between CRF, clinical skills, and patient satisfaction among physiotherapy students.

Keywords: cardiorespiratory fitness, maximal oxygen uptake, physiotherapy students, submaximal cycle ergometer test.

Introduction

The understanding of good health practices and the development of skills required to maintain physical fitness are becoming increasingly important in modern society due to their strong connection with self-realization and overall well-being (Alparslan et al., 2024; Klussman et al., 2021; Wong et al., 2021). Cardiorespiratory fitness (CRF) is widely recognized as a crucial determinant of general health and physical work capacity (Raghuveer et al., 2020). CRF refers to the capacity of the circulatory and respiratory systems to supply oxygen during sustained physical activity (PA) (Raghuveer et al., 2020) and is commonly measured using maximal oxygen uptake (VO_2 max). This metric serves as a measure of the functional capacity of both the respiratory and cardiovascular systems. It encompasses several processes, including ventilation, perfusion, gas exchange, vasodilation, and oxygen delivery to body tissues. As an integrated physiological trait, CRF reflects the coordinated function of various body systems to support muscle activity during prolonged, rhythmic, and large muscle group-involving physical exertion (Harber et al., 2017). CRF is a key marker of physical health, associated with a reduced risk of chronic diseases and lower mortality rates (Lang et al., 2024). A lack of PA contributes to the deterioration of health across multiple bodily systems (Fernström et al., 2017; Isath

et al., 2023), increasing cardiovascular risk factors such as elevated body mass index (BMI), fat percentage, and blood pressure (Chaabna et al., 2022). Low CRF levels have been linked to an elevated risk of coronary heart disease and mortality (Salier Eriksson et al., 2021). Moreover, it serves as a predictor of well-being and longevity. Despite its importance, studies highlight that many individuals, particularly students, demonstrate poor CRF levels (Ali et al., 2020; Sovová et al., 2020).

Healthcare professionals are strongly encouraged to improve their CRF, as those who enhance their own fitness levels are better positioned to guide others on maintaining physical fitness (Mandsager et al., 2018). Students enrolled in health programs have opportunities to explore the scientific foundations of maintaining an active lifestyle (Ali et al., 2021), fostering self-management skills essential for sustaining fitness (García-Suárez et al., 2022). For physiotherapists, maintaining optimal CRF is critical, as physical fitness not only reduces the risk of injury but also enhances work efficiency within healthcare professions (Al-Khlaifat et al., 2024; Tišlar et al., 2022). Beyond meeting the physical demands of their roles, CRF enables physiotherapists to serve as role models for a healthy lifestyle to their patients (Maldonado-Alicea et al., 2024). A study conducted in Poland suggests that improvements in the physical fitness of physiotherapy students may be associated with greater awareness of job requirements and prevailing fitness trends (Lewandowski et al., 2020). Emphasizing health- and skill-related physical fitness among physiotherapy students benefits both their personal health and injury prevention while ensuring their long-term ability to meet professional demands (Al-Khlaifat et al., 2024).

Maintaining adequate CRF is vital for these future professionals to safeguard their well-being, prevent occupational injuries, and provide effective patient care. This study differs from previous research by specifically examining the longitudinal trends in CRF among physiotherapy students over a 15-year period, offering a unique perspective on how fitness levels have evolved within this population. The objective of the study was to analyze CRF trends among physiotherapy students over the period from 2007 to 2023 and to assess variations in VO_2 max across gender and BMI categories.

Materials and Methods

This study used a repeated cross-sectional research design to assess the CRF of physiotherapy students. This design was chosen because it allows for the comparison of different cohorts over time using consistent methodology, enabling the identification of population-level trends in cardiorespiratory fitness without the need to follow the same individuals longitudinally.

Participants and Ethics

The study included first- and second-year students in Latvia (n = 263 (41 male)), enrolled in a four-year "Physiotherapy" bachelor's study program at university. The open method was used to select the sample. All students of physiotherapy programs were invited to participate in the study. The sample group included physiotherapy students who were in the first years of their studies and had learnt strategies for evaluating and developing CRF as part of their study program. One set of measurements was taken for each student. Second-year students who had already been tested in the previous year were excluded from testing in their second year. Inclusion criteria included both male and female physiotherapy programs students aged 18-25 years old who have no contraindications to participate in PA and agreed to participate in the study. Exclusion criteria were also defined. According to these criteria, students who had experienced an acute illness within the last month and who used medication that can affect cardiorespiratory function were excluded due to possible the effects of these factors on the measurement data. Pregnant women were also excluded due to possible medical complications, as the tests predict an increased physical load. Top-level athletes participated in the test as part of their education program, but their data were not included in this study as their aerobic capacity should be viewed in the context of the specifics of their sport and does not correspond to average indicators. The study compared secondary data available from 2007 to 2012 with data collected in 2022 and 2023. The secondary data (university data base 2007-2012 on secure servers, accessible only to authorized research team members from 1.04.2022. Authors hadn't access to information that could identify individual participants) were divided into three-year periods and analysed to compare these periods allowing for the examination of valuable insights into long-term trends in the studied variables. The minimum sample size was determined to be 157 students through a power analysis with a 95% confidence level and a 5% margin of error. The final sample consisted of 242 students, which exceeds this threshold, ensuring the statistical validity of the results. Data collection in 2022 and 2023. The participants recruitment and data collection period lasted from 1 April 2022 and concluding on 1 December 2023. Participation in the study was voluntary and anonymous, with participants being informed that their data would be used solely within the framework of this research. The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Riga Stradins University (Protocol No. 2-PĒK-4/163/2022, 16 March 2022. Prior to the study, participants provided written informed consent, ensuring they were aware of the study's purpose and the intended use of their data. Also participants provided informed consent, confirming their eligibility, willingness to follow instructions, and the right to withdraw from the study at any time without explanation or penalties. No minors participated in this study, and all participants were competent adults who voluntarily consented to partake. Confidentiality was strictly maintained, all data anonymized and securely stored to protect participant privacy. Data was encrypted and stored on secure servers, accessible only to authorized research team members (Veseta et al., 2023). Authors declare there are no conflicts of interests, acknowledging all financial and any other relevant financial or nonfinancial competing interests.

Procedure

Prior to the study, participants were informed about CRF, the submaximal test, its procedure, and potential

contraindications. They were given preparation guidelines, including consuming the last meal at least 3 hours before the test, abstaining from smoking for at least 3 hours prior to the test, avoiding intense PA for 24 hours before the test, and wearing comfortable sports clothing and footwear. In cases of participant withdraw, any identifiable data would be immediately deleted to uphold their privacy rights. To assess the students' CRF, participants' weight and height were measured at an accuracy of 0.1 kg and 0.5 cm and their BMI was calculated. The Monark Ergomedic 839E cycle ergometer submaximal exercise test was used to estimate VO_2 max data for the physiotherapy students. This test methodology has previously been compared with direct VO_2 max measurements and has shown the smallest margin of error and the strongest correlation with direct gas analysis, regardless of participants' sex, age, fitness level, or of PA frequency (Liepiņa L. et al., 2013). Participants' data, including age, date of birth, gender, height, and weight, were entered into the Monark Ergomedic 839E cycle ergometer program. A heart rate (HR) belt was attached to each participant's chest and transmitted data to the Monark Software 2.5.

1. The test was performed following these steps:
2. The participant was informed about the test process.
3. The seat height was adjusted.
4. The pedaling speed was set to 60 RPM, and the participant was instructed to maintain this speed.
5. The test began with a 5-minute warm-up, during which the participant adjusted to pedaling.
6. Finally, the data transmitted from the HR belt to the Monark software was checked.

The test consisted of three 4-minute exercise periods, with stepwise increases in load. Based on the entered data, the Monark software determined the appropriate test load and predicted the heart rate range for the test. The software displayed each load in watts (W) and the recommended HR range. The next load was automatically applied by the software, with increments of about 25-50 W between each test, such that the final HR load reached about 80% of the maximum HR. Maximum HR was calculated using the formula: 220 – participant's age. If the participant's HR exceeded the predicted value during the test, the load was reduced to bring the HR back within the recommended range. If the HR was too low, the load was increased.

The criteria for discontinuing the test were as follows:

1. An incomplete test;
2. A participant expressed desire to stop participating in the study;
3. Technical problems occurred during the test.

The Monark software calculated the maximum load the participant manage with their maximum HR considering all three loads and the HR at the end of each load, and calculated the respective maximum oxygen consumption using the following formula:

$$W_{max}\ (W) = 3\ .load\ (W) + \left[(max\ HR^* - HR\ 3.load) * \frac{3.load\ (W) - \frac{1.load\ (W) + 2.load\ (W)}{2}}{HR\ 3.load - \frac{HR\ 1.load + HR\ 2.load}{2}}\right]$$

$$VO_2 max = \frac{W_{max}\ (W) * 12{,}48 + 217}{weight\ (kg)}$$

VO_2 max was expressed as body weight in kilograms and was evaluated according to Shvartz and Reibold's normative data (Shvartz & Reibold, 1990).

Following the cycle ergometry test, the data from participants who did not complete the test or experienced technical problems during the test were excluded from the analysis. The test procedure is shown in the flow chart below (Fig. 1).

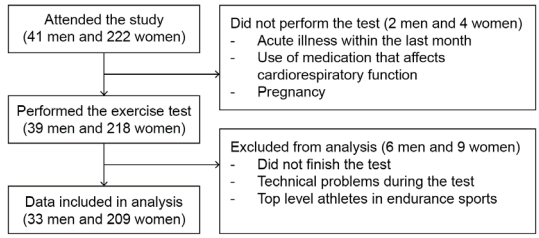

Fig. 1. Flow chart of the test procedure

Statistical Analyses

Statistical data analysis was performed using SPSS Statistics v. 29.0 (IBM Corporation, USA) with the significance level set at $p < 0.05$. The analysis included descriptive statistics for the whole sample and was stratified by gender in all cases. The results are presented as the mean value with standard deviation. The Kolmogorov-Smirnov test was performed to assess the normality of the distribution of continuous variables. The significance level for the Kolmogorov-Smirnov test was set at $p < 0.05$. Due to the Gaussian distribution, ANOVA tests were used to assess differences in height and weight at three-year intervals, as well as differences in the VO_2 max of the female students in the three BMI groups. The Levene's test for equality of variances was used to test homogeneity of age, weight, height, BMI and the VO_2 max. An independent samples t-test assuming the equal variances was used to assess differences in age, height, weight, BMI, and VO_2 max between the male and female participants, as well as inequalities in the VO_2 max values between males in the normal and elevated BMI groups. As the distribution of VO_2 max in the groups stratified by year of testing was not Gaussian, inequalities in VO_2 max within these groups were assessed using the Kruskal–Wallis test. Associations between the VO_2 max and age, height, weight and BMI values were assessed using the Pearson correlation test for parameters with Gaussian distribution or the Spearman correlation test for those with non-Gaussian distribution.

Results

A total of 242 students met the inclusion criteria for the study, and their data were considered valid for the analysis. The majority of the study population (89%) were female. The physical characteristics, as well as the predicted VO_2 max, of the males and females participants included in the study, are presented in Table 1. The Levene's test for equality of variances was not significant ($p > 0.05$), indicating that the assumption of equal variances was met. Consequently, a t-test assuming equal variances was used to compare the variables between males and females.

Table 1. The physical characteristics and calculated VO_2 max of the male and female participants.

	Males (n = 33)		Females (n = 209)		Levene's Test (F, p-value)	t-test of sex group differences (Equal Variances Assumed)
	M	SD	M	SD		
Age (years)	21.1	1.7	21.0	1.4	F = 1.538, p = 0.216	t = 0.295, p = 0.768
Height (cm)	181.4	6.3	168.8	5.7	F = 1.344, p = 0.248	t = 11.517, p < 0.001
Weight (kg)	75.7	9.4	62.2	9.3	F = 0.152, p = 0.697	t = 7.803, p < 0.001
BMI (kg/m^2)	23.0	2.4	21.8	3.0	F = 1.917, p = 0.167	t = 2.154, p = 0.032
VO_2 max(ml/min/kg)	44.0	6.3	35.2	5.0	F = 1.740, p = 0.188	t = 9.069, p < 0.001

* p of group differences due to independent-samples t-test

There was no difference in age between the two sex groups, while the heights, weights and BMIs of the female participants were lower the males'. The female participants had a 20% lower VO_2 max than the males (35.2 ± 5.0 ml/min./kg vs. 44.0 ± 6.3 ml/min./kg).

The distribution of VO_2 max for males had a skewness of -0.080 (standard error = 0.49) and a kurtosis of 0.098 (standard error = 0.80), and female data had a skewness of 0.114 (standard error = 0.168) and a kurtosis of -0.126 (standard error = 0.335), indicating a nearly symmetrical and slight mesokurtic distribution consistent with normality.

The most recent normative data on the VO_2 max of the European population, measured using the cycle ergometry test, have been derived from the results of exercise testing in the USA, Canada, and seven European countries (Shvartz & Reibold, 1990). The VO_2 max values obtained for the physiotherapy students were classified according to evaluation classes for their respective age groups (Fig. 2).

In this study, 30% of the male participants and 24% of the female participants had moderate VO_2 max values. Only 18% of the males and 12% of the females had good and very good VO_2 max values, while 52% of males and 63% of females had a lower than average VO_2 max, with 3% and 4% of the males and females, respectively, being in the very poor range (Fig 2 and 3).

To evaluate the differences in the VO_2 max values of students who entered the university program directly after secondary school and those who delayed their entry by a year or more, all of the students were divided into two age groups—18-20 and 21-25 years of age. The differences in the VO_2 max value were not statistically significant for both male and female students in these age groups.

To investigate whether there was a change in VO_2 max during the study period, the data were divided into 3-year time intervals corresponding to when the cycle ergometry tests were carried out. The characteristics of the participants in these ranges and the differences between them are detailed in Table 2.

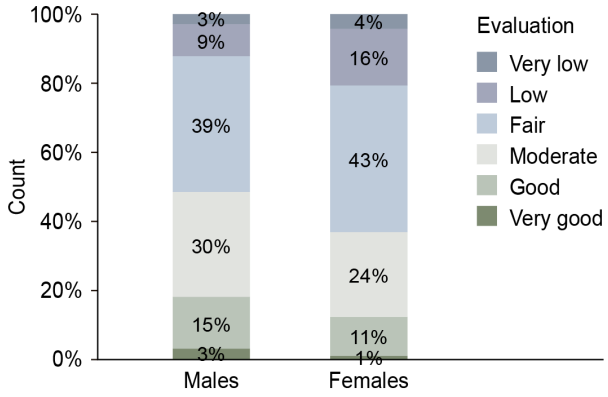

Fig. 2. Distribution of study population according to the evaluation of VO_2 max

The VO_2 max values for three periods were compared (Fig. 3 and 4). Over the entire testing period from 2007 to 2023, a decline in the VO_2 max values was observed for both sexes, but a statistical significance was found only for the female participants between years 2007-2009 and 2022-2023 (Fig 4 and 5). The proportion of women that had a below-moderate VO_2 max in 2007-2009 was 54 %, but in 2022-2023, this rose to 71 %.

The effect of BMI on the VO_2 max was determined by dividing all the students into groups with low (< 18.5 kg/m^2), normal (18.5-24.9 kg/m^2), and increased (>24.9 kg/m^2) BMIs (Fig 5 and 6).

Table 2. Characteristics of participants in three testing periods.

	2007-2009		2010-2012		2022-2023		p*
	M	SD	M	SD	M	SD	
Males	n = 9		n = 12		n = 12		
Height (cm)	181.2	5.56	180.1	7.6	182.9	5.7	0.562
Weight (kg)	77.3	8.4	74.8	11.4	75.5	8.4	0.827
Females	n = 76		n = 63		n = 70		
Height (cm)	169.3	6.2	168.9	4.7	168.3	6.1	0.590
Weight (kg)	61.5	7.9	62.1	9.1	62.9	10.8	0.646

* p of differences in measured parameters obtained using One-Way ANOVA test

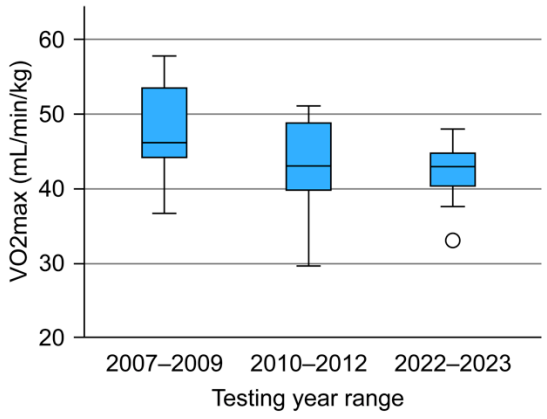

Fig. 3. Boxplot of the VO_2 max of male participants according to the testing year.

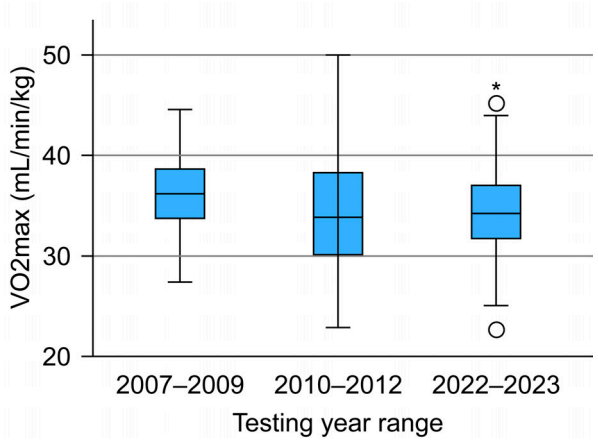

Fig. 4. Boxplot of the VO_2 max of female participants according to the testing year (* $p < 0.05$ vs year 2007-2009 according to the independent samples Kruskal–Wallis test)

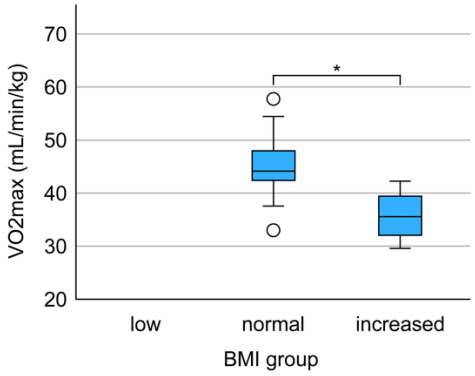

Fig. 5. Boxplot of the VO_2 max of male students in the three BMI groups (* $p < 0.05$ of difference between groups according to the independent samples t-test)

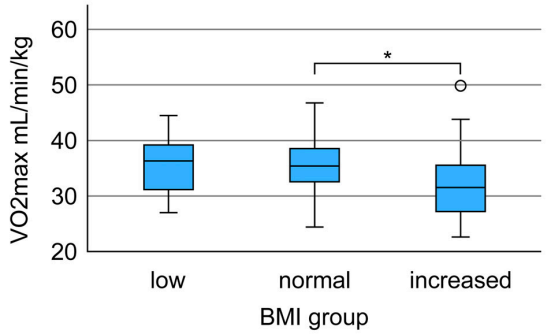

Fig. 6. Boxplot of the VO_2 max of female students in the three BMI groups (* $p < 0.05$ of difference between groups according to the one-way ANOVA with the Tukey post hoc test)

No correlations were observed between the VO_2 max calculated for the different age and height groups for both sexes, but there was a correlation between VO_2 max and BMI ($r = -0.362$ and $r = -0.319$ for males and females, respectively, $p < 0.05$). Students with an increased BMI in both sex groups presented lower VO_2 max than those with a normal BMI. There were no male participants with a low BMI, and male students with a BMI greater than 25 kg/m^2 had a 9.4 ml/min/kg lower VO_2 max on average than males with a normal BMI ($t_{(31)} = 3.162$; $p = 0.03$). Female students with an increased BMI had lower VO_2 max than those with a normal BMI, as demonstrated by the ANOVA test ($F_{(2, 206)} = 5.019$; $p = 0.007$). The post hoc comparisons using the Tukey HSD test indicated that the mean VO_2 max for females with an increased BMI ($M = 32.1$, $SD = 6.6$) was significantly different from that of those with a normal BMI ($M = 35.6$, $SD = 4.6$).

Discussion

The aim of this study was to investigate trends in CRF among physiotherapy students across three cohorts (2007-2009, 2010-2012, and 2022-2023) and assess differences in VO_2 max based on gender and BMI categories. The findings provide important insights into the fitness levels of physiotherapy students, particularly in light of their future roles in healthcare. Given that physiotherapists are expected to be role models for healthy living, understanding their CRF levels is essential not only for their personal health but also for their professional credibility in promoting healthy lifestyles. Moreover, the results shed light on potential impacts of the COVID-19 pandemic on students' fitness, with implications for long-term public health outcomes.

The results of this study show that the mean VO_2 max of the male participants in this study is similar to the Latvian data recorded for individuals who are engaged in high-intensity dynamic and medium–high-intensity static exercise for 300 minutes a week or more and participate in competitions, but is higher than that for those who train for less than 300 minutes a week (Rozenštoka & Ērglis, 2020). The mean VO_2 max of the females participants in this study was between that of both groups in the Latvian study. This study included participants who do not compete in sports competitions; thus, the summary data may be lower than those for the athletes participating in the Latvian study.

The VO_2 max of students of both sexes was similar to the data published for Lithuania (Grigaliūnienė et al., 2013), Germany (Rapp et al., 2018), and the USA (Kaminsky et al.,

Table 3. Comparison of VO_2 max levels between physiotherapy data and other values from Latvia and other countries.

	VO_2 max (**ml/min./kg**)			
	Man		**Woman**	
	M	**SD**	**M**	**SD**
Physiotherapy students in the current study	44.0	6.3	35.2	5.0
Latvia (Rozenštoka & Ērglis, 2020)				
training < 300 min. per week	37.6	7.1	31.4	5.0
training ≥ 300 min. per week	44.4	7.0	37.6	6.0
Lithuania (Grigaliūnienė et al., 2013)	40.4	5.77	34.7	6.8
Norway (Loe et al., 2013)	54.4	8.4	43.0	7.7
Germany (Rapp et al., 2018)	(35-45)[a]		(29-38)[a]	
Switzerland (Wagner et al., 2021)	46.6	7.9	39.3	6.5
Greece (Triantafyllidi et al., 2021)	37 (34-40)[a]		30	5
The Netherlands and Belgium (van der Steeg & Takken, 2021)	47.7	6.5	39.5	8.8
USA – FRIEND update (Kaminsky et al., 2022)	45.1	13.3	32.0	10.6

a Median (25-75% CI)

2022). The data for the USA (Kaminsky et al., 2022) are an update to normative values recommended by the American College of Sports Medicine for the cycle ergometer CRF test (Kaminsky et al., 2017). In this study, the VO_2 max for both sexes was higher than that in a study performed in Greece (Triantafyllidi et al., 2021), but lower than what was found in the populations of the Netherlands and Belgium (van der Steeg & Takken, 2021) and that of Norway in the Nord-Trøndelag study (Loe et al., 2013). The data for the male participants in this study were similar to those recorded for Switzerland, but the females in this study had a lower VO_2 max (Table 3). Based on the other countries' data, it seems that the students tested in this study fit into the young adult population results of Europe and North America, but there is still work to be carried out to reach more advanced countries' data.

Compared with the normative data of Shvartz and Reibold (Shvartz & Reibold, 1990), which is derived from the directly measured VO_2 max in the USA, Canada and 7 European countries, the relative VO_2 max estimate in this study was lower, especially in females, where 63% of the tested participants had lower than average VO_2 max According to the data, increased PA levels in students should be promoted to raise CRF for future specialists, who should be able to recommend PA for their clients.

VO_2 max is highest at a young age and decreases with age. In a longitudinal study carried out in Germany, VO_2 max was found to decrease by about 5 ml/min/kg each decade (Bahls et al., 2021). In a cross-sectional study in Switzerland, VO_2 max was highest in 20–29 year-olds and reduced by 10% for each subsequent decade (Wagner et al., 2021). Similar data can be found in the other studies which involve participants of different ages (Kaminsky et al., 2022; van der Steeg & Takken, 2021; Wagner et al., 2021). Thus, young adults who have a current VO_2 max below the average level are at a greater risk of an increased risk of morbidity and mortality from cardiovascular and other causes (Isath et al., 2023; Taylor et al., 2021). Despite genetics significantly contributing to VO_2 max (Schutte et al., 2016) and its trainability (Williams et al., 2017), those who are more active have higher values for both relative and absolute VO_2 max (Tangen et al., 2022). The frequency of exercise per week has an impact on mean VO_2 max it is significantly higher when exercising two or more times per week regardless of the exercise being carried out (Sovová et al., 2020). High-intensity interval running (HIIT-R) and high-intensity functional training (HIFT) lead to similar improvements in VO_2 max (17.1 % ± 5.6 % and 12.7 % ± 6.7 %, respectively, $p > 0.05$) (Lu et al., 2021). Further recommendations after the determination of aerobic capacity could help in guiding students towards PA and exercise at university and sports clubs in their city.

The relative VO_2 max did not differ for the students who entered university immediately after secondary school compared to those who took one or two years off. This indicates that the school physical education program has a small or no impact on the VO_2 max of future students, and the results most likely depend on extracurricular activities which do not change following secondary school. The review of studies showed that the level of PA in university students in general is satisfactory, but this depends on the cultural differences and educational program in a particular country (Kljajević et al., 2021). However, in a longitudinal study on teenagers who were followed until 24-27 years of age, a decrease in PA level was found in the period of transition from young adults into early adulthood. The greatest decline was found in men who entered college or university (Kwan et al., 2012). This study involved predominantly female students in which the decline is not as significant, and at the beginning of the study program, the effect of decreased PA on VO_2 max was likely not yet visible.

The VO_2 max and the proportion of students placing in below-moderate fitness groups in the years 2022-2023 increased compared to 2007-2009. This might be related to the COVID-19 pandemic, which influenced people's ability to exercise due to the decreased availability of sports facilities and the increased risk of infection. In multiple studies in Europe, America, and Australia, a decrease in

cardiorespiratory endurance until 2010-2012 was found in children and adolescents, which then stabilized or even improved (Fühner et al., 2021). In 2019, the COVID-19 pandemic began, leading to a worldwide decrease in PA (Ng et al., 2022; Park et al., 2022; Wunsch et al., 2022).

The CRF of students with an increased BMI was lower than that of students a with normal BMI. Obesity might lead to decreased respiratory and cardiovascular function, which decreases oxygen uptake and delivery to the muscles (Sood, 2009). Negative associations between BMI and VO_2 max were also found in Pakistani physiotherapy students (Ali et al., 2020). However, the results of other studies, depending on the expression of VO_2 max values, did not prove that people with moderate-to-mild obesity have reduced CRF compared to normal-weight people (O'Donnell et al., 2012). In this study, only one male participant and two female participants had a BMI above 30 kg/m2. Both BMI and aerobic capacity can be improved by increasing PA. In a study comparing the effects of regular and irregular training on the aerobic fitness, blood markers, and anthropometric characteristics of obese adolescent males, health benefits were found regardless of training regularity. Body mass, BMI, and waist circumference decreased, and the peak VO_2 increased in both groups, with no significant differences between the groups (Karami et al., 2021). Thus, the negative associations between the BMI and VO_2 max found in this study could be due to low PA together with a higher than necessary caloric intake that causes both an increase in BMI and a decrease in VO_2 max Further studies might be necessary to clarify this correlation.

This study has several strengths and limitations. Strengths: The study features a long-term measurement period, with exercise test results collected over 15 years to observe changes in the VO_2 max of physiotherapy students. The post-pandemic timing of the exercise stress tests, conducted after the return to full-time university studies, offers valuable insights into how the pandemic may have influenced VO_2 max levels. A uniform protocol was applied across all exercise tests, ensuring data comparability throughout the measurement period. Additionally, the inclusion of physiotherapy students is significant, as their lifestyle choices—such as PA levels—can influence their professional credibility and effectiveness as role models for promoting healthy behaviors. Studying this group provides insights into whether those expected to inspire healthy living practices also embody such behaviors themselves, with implications for their future professional roles and their potential impact on public health.

Limitations

A key limitation is the indirect determination of VO_2 max using heart rate (HR) data during submaximal exercise. However, indirect VO_2 max tests are increasingly favored for fitness assessments due to their practicality—they do not require participants to exercise to exhaustion (minimizing health risks), nor do they demand costly equipment or highly specialized personnel (ACSM, 2021). Additionally, this was a cross-sectional study, which limits the ability to establish cause–effect relationships between parameters. Future studies should adopt a longitudinal design to better explore causality. Furthermore, assessing PA levels during the pandemic would have provided more precise insights into changes in PA before and during COVID-19, helping to correlate these changes with VO_2 max variations. The gender imbalance limits the ability to draw direct comparisons between sexes.

Despite the limitations, the data obtained highlight a significant trend that could continue to develop if PA is not given special attention. It is necessary to comprehensively plan PA and help students/young specialists not to forget about their own health during their studies, which will be essential throughout their professional and personal lives. This study provides crucial foundational data for future research investigating the relationship between cardiorespiratory fitness, clinical skills, and patient satisfaction among physiotherapy students.

Conclusion

This study provides valuable insights into the trends of VO_2 max among physiotherapy students, highlighting the importance of CRF as a key health indicator. It emphasizes the need for healthcare students, particularly younger individuals, to prioritize their own health, not only for personal well-being but also as role models for society. Given the association between CRF and combating sedentary lifestyles, the study underscores the importance of strategic planning to maintain fitness levels. To improve CRF among future physiotherapists, it is recommended that universities implement targeted interventions to boost PA and overall fitness levels. Further research should focus on longitudinal studies and comparisons with other student populations to deepen understanding of the factors affecting student fitness. Additionally, the findings suggest the need for exploring physiotherapy students' awareness of CRF and how they apply this knowledge in maintaining their health. By addressing the limitations of this research and building on its strengths, more effective strategies can be developed to promote healthier lifestyles among future healthcare professionals.

Supporting Information

S1 Table. The physical characteristics and calculated VO_2 max of the male and female participants. https://dataverse.rsu.lv/dataset.xhtml?persistentId=doi:10.48510/FK2/7AQABY.

S2 Table 2. Characteristics of participants in three testing periods. https://dataverse.rsu.lv/dataset.xhtml?persistentId=doi:10.48510/FK2/7AQABY.

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Оцінка тенденцій кардіореспіраторної підготовленості серед студентів-фізіотерапевтів: Поперечне дослідження тривалістю 15 років (2007–2023)

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 3 табл., 6 рис., 46 джерел.

Історія питання. Кардіореспіраторна підготовленість (КРП) є ключовим показником здоров'я, зокрема для студентів-фізіотерапевтів, які повинні дотримуватися моделі здорового способу життя.

Мета дослідження. Метою дослідження було проаналізувати тенденції розвитку КРП серед студентів-фізіотерапевтів у період з 2007 по 2023 рік та оцінити відмінності в показниках максимального споживання кисню (VO_2 max) залежно від статі та індексу маси тіла (ІМТ).

Матеріали та методи. Проведено порівняльний аналіз вторинних даних за 2007–2009 та 2010–2012 роки з первинними даними, зібраними у 2022–2023 роках. Вимірювання КРП проведено за допомогою субмаксимального тесту на велоергометрі Monark Ergomedic 839E у 242 студентів (віком 18–25 років). Статистичні методи аналізу включали t-критерії, дисперсійний аналіз, непараметричні критерії ($p < 0.05$). З метою проведення міжгрупових порівнянь застосовано критерій Краскела- Волліса, а для оцінки тенденцій протягом певного періоду часу — кореляцію Спірмена.

Результати. У понад половини учасників чоловічої статі (52%) та жіночої статі (63%) рівні КРП були нижчими за референтні значення. У студенток спостерігалося значне зниження показника VO_2 max у 2022–2023 роках порівняно з 2007–2009 роками (середня різниця = 1.78 мл/хв/кг, $p < 0.05$), тоді як у представників чоловічої статі такої тенденції не виявлено. Студенти з ІМТ > 25 кг/м² мали значно нижчий показник VO_2 max, аніж особи з ІМТ ≤ 25 кг/м² ($p < 0.05$).

Висновки. Отримані результати підкреслюють необхідність впровадження цільових програм з фізичної підготовки для студенток та осіб з підвищеним ІМТ. Подальші дослідження повинні бути спрямовані на вивчення факторів способу життя та інтервенційних стратегій з метою поліпшення КРП у студентів. Представлене дослідження надає фундаментальні дані для проведення подальших досліджень щодо взаємозв'язку між КРП, клінічними навичками та задоволеністю пацієнтів серед студентів-фізіотерапевтів.

Ключові слова: кардіореспіраторна підготовленість, максимальне споживання кисню, студенти-фізіотерапевти, субмаксимальний велоергометричний тест.

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