

Maximal Aerobic Capacity Decreases Shortly after Beginning Medical School: A Prospective Cohort Study of US Medical Students

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Research Article

Keywords: VO2max, Cardiorespiratory fitness, Medical students, Prospective cohort study, Metabolic health, Physical activity, Medical education, Student wellness

Posted Date: June 9th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9762955/v1>

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Additional Declarations: No competing interests reported.

Abstract

Medical school has long been thought to have a potentially detrimental effect on the health of its students. We sought to understand if students experienced a decline in their cardiorespiratory physical fitness during their first year of medical school. A cohort of 1st year medical students ($n = 13$) were recruited during their first month of school to undergo VO₂max testing via indirect calorimetry. They were re-tested approximately 8 months later near the end of the academic year using the same protocol. Measurements of weight, bodyfat percentage, and resting metabolic rate were also taken before VO₂max testing. Participants were also asked to complete surveys related to diet, exercise, sleep, and mental health. We observed a statistically significant decrease in mean VO₂max from 37.31 ml/kg/min to 34.98 ml/kg/min ($p = 0.048$). No significant changes in overall dietary quality, physical activity, sleep quality, body composition, or reported mental health were observed.

1 Introduction

Medical students face unique challenges, including high academic demands, long study hours, and clinical responsibilities, which can negatively impact both their physical and mental health. While much attention has been given to the mental health of medical students, with high rates of anxiety, depression, and burnout being well-documented, the role of metabolic health as a mediator of wellness is underexplored. Metabolic health, particularly cardiovascular fitness (often measured as VO₂max) and resting metabolic rate (RMR), is crucial for overall health and may influence mental well-being and academic performance.¹

Existing studies have shown that physical activity can mitigate symptoms of anxiety and depression in a dose-dependent manner, with peak benefits observed between 2 to 7.5 hours of exercise per week.² However, as medical students progress through their education, physical fitness tends to decline possibly due to increased academic pressures.^{3,4} This decline in fitness is often accompanied by weight gain and worsening mental health outcomes.⁵ While these trends are well-documented in certain populations, there is limited research on how metabolic health changes over time in medical students and how these changes relate to mental health.

Physical fitness of medical students has potential downstream effects that are not only limited to the health of the students themselves. There is also evidence suggesting a weak but positive correlation between physical fitness and academic performance in medical students. Studies have found that students with higher fitness scores tend to perform better on exams such as the USMLE Step 2 CK.³ In addition to the benefit of higher academic achievement, health habits of medical students may one day influence how they counsel patients. Healthcare practitioners who report a healthier lifestyle are more likely to counsel their patients on lifestyle interventions.⁶⁻⁸ Understanding and improving the health of medical students offers a wide array of benefits.

The current study was designed to collect detailed, prospective data about a cohort of students as they complete their first year of medical school. We sought to prospectively measure changes in the VO2max of United States medical students across their first year of training using indirect calorimetry. Alongside this primary endpoint, we aimed to understand if other critical wellness metrics also deteriorate during this timeframe. By establishing exactly what happens to a student's health during the initial months of medical school, this study aims to determine if preventative interventions should be deployed from "day one" to help students maintain their health throughout their medical careers.

2 Results

Baseline characteristics are reported in Table 1. A total of 13 first-year medical students (6 male, 7 female) enrolled in and completed the study. At baseline, the mean age of the cohort was 24.5 ± 2.7 years. Initial VO2max for the cohort was 37.3 ± 9.4 ml/kg/min. Baseline mental health screening indicated minimal depression and anxiety, with average PHQ-9 and GAD-7 scores of 3.9 ± 2.8 and 3.0 ± 4.1 , respectively.

Over the first year, the cohort of 13 medical students exhibited a statistically significant decrease in cardiorespiratory fitness, with VO2max dropping from 37.31 ± 9.37 to 34.98 ± 8.87 ml/kg/min (a reduction of 2.33; $p = 0.048$, $d = -0.603$). Increases in total weight and body fat percentage were observed but were not statistically significant. Self-reported physical activity levels remained stable. Total weekly MET expenditure showed a negligible increase of 59.10 ($p = 1.000$), and average weekday sitting time decreased non-significantly by 0.85 hours ($p = 0.297$). While overall dietary scores were largely unchanged, there was a significant decline in the REAP-S food sufficiency subscale from 9.69 ± 2.46 to 8.23 ± 2.42 ($p = 0.041$, $d = -0.658$). In the food sufficiency subscale you are penalized for skipping meals, not eating sufficient protein, and not eating food rich in calcium and vitamin D. Psychological well-being and sleep metrics remained stable. Shifts in depressive symptoms (PHQ-9), anxiety (GAD-7), and sleep quality (Sleep SQS) were minimal and not statistically significant. Data for all measures taken at baseline and at follow-up is found in Table 2.

The majority, though not all students, saw a decrease in their VO2max from baseline to follow-up (Figure 1). In 10/13 students there was at least a small decrease in their measured VO2max values over the course of their first year of medical school.

3 Tables

Table 1 Baseline Characteristics

Characteristic	Total (n=13)	Male (n=6)	Female (n=7)
DEMOGRAPHICS			
Age (years)	24.5 ± 2.7	26.2 ± 3.2	23.1 ± 0.9
Height (inches)	67.5 ± 5.0	71.8 ± 4.1	63.8 ± 1.1
BIOMETRICS			
Weight (lbs)	161.0 ± 33.0	182.2 ± 37.2	142.7 ± 13.8
Body fat (%)	26.4 ± 7.6	21.2 ± 7.3	30.9 ± 4.6
VO2max (ml/kg/min)	37.3 ± 9.4	43.3 ± 10.3	32.2 ± 4.7
Max HR (bpm)	184.7 ± 6.9	186.7 ± 8.3	183.0 ± 5.4
MENTAL HEALTH & WELLNESS			
PHQ-9 score	3.9 ± 2.8	4.3 ± 2.5	3.6 ± 3.1
GAD-7 score	3.0 ± 4.1	4.3 ± 5.6	1.9 ± 2.0
Sleep quality (SQS, 0-10)	6.7 ± 0.9	6.8 ± 0.8	6.6 ± 1.1
PHYSICAL ACTIVITY (IPAQ-SF)			
Vigorous METs/wk [8.0 × days × min]	907.7 ± 804.2	986.7 ± 1100.0	840.0 ± 523.1
Moderate METs/wk [4.0 × days × min]	438.5 ± 388.9	333.3 ± 316.6	528.6 ± 445.4
Walking METs/wk [3.3 × days × min]	506.4 ± 587.6	635.2 ± 737.3	396.0 ± 454.6
Total METs/wk	1852.6 ± 1164.8	1955.2 ± 1383.9	1764.6 ± 1047.9
Sitting time (hrs/weekday)	8.6 ± 2.7	9.5 ± 3.3	7.8 ± 1.9
DIETARY QUALITY – REAP-S v.2(0-3 scale; higher = healthier)			
Food Sufficiency subscale (max=12)	9.7 ± 2.5	8.7 ± 3.0	10.6 ± 1.6
Healthy Eating Pattern subscale (max=21)	9.6 ± 3.3	8.3 ± 3.1	10.7 ± 3.3
Low Nutrient Density Foods subscale (max=24)	15.8 ± 2.7	13.8 ± 1.8	17.4 ± 2.1
Exercise subscale (max=3)	2.5 ± 0.7	2.5 ± 0.8	2.6 ± 0.5
Total REAP-S score (max=60)	37.6 ± 4.8	33.3 ± 2.3	41.3 ± 2.8

Table 1. Participant characteristics by sex. Values are mean ± SD for the total sample (n=13), males (n=6), and females (n=7). Measures include demographics (age, height), biometrics (weight, body fat, VO₂max,

HR), mental health (PHQ-9, GAD-7, SQS), physical activity (IPAQ-SF MET-min/week and sitting time), and dietary quality (REAP-S v.2; higher scores indicate healthier patterns).

Table 2 Outcomes

Outcome	Start	End	Delta	p (W)	d
Cardiorespiratory fitness					
VO2max (ml/kg/min)	37.31 ± 9.37	34.98 ± 8.87	-2.33 ± 3.87	0.048*	-0.603
Body composition					
Weight (lbs)	160.95 ± 33.03	164.28 ± 34.13	+3.32 ± 7.86	0.216	0.423
Body fat (%)	26.43 ± 7.57	27.02 ± 7.85	+0.58 ± 2.22	0.312	0.264
Mental health					
PHQ-9	3.92 ± 2.75	4.15 ± 3.11	+0.23 ± 3.72	0.748	0.062
GAD-7	3.00 ± 4.08	2.77 ± 2.45	-0.23 ± 4.78	0.879	-0.048
Sleep					
Sleep SQS (0-10)	6.69 ± 0.95	6.08 ± 1.38	-0.62 ± 1.61	0.236	-0.382
Physical activity (IPAQ-SF)					
Vigorous METs/wk [8.0 × days × min]	907.69 ± 804.22	932.31 ± 606.27	+24.62 ± 913.83	0.851	0.027
Moderate METs/wk [4.0 × days × min]	438.46 ± 388.88	307.69 ± 290.92	-130.77 ± 560.75	0.331	-0.233
Walking METs/wk [3.3 × days × min]	506.42 ± 587.56	671.68 ± 604.05	+165.25 ± 756.73	0.413	0.218
Total METs/wk	1852.58 ± 1164.81	1911.68 ± 1205.12	+59.10 ± 1483.72	1	0.04
Sitting time (hrs/weekday)	8.58 ± 2.66	7.73 ± 2.80	-0.85 ± 2.40	0.297	-0.352
Dietary quality — REAP-S v.2	(0-3 scale; higher = healthier)				
Food Sufficiency subscale (max=12)	9.69 ± 2.46	8.23 ± 2.42	-1.46 ± 2.22	0.041*	-0.658
Healthy Eating Pattern subscale (max=21)	9.62 ± 3.33	9.62 ± 2.22	+0.00 ± 3.39	0.906	0
Low Nutrient Density Foods subscale (max=24)	15.77 ± 2.65	16.38 ± 3.80	+0.62 ± 2.47	0.453	0.249
Exercise subscale (max=3)	2.54 ± 0.66	2.23 ± 0.83	-0.31 ± 0.95	0.406	-0.325
Total REAP-S score (max=60)	37.62 ± 4.81	36.46 ± 6.75	-1.15 ± 6.53	0.734	-0.177

Table 2. *Changes in outcomes from baseline (Start) to follow-up (End). Values are mean $\pm$ SD; Δ represents mean change (End – Start). p-values from Wilcoxon signed-rank tests; effect sizes reported as Cohen’s d. Outcomes include cardiorespiratory fitness (VO₂max), body composition, mental health (PHQ-9, GAD-7), sleep (SQS), physical activity (IPAQ-SF; MET-min/week and sitting time), and dietary quality (REAP-S v.2; higher scores indicate healthier diet). p < 0.05 denoted by *.*

4 Figures

Figure 1 Change in individual VO₂max during the first year of medical education

Figure 1. *Individual changes in cardiorespiratory fitness (VO₂max, mL·kg⁻¹·min⁻¹) from baseline to follow-up, stratified by sex: (A) men and (B) women. Each line represents a single participant. Horizontal dashed lines indicate age- and sex-specific normative percentiles (10th–90th).*

5 Statistical Analysis

Data for metabolic and anthropomorphic measurements were recorded in a Microsoft Excel spreadsheet. Data collected from Qualtrics surveys was downloaded as Excel files and combined with the metabolic and anthropomorphic measures. The data was then anonymized and analyzed. Data was analyzed using Python 3.14.3 with the libraries pandas, SciPy, and matplotlib.

Given the small sample size, non-parametric tests were used for inferential statistics. Start of year and end of year differences were analyzed using the Wilcoxon signed-rank test. Correlations were calculated using Spearman’s correlation coefficient. Effect sizes are calculated using Cohen’s d. Mean values are reported along with the standard deviations for all values.

6 Methods

6.1 Study Design and Participants

This was a prospective longitudinal cohort study designed to evaluate changes in cardiorespiratory fitness and health behaviors during the first year of medical school. The study protocol was reviewed and approved by the Institutional Review Board at Rocky Vista University (Protocol #2025-106). All participants were informed of the study's purpose, procedures, and potential risks, and all provided written informed consent prior to participation and data collection. The initial study protocol stated that measurements would be taken at three points during the year, but this was later changed to two measurements due to scheduling conflicts. Participants were recruited via word-of-mouth from the matriculating first-year class at the Utah campus of Rocky Vista University during the months of July and August 2025. A power calculation (effect size 0.5, significance level 0.05, 80% power) indicated that we should have recruited 32 students. However, a total of only 13 students volunteered and were enrolled in the study.

Prior to participation, students completed a basic medical screening survey administered via Qualtrics (Provo, Utah). Participants were excluded if they reported severe medical comorbidities or musculoskeletal injuries that would preclude exercise testing. If participants were generally healthy and free of serious cardiorespiratory or musculoskeletal contraindications, they were cleared to participate.

6.2 Procedures

Data collection for the initial timepoint occurred during the month of August 2025 approximately a month after students their first year of medical school. Data collection for the second timepoint occurred at the end of the month of March 2026, approximately 2 months before the end of their first year. At each session, participants underwent physiological testing and completed several questionnaires on their mobile devices.

The primary endpoint of this study was cardiorespiratory fitness, quantified by VO₂max. VO₂max was measured via indirect calorimetry using the VO₂ Master device, a validated wearable metabolic analyzer.^{9,10} Participants underwent an incremental exercise protocol on a stationary cycle ergometer, with resistance increasing progressively until exhaustion.

The protocol began with a 4-minute warm-up at a workload below 50 watts, followed by 1 minute at 50 watts. Resistance was then increased by 50 watts every minute until the participant reached maximal effort or could no longer maintain the required cadence. The protocol concluded with a 3-minute cool-down at a workload below 50 watts. This protocol was adapted from a previously validated method for assessing VO₂max.^{11,12}

Several other datapoints were collected as secondary endpoints. Resting metabolic rate (RMR) was measured using and FDA approved MedGem indirect calorimeter.¹³ Participants were instructed to abstain from consuming caffeine or any calories for at least 4 hours prior to testing. Weight and body fat percent were determined using the Tanita BC-533 bioelectrical impedance scale which has been used in previous longitudinal body composition studies.¹⁴ Dietary habits were evaluated using the using the Rapid Eating Assessment for Participants - Short Version (REAP-S v.2) which has been validated specifically in 1st year medical students.¹⁵ Total metabolic equivalents (METs) were calculated using the well-known International Physical Activity Questionnaire Short Form (IPAQ-SF).¹⁶ Sleep quality was assessed using a 1-10 scale according to the Sleep Quality Scale (SQS).¹⁷ Depression and anxiety were screened using the Patient Health Questionnaire-9 (PHQ-9) and the General Anxiety Disorder-7 (GAD-7) scale.^{18,19}

6.3 Ethical Approval declarations

- This study protocol was reviewed and approved by the Institutional Review Board at Rocky Vista University College of Osteopathic Medicine (Protocol #2025-106).

- This study was conducted in accordance with the ethical standards of Rocky Vista University College of Osteopathic Medicine and the Declaration of Helsinki.
- All participants provided written informed consent prior to enrollment in the study protocol.
- Clinical trial number: not applicable.

7 Discussion

We showed an abrupt decrease in cardiorespiratory fitness during the first year of medical education for American students. A decrease of 2.33 ml/kg/min or roughly 6% from baseline represents a relatively large decline for such a short period of time. For generally healthy people in their 20s, VO₂max is expected to decline about 3–6% over the course of a decade.^{20,21} The fact that we observed this change in a matter of months and not years suggests that beginning medical school in the United States rapidly decreases the average student's aerobic fitness.

The observed 2.33 ml/kg/min decrease may also carry clinical significance. A change in 1 ml/kg/min is associated with altered risk for hypertension, dyslipidemia, and metabolic syndrome.²¹ In heart failure patients, a 6% change in VO₂max is associated with 5% change in mortality or hospitalization.²² However, the exact clinical significance of this finding in our study population is unclear. Brehm et al. published one of the few studies that have looked at medical student health longitudinally. They found that between the 1st and 4th year of school American medical students had decreased cardiovascular fitness (as measured by the Forestry step test) and small changes in certain metabolic biomarkers.²³ Our study was not able to measure any blood biomarkers associated with decreased VO₂max. We also do not know if the change we observed was only transient or if it represents a loss that will not be recovered.²⁴

To our knowledge, this is the first study to demonstrate a decline in cardiovascular fitness in medical students using the gold standard of VO₂max via indirect calorimetry. Decreases in other metrics of cardiovascular fitness such as a 1.5 mile timed run⁴ or by a step test²³ have been reported before, but none measure the function of the cardiopulmonary system with the same precision as a VO₂max test using calibrated equipment. Another strength of our research is the prospective design as much of the data on medical student wellness relies on cross-sectional surveys and retrospective analysis. While a prior retrospective study at our institution found early declines in student mental health and exercise,²⁵ our prospective cohort did not mirror these effects. Finally, our study had 100% retention which eliminates attrition bias.

This study also has several significant limitations. Foremost among the limitations is the small sample size of only 13 participants. Our initial power calculations predicted that we would need to recruit many more participants, but we observed a larger effect size than anticipated. Our cohort was also subject to a number of biases. Students who volunteer for a rigorous VO₂ max study are likely more health-conscious and physically active than the general student body at baseline. Another limitation is that desirability bias

may have skewed our secondary self-reported questionnaires, particularly regarding mental health and exercise volume, potentially masking steeper behavioral declines. During one participant's VO_2max test, the data collection application malfunctioned, producing an erroneous final value of $13.5 \text{ mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$. Attempts to manually calculate VO_2max from the available data were unsuccessful due to incomplete data capture. The participant was therefore asked to return for a repeat test, which was conducted more than 48 hours later and completed without technical error. Although this participant completed two maximal exercise tests within the same week, prior research demonstrates that VO_2max measured on a cycle ergometer is highly reproducible across tests performed within one to two weeks, with coefficients of variation of approximately 4–6% and no significant learning effect.^{11,26} Another study specifically showed that VO_2max and maximal work rate remained unchanged between two bicycle exercise tests performed one week apart in both trained and untrained subjects.²⁷ Accordingly, the repeat test performed after more than 48 hours of recovery is unlikely to have been meaningfully affected by the initial test. Finally, this is a single-center study, and the results may not perfectly generalize to different institutions.

Our limited sample size also greatly limited our ability to correlate changes in VO_2max with other changes in student health. Future studies may be designed with sufficient statistical power to understand how VO_2max in medical students interacts with mental health, diet, and exercise. Future research would also benefit from larger, more diverse cohorts to increase the generatability of the results. The field of medical student wellness may also benefit from more prospective data. This could include trials on which interventions are most effective for increasing student physical and mental wellbeing.

8 Conclusion

The first year of medical school triggers a significant decline in cardiorespiratory fitness and dietary sufficiency. Because a physician's personal lifestyle habits dictate their efficacy in prescribing preventative medicine, student physiological health cannot be treated as a secondary priority. Proactive interventions should begin early to ameliorate the detrimental effect medical education can have on student health.

Declarations

- This study received funding from an internal research grant from Rocky Vista University College of Osteopathic medicine.
- This study was conducted in accordance with the ethical standards of Rocky Vista University College of Osteopathic Medicine and the Declaration of Helsinki.
- This study protocol was reviewed and approved by the Institutional Review Board at Rocky Vista University College of Osteopathic Medicine (Protocol #2025-106).
- All participants provided written informed consent prior to enrollment in the study protocol.

- All data supporting the findings of this study are available within the paper and its Supplementary Information.

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Figures

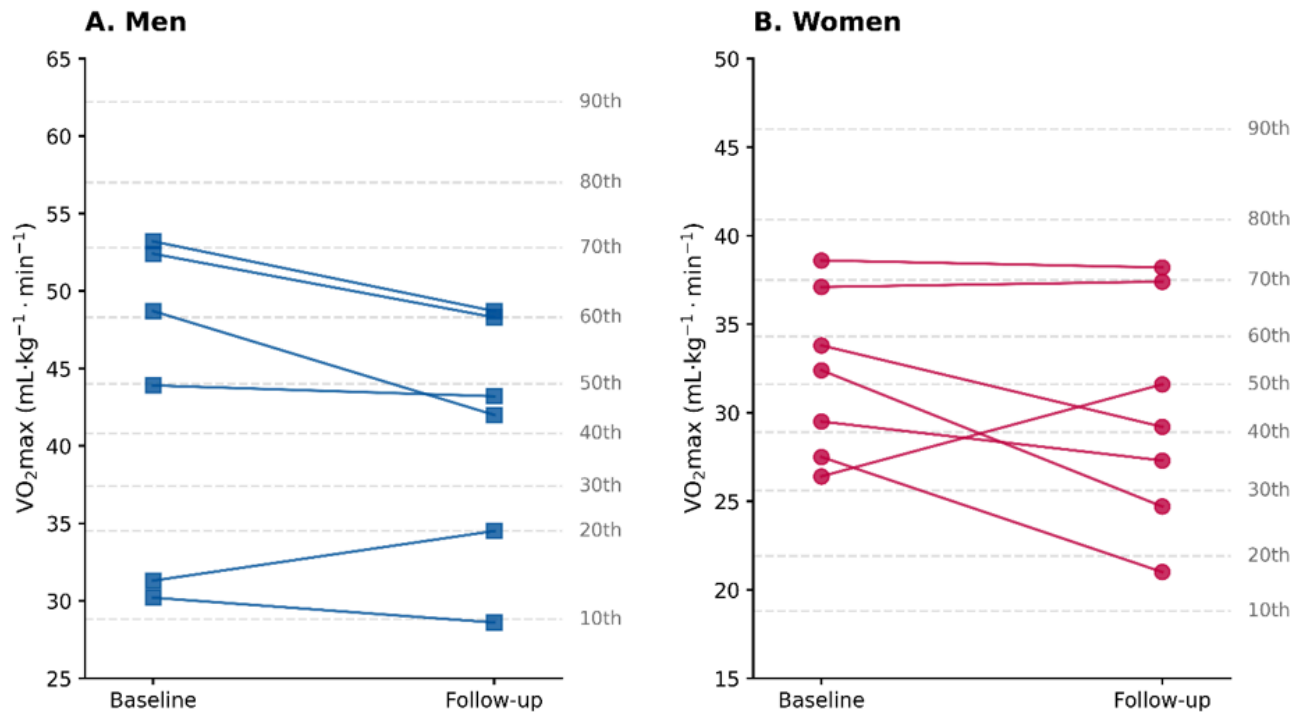


Figure 1

Change in individual $\dot{V}O_{2\max}$ during the first year of medical education

Individual changes in cardiorespiratory fitness ($\dot{V}O_{2\max}$, mL·kg⁻¹·min⁻¹) from baseline to follow-up, stratified by sex: (A) men and (B) women. Each line represents a single participant. Horizontal dashed lines indicate age- and sex-specific normative percentiles (10th–90th).