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Associations Between Daily Wellness Behaviors and Outcomes among Medical Students

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Abstract

Objective: Explore which wellness behaviors have the greatest impact on wellbeing outcomes in medical students.

Methods: A total of 213 medical students were enrolled in this study between June and September 2021. Participants completed a battery of online surveys, including demographic information, and 60-second nightly surveys on the WE-MD smartphone app, which assessed wellness-related indicators (exercise duration, sleep quality, nutrition quality, etc.) and wellbeing outcomes (mood, focus, stress, etc.).

Results: 116 participants completed >50% of nightly surveys between September 2021 and November 2021 and were included in the analysis. All wellness indicators were significantly associated with at least one wellness outcome. Quality of social interactions had the greatest relative positive association with wellbeing. Any amount of exercise, including 1-30 minutes, was significantly associated with improved wellbeing outcomes compared to no exercise. A lagged analysis separating indicators and outcomes by one day found wellbeing was only associated with limited sleep (< 6 hours) and higher nutritional quality the day prior.

Conclusion: This study provides substantial information on daily wellness behaviors and their relative impact on medical student wellbeing. Social interaction and exercise of any duration may be more important to wellbeing than previously recognized. Infrequently studied behaviors, including kindness, nutrition, and screen time, were also found to have significant associations with wellbeing. The numerous significant associations between

behaviors and outcomes suggest a cumulative effect and point to the multifactorial nature of medical student wellbeing. This study may aid medical schools in developing high-impact initiatives and curricular changes that promote wellbeing for their students.

Keywords: wellbeing, mental health, medical school, technology, mobile app, exercise, nutrition, sleep, mood, fitness, physical activity, social interaction, socialization, kindness, focus, stress

Introduction

Medical students experience elevated levels of stress due to academic demands, clinical duties, extracurricular participation, and leadership roles[1]. This is exacerbated by the highly competitive and unpredictable process of the residency match[2]. Therefore, it is unsurprising that medical students experience higher rates of depression, anxiety, and suicidal ideation compared to age-matched peers[3–6]. Common stressors include excessive workload, inability to maintain meaningful relationships and extracurricular activities, and lack of sleep, exercise, and proper nutrition[1]. Medical students struggling with their wellbeing are more likely to perform poorly on exams, receive fewer residency interviews, or even drop out of medical school altogether[7–9]. Further, many schools implemented COVID-19 pandemic measures that created additional barriers to social interactions, fitness resources, and other wellness-promoting behaviors[10].

Previous studies on medical student wellbeing explored relationships between various wellness behaviors and outcomes, such as stress, anxiety, depression, and burnout[11–18]. One study suggested that general engagement in self-care behaviors (e.g.,

nutrition, exercise, spiritual growth) moderated the effects of school-related stress on wellbeing[11]. Other research on stress demonstrated an inverse relationship with exercise[12,14,16], as well as a positive correlation with poor sleep quality[17,19]. Evidence also supports mindfulness techniques as effective stress mitigants for medical students[18,20]. Existing literature around certain behaviors (e.g., healthy eating, social engagement, and intentional kindness) is lacking. Further, the differential impact of certain behaviors is unclear, as most studies examined only one wellness behavior or intervention in isolation, cross-sectionally.

It may be important for students to practice wellness behaviors early, as mental health struggles often continue beyond medical school: residents and physicians also appear to suffer from higher rates of mental illness and burnout relative to peers in other professions[5,21,22]. Physician burnout is linked to poor health outcomes for patients, higher healthcare costs, and decreased patient satisfaction, highlighting the importance of medical student and physician wellbeing[23,24]. Further investigation on medical student wellbeing may thus benefit students, physicians, patients, and the healthcare system as a whole.

The present study explored medical student wellbeing by tracking multiple behaviors and outcomes longitudinally. Participants from four contemporaneous classes of medical students completed nightly surveys to track wellness behaviors along with wellbeing outcomes. The primary purpose of the study was to test the associations between these behaviors and outcomes in our sample and assess the comparative strength of these associations.

Methods

Sample

This study used an institutional review board-approved protocol from the Robert Larner, M.D. College of Medicine (LCOM) at the University of Vermont (CHRBSS - Behavioral #STUDY00001086 Approved: 8/13/2021). Participants were recruited through emails, social media graphics, and college-wide newsletters. Inclusion criteria were: being a full-time LCOM student, over the age of 18, and owning a smartphone. Recruitment ran from June to September 2021. All participants completed an approved informed consent process. Sample characteristics are displayed in Table 1.

Participants used the WE MD smartphone app, designed to help them track daily wellness behaviors and outcomes. Within the app, participants could earn tokens (WE Coin) by completing nightly surveys and engaging with app content (e.g. watching educational videos, reading articles, or scheduling local wellness events). WE Coin could be exchanged for items (e.g., shirts, hats, local business gift cards) from the in-app "WE Store." Participants were given a Series 3 Apple Watch to track biometrics (not included in this study).

Assessment

Baseline surveys

Participants completed a battery of online self-reported surveys. From those, this study included gender, age, race/ethnicity, year in medical school, and subjective SES, where

participants rank their family's position in American society (1=lowest wealth, education, job status to 10=highest)[25]. We coded race/ethnicity using underrepresented in medicine (URiM) status, defined by the AAMC as "racial and ethnic populations that are underrepresented in the medical profession relative to their numbers in the general population." Participants were coded as either URiM or non-URiM.

Nightly Surveys

Nightly from 7 PM to 11:59 PM, via the app, participants were prompted to complete a 60-second survey on 17 health and wellness-related items from that day. Four items assessed wellbeing outcomes: overall wellbeing, mood, stress, and focus. Eight items assessed wellness indicators that might be associated with outcomes: sleep hours, sleep quality, nutritional quality, hydration, exercise time, screen time, quality of social interactions, and acts of intentional kindness. Additional items not used in this analysis assessed substance use and mindfulness. Table 2 shows the 12 of 17 survey items included in this study. All 4 outcomes, and the indicators of nutritional quality and hydration, used a 0 to 100 scale (response anchors at 0, 50, and 100). Exercise used a scale of 0 to 180+ minutes. Quality of social interactions, practice of intentional kindness, and sleep quality used a 0 to 10 scale (response anchors at 0, 5, and 10). Hours of sleep and non-academic screen time were collected on a scale of 0 to 12+ hours. Higher ratings indicated higher levels.

Statistical Analyses

Mixed linear models were estimated in SAS 9.4 using PROC MIXED. These models included a random intercept to account for repeated, correlated observations within individuals of daily survey items. First, cross-sectional associations were tested using multivariable models between wellness indicators with wellness outcomes on any given day. All models accounted for age, class year, gender, subjective social status, URiM status, and day of the week. Next, longitudinal associations were tested between wellness indicators on one day and wellness outcomes the next day. Again, all models accounted for age, class year, gender, subjective social status, day of the week, and URiM status. These models were also adjusted for the value of the outcome variable (e.g., focus) on the prior day. The alpha value for significance testing was set at .05.

Results

Sample Description

Forty-three percent (n=213) of all LCOM medical students were consented and, of these, 54.4% (n=116) completed the nightly surveys on a regular basis (at least 50% of surveys completed in the study period of September 1st-November 30th, 2021). Descriptive statistics including gender, class year, and URiM status are presented on the overall medical school population, the consented sample, and the analytic sample (Table 1). The analytic sample had a similar proportion of male/female students, but fewer third- and fourth-year medical students, and fewer students in the URiM category as compared to the consented sample or the medical student population. The subjective SES status score of both the consented and analytic samples were similar (Consented=6.65, Analytic=6.67).

Table 1: Descriptive information about the medical student sample. A description of the: (1) consented sample, (2) analytic sample used for this study, and (3) entire population of this medical school. The total n, gender composition, class year composition, and number of students identifying as Underrepresented in Medicine (URiM) are included. The right two columns contain p-values of chi-square tests comparing the (1) consented sample to the (2) analytic sample, and the (2) analytic sample to the (3) medical school population.

	(1) Consented Sample		**(2) Analytic Sample**		**(3) Med School Population**		***1 vs. 2***	***2 vs. 3***
	n	**%**	**n**	**%**	**n**	**%**	***p***	***p***
Total	213		116		495			
Gender*								
Male	76	34.7	43	36.4	211	42.5	-	-
Female	137	62.6	73	61.9	284	57.1	0.802	0.274
Class Year								
M1	58	26.4	42	35.6	154	31.0	-	-
M2	64	29.2	40	33.9	125	25.2	-	-
M3	45	20.5	22	18.6	131	26.4	-	-
M4	53	24.2	14	11.9	117	23.5	0.033	0.008

Representation								
Represented in Medicine	179	81.7	108	91.5	382	76.9	-	-
Underrepresented in Medicine	34	15.5	10	8.5	100	20.1	0.054	0.002

*Users in all samples who identified as gender non-binary are not included here due to the limited cell size and low quantity of reports.

Outcomes description

Descriptive information about the four wellbeing outcomes is provided in Table 2. With all outcomes assessed on a 100-point scale, levels of wellbeing and mood were relatively high (means of 67.5 and 66.9, respectively) while stress levels rated as just below 'moderate' (mean=44.4), and focus rated as just above 'moderate' (mean = 56.2). Each of the 4 outcomes varied across a given week. Figure 1 displays the average levels of wellbeing, mood, stress, and focus reported over the 3-month period for each day of the week. The weekly pattern for wellbeing and mood were similar with higher levels on Monday, and lower levels midweek that rose toward the end of the week. Conversely. stress and focus showed levels peaking midweek and falling off later in the week. The intraclass correlations for the outcomes ranged from 0.31 (focus) to 0.39 (wellbeing) suggesting that a third of the variation in these outcomes was variability within individuals from day to day.

Table 2: Nightly in-app survey questions. 12 of the 17-item nightly in-app survey. Variables are separated into Outcomes (self-reported feelings of wellbeing) and Indicators (wellness behaviors contributing to Outcomes).

Survey Question	Minimum	Maximum	Response Anchors	Mean	SD
Outcomes					
What was your wellbeing score today?	0	100	0, 50, 100	67.47	19.09
How was your mood today?	0	100	Sad (0), Okay (50), Happy (100)	66.91	20.79
How was your anxiety/stress level today?	0	100	Low (0), Moderate (50), High (100)	44.41	27.55
How was your focus today?	0	100	Low (0), Moderate (50), High (100)	56.18	23.50
Indicators					
How many minutes did you exercise?	0	180		31.06	38.01
How well did you eat today?	0	100	Poor (0), Okay (50), Great (100)	61.58	21.37
Do you think you drank enough water today?	0	100	No (0), Maybe (50), Yes (100)	59.52	29.08

How many hours of non-academic screen time/gaming did you engage in today?	0	12+		2.31	1.90
How would you describe the quality of your social interactions today?	0	10	Poor (0), Okay (5), Great (10)	6.79	2.23
How would you describe your practice of intentional kindness today?	0	100	Poor (0), Okay (50), Great (100)	65.07	23.21
How many hours did you sleep?	0	12+		7.28	1.45
How restful was your sleep?	0	10	Poor (0), Somewhat (5), Great (10)	6.06	2.39

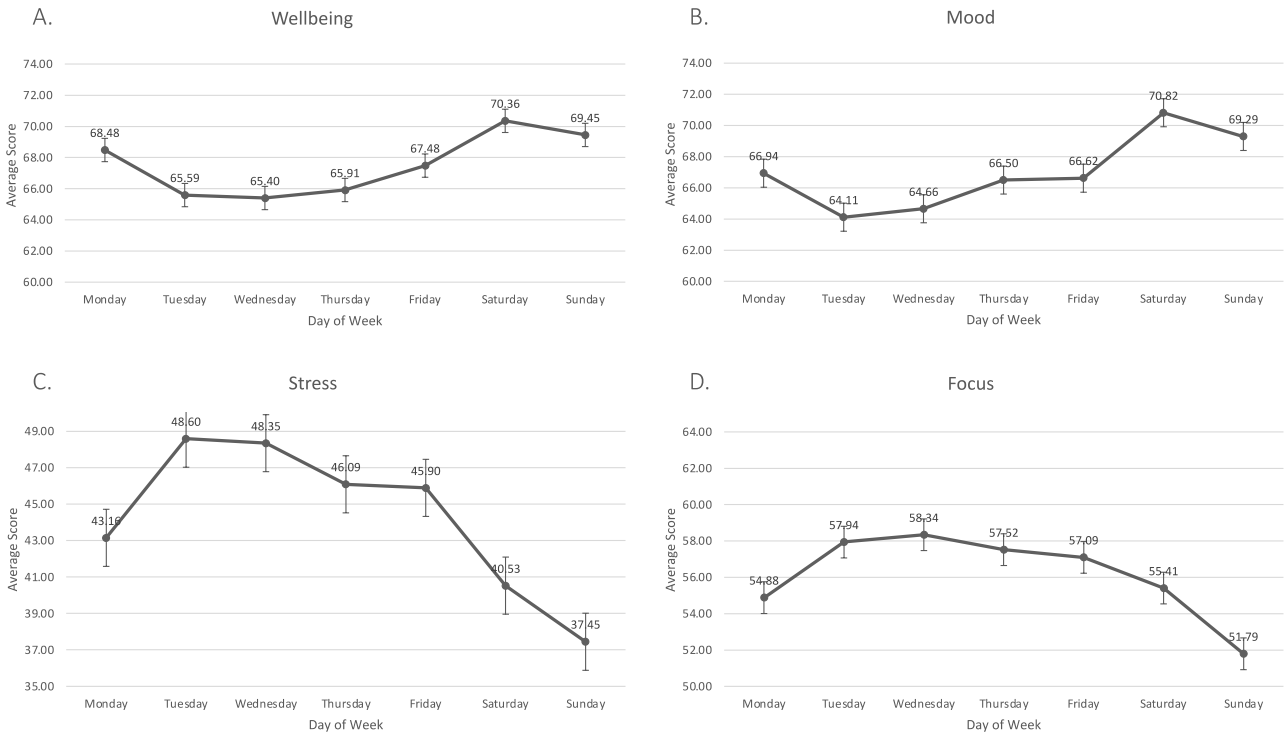

Figure 1: Average wellbeing outcomes by day of week. The average scores of daily wellbeing, mood, stress, and focus across a week, were collapsed over all study weeks and participants. Average self-reported scores for: (A) overall wellbeing (B) mood (C) stress (D) focus.

Cross-sectional, Same-day associations

A series of multivariable models tested cross-sectional associations between wellness indicators with wellbeing outcomes on any given day (Table 3). All models accounted for age, class year, gender, subjective social status, URiM status, and day of the week. Of these covariates, only day of the week was significantly associated with all four outcomes. The general pattern suggested that multiple wellness behaviors were associated with each outcome on a daily basis. Overall wellbeing was significantly associated with exercise, higher nutritional quality, more hydration, higher quality of social interactions, more

intentional kindness, and higher sleep quality, but not with screen time or hours slept. The effects of these individual indicators was moderate. For example, each 1 point increase in quality of social interactions (10-point scale) was associated with a 2.26 point improvement in wellbeing. Thus, the difference between okay social interactions (score of 5) and great social interactions (score of 10) would be associated with an 11 point increase in wellbeing. The cumulative effect of these indicators was greater still. Engagement in each of the wellness indicators could be associated with a 20-25 point higher rating in reported wellbeing on the100 point scale. A similar set of associations was observed with daily mood, although it was also associated with sleeping 10 or more hours a night. Focus was associated with every individual wellness indicator. This included fewer hours of screen time and fewer than seven hours of sleep. Finally, levels of stress were inversely associated with exercise, higher nutritional quality, fewer hours of screen time, higher quality of social interactions, more intentional kindness, higher sleep quality and fewer than seven hours of sleep. Across the models, most wellness indicators were associated with all outcomes (i.e., sleep quality, exercise, nutrition, social interactions, and kindness), whereas a few indicators were specific to particular outcomes (e.g., lower screen time with focus and stress levels). Follow-up models tested whether the pattern of associations varied by gender or URiM status. There was no evidence of significant between-group differences.

Table 3: Cross-sectional regression analysis of daily wellbeing outcomes by wellness indicator and demographics.

	Wellbeing			Mood			Focus			Stress		
	Std Reg Coeff	Std Err	p-val	Std Reg Coeff	Std Err	p-val	Std Reg Coeff	Std Err	p-val	Std Reg Coeff	Std Err	p-val
Exercise												
0 min	-	-	-	-	-	-	-	-	-	-	-	-
1-30 mins	1.47	0.47	0.002	0.98	0.52	0.057	3.24	0.66	<.0001	0.38	0.76	0.618
> 30 min	3.38	0.44	<.0001	2.54	0.48	<.0001	2.08	0.62	0.001	-3.19	0.71	<.0001
Nutrition	1.43	0.1	<.0001	0.97	0.1	<.0001	1.54	0.14	<.0001	-0.33	0.16	0.035
Hydration	0.85	0.1	<.0001	0.44	0.09	<.0001	0.84	0.12	<.0001	-0.01	0.12	0.475
Screen time												
0-1 hours	0.93	0.57	0.102	1.06	0.62	0.086	8.38	0.79	<.0001	4.98	0.91	<.0001
2-3 hours	0.89	0.5	0.076	0.55	0.54	0.317	4.95	0.7	<.0001	3.02	0.8	0.0002

4+ hours	-	-	-	-	-	-	-	-	-	-	-	-
Social quality	2.26	0.1	<.0001	3.5	0.11	<.0001	0.56	0.14	<.0001	-2.18	0.16	<.0001
Kindness	0.84	0.1	<.0001	0.9	0.11	<.0001	0.71	0.14	<.0001	-0.33	0.16	0.042
Sleep hours												
0-6 hours	-0.42	0.47	0.365	0.28	0.51	0.590	1.43	0.65	0.026	2	0.75	0.007
7-9 hours	-	-	-	-	-	-	-	-	-	-	-	-
10+ hours	-1.59	0.88	0.070	-2.24	0.96	0.019	-2.24	1.23	0.068	-2.37	1.4	0.094
Sleep quality	1.36	0.09	<.0001	1.56	0.09	0.020	1.35	0.13	<.0001	-1.12	0.14	<.0001
Significant Covariates **		2, 6			6			2, 6			3, 6	

**All models accounted for the following numerically coded covariates: (1) Age (2) Class Year (3) Gender (4) SES (5) Underrepresented in Medicine (6) Day of Week

Longitudinal, Next-day associations

We tested whether wellness indicators have a lasting effect on wellbeing outcomes beyond the current day. Table 4 displays results from a series of four multivariable models testing longitudinal associations between wellness indicators on one day and wellbeing outcomes the next day. Again, all models accounted for age, class year, gender, subjective social status, day of the week, and underrepresented in medicine status. These models were also adjusted for the value of the outcome variable on the prior day. Not surprisingly, outcome status on the prior day (e.g., lagged mood) was a significant predictor of the outcome variable the next day for all outcomes. As in the cross-sectional models, day of the week was significantly associated with all four outcomes. There were fewer associations as compared to the cross-sectional models. Overall wellbeing was only associated with higher nutritional quality and limited sleep (< 6 hours) the prior day. Similarly, positive mood was associated with higher nutritional quality and limited sleep, but also higher quality of social interactions and high sleep quality the prior day. Focus was associated with past day's hydration, lower quality of social interactions, and more intentional kindness. Finally, stress levels were only associated with the past day's report of 10 or more hours of sleep. In almost all cases, the effect of the prior day's behavior - even when statistically significant - was modest, rarely affecting the outcome by more than 1-2 points. While each of the wellbeing outcomes was associated with at least one indicator from the prior day, many of the same-day associations did not carry over to the next.

Table 4: Longitudinal one-day lagged regression analysis of wellbeing outcomes by wellness indicators from the previous day and demographics.

	Wellbeing			**Mood**			**Focus**			**Stress**		
	Std Reg Coeff	Std Err	p-val	Std Reg Coeff	Std Err	p-val	Std Reg. Coeff	Std Err	p-val	Std Reg Coeff	Std Err	p-val
Exercise												
0 min	-	-	-	-	-	-	-	-	-	-	-	-
1-30 min	0.46	0.52	0.38	0.33	0.59	0.58	0.35	0.68	0.60	0.07	0.74	0.92
≥30 min	-0.15	0.49	0.76	0.34	0.56	0.54	0.05	0.64	0.93	-0.16	0.69	0.82
Nutrition	0.39	0.11	0.0003	0.46	0.12	0.0002	0.18	0.14	0.220	-0.26	0.15	0.088
Hydration	0.11	0.09	0.211	-0.07	0.11	0.496	0.33	0.12	0.008	0.24	0.13	0.071
Screen time												
0-1 hours	-0.01	0.62	0.996	-0.69	0.71	0.328	0.7	0.81	0.389	1.15	0.88	0.190
2-3 hours	0.19	0.55	0.733	0.61	0.63	0.332	0.05	0.72	0.939	1	0.78	0.200

4+ hours	-	-	-	-	-	-	-	-	-	-	-	-
Social quality	0.07	0.11	0.518	0.32	0.13	0.016	-0.46	0.14	0.001	-0.13	0.15	0.408
Kindness	0	0.11	0.978	0.13	0.13	0.315	0.43	0.14	0.002	0.14	0.16	0.371
Sleep hours												
0-6 hours	1.09	0.51	0.03	1.29	0.59	0.028	0.32	0.67	0.630	-0.65	0.73	0.375
7-9 hours	-	-	-	-	-	-	-	-	-	-	-	-
10+ hours	-0.87	0.97	0.368	-1.04	1.11	0.326	-2.01	1.27	0.114	2.92	1.38	0.034
Sleep quality	0.08	0.1	0.453	0.28	0.11	0.014	0.23	0.13	0.077	0.05	0.14	0.727
Significant Covariates **		2, 4, 6			2, 6			2, 6			2, 3, 4, 6	

**All models accounted for the following numerically coded covariates: (1) Age (2) Class Year (3) Gender (4) SES (5) Underrepresented in Medicine (6) Day of Week

Discussion

Using 3 months of nightly survey responses, we tested associations between wellness indicators and outcomes among medical students. All wellbeing outcomes varied significantly within a given week: mood and wellbeing improved toward the end of the week, while stress and focus levels peaked in tandem midweek. Each of the wellbeing outcomes was strongly associated with multiple, daily wellness indicators. The effect of various combinations of multiple wellness indicators was typically equal to one standard deviation in the outcome. Findings were consistent across sociodemographic groups. Finally, some wellness indicators had a carryover correlation on next-day outcomes, (e.g., higher nutritional and social quality; limited sleep). Overall, these findings support the complex interplay between multiple behaviors and wellbeing.

In the same-day analysis, social quality had the strongest associations for 3 of the 4 outcomes (positive: wellbeing and mood; negative: stress; not strongest for focus). Longitudinally, social quality was *only* positively associated with mood and negatively associated with focus. Perhaps medical student wellbeing is most impacted by interactions on a single day, and superseded by subsequent experiences. Perceived lack of social support from family, friends, and fellow students has been linked to increased risk for depression, and URiM students experience less social support than non-URiM students[26,27]. As many medical students live far from family and friends, their in-person social support system comprises fellow students, faculty, and staff. Our findings suggest medical schools help students develop these newer social connections and maintain previous connections.

Sleep quality was also strongly associated with multiple wellbeing outcomes. Poor sleep quality has correlated with increased stress and burnout[12,17,19,28,29]. Recent research found poor sleep quality to be an independent predictor of worse mental health[30] . Our findings suggest that increased sleep quality was associated with improved wellbeing, mood, and focus, as well as decreased stress. Consistent with the literature[31], we found sleep quality more closely associated with wellbeing than sleep duration, though both mattered.

Compared to the recommended 7-9 hours[32,33], too little sleep (<7 hours) was associated with increased stress, while too much sleep (>9 hours) was associated with decreased wellbeing, mood, and focus. This mirrors previous research suggesting that too much or little sleep was associated with adverse health outcomes[32,33]. Unfortunately, medical student obligations may conflict with ideal sleep habits. Notably, too little sleep was associated with increased focus, potentially due to evening or overnight clinical shifts. This may be elucidated by the lagged analysis where 0-6 hours of sleep was associated with improved wellbeing and mood, and 10+ hours of sleep with increased stress. Reduced sleep the night before a high stress event might be followed by increased wellbeing when it is over. Additionally, oversleeping leaves fewer active hours, perhaps increasing stress. Conversely, high stress may lead to an increased need for sleep. Research suggests that medical students who get poorer sleep demonstrate higher academic performance[29], which may inflate mood and wellbeing.

Exercise also plays a key role in multiple wellbeing outcomes. Previous research suggested exercise was associated with improved stress[16], decreased burnout risk[12,14] and emotional wellbeing[20]. Our results indicated that participation in exercise was significantly associated

with increased wellbeing, mood, and focus and decreased stress. Elevated mood and decreased stress were found after 30+ minutes, while higher levels of wellbeing and focus were observed with any amount. Students may feel time is a barrier to exercise; however, our results, supported by the literature[35,36], suggested that even a small amount may have positive outcomes. Medical schools should thus provide adequate support, space, and resources to promote student fitness.

Importantly, these indicators had independent positive effects when tested simultaneously, suggesting cumulative effects - more wellness behaviors were associated with better outcomes. Our findings build on the existing literature, which largely supports the importance of a multifactorial and layered approach toward medical student wellbeing. One study found medical students in group fitness classes experienced better outcomes than those exercising independently[34]. Another study showed undergraduate students who participated in multiple wellness-promoting behaviors in a given day exhibited a cumulative positive effect on mood and overall wellbeing[35]. Conversely, the lack of social interaction contributes to reduced exercise, impaired sleep, and therefore, increased risk for disease[36]. Simultaneously practicing multiple wellness behaviors can save time while promoting wellbeing. Ayala et al. surveyed medical students who reported 99 distinct wellness practices that were important to them[37]. Thus, medical schools' approach to wellbeing should allow for the flexibility of choice rather than a "one size fits all" model.

This study helps clarify the relative impact of daily wellness behaviors on student wellbeing and expands knowledge on wellness behaviors less frequently examined: nutrition, hydration, screen time, and kindness. Nightly, longitudinal tracking of multiple

wellness behaviors and wellbeing outcomes in medical students is novel, representing an important step addressing medical student wellbeing. There are limitations, however. First, an Android or iPhone 6s or greater was required for participation, potentially limiting enrollment. Second, the self-selecting sample from one institution may lack generalizability. Demographically, this sample was slightly younger and had a greater number of non-URiM students than the population of LCOM students. Further, participants who followed the required protocol may have differed from those that did not (e.g., held a stronger interest in wellness). These data were self-reported, relying on recall and subjective reflection. Finally, directionality could not be determined in our study (e.g., positive mood may have led students to engage in wellness behaviors).

This study can inform wellbeing initiatives for medical students. Structural interventions (e.g., pass/fail curricula; limiting work hours) are effective, though challenging to implement[38,39]. Given the high stress mid-week, redistributing the workload to prioritize mid-week personal time may help. Further, medical schools can identify regular opportunities for socialization (e.g., team-based learning) given the importance of these interactions. Future research could utilize longer-duration lagged analyses to identify associations between behaviors and outcomes that may occur over longer periods of time. Increased understanding of the additive effects of wellness behaviors will also be important to investigate. The limited impact of demographic differences in this study also requires further exploration. Finally, a controlled trial of the suggested interventions is key in identifying causal relationships. There are unavoidable stressors and challenges that arise within medical education; however, it is in medical schools' best interests to identify ways

to enhance the wellbeing of their students. This study takes important steps toward understanding effective ways to accomplish that goal.

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