ORIGINAL RESEARCH

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Metabolic Health Immersion for Medical Education: A Pilot Program with Continuous Glucose Monitors in Medical and Dental Students

Abstract: *Diet-related chronic diseases are increasing in prevalence and poised to dominate the future careers of current medical students. While the value of nutritionally-informed care and nutrition-based health interventions is increasingly recognized, nutrition education is inconsistently and often inadequately included in medical school curricula. One obstacle to incorporating nutrition into medical and dental school curricula is the density of existing coursework, with incorporation of new material necessitating removal of other material. One solution is to engage students outside the classroom in immersive education in nutrition and metabolism using health-wearables. We report the Metabolic Health Immersion for Medical Education pilot program, spearheaded and designed by Harvard Medical students centering on use of continuous glucose monitors (CGM). Students reported enjoyment with the study, felt encouraged to improve health behaviors, and shared that the experience enhanced their understanding of nutrition and metabolism, was valuable to their medical education, and would influence their future patient care. This study demonstrates proof-of-principle that metabolic health immersion opportunities for health care trainees provide a means of helping to address the current deficit in medical school nutrition education.*

> "The combination of chronically high-stress, long work hours, circadian rhythm disruption, and limited food environment pose an obstacle to physicians achieving better health."

Keywords: Continuous glucose monitors; diabetes; immersive learning; metabolism; nutrition

Introduction

Diet-related chronic diseases are among the leading causes of morbidity and mortality and are

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increasing in prevalence at alarming rates. Diabetes mellitus provides a useful case in point. Currently, 1 in 10 Americans have diabetes.[1] By 2050, some estimates project that 1 in 3 Americans will have diabetes,[2] a tide that will presumably rise in parallel with obesity and other comorbid conditions given their intricately linked pathophysiology. In brief, diabetes and other metabolic diseases related to insulin resistance are on course to comprise a major share of care provided over the careers of current medical students.

Despite this upward trend in the prevalence of diet-related metabolic disorders across the United States, and in countries that have adopted a more post-industrial lifestyle, most medical students still receive minimal instruction on nutrition in the classroom.[3] Furthermore, prior survey studies have demonstrated that physicians are largely dissatisfied with the nutrition education they received during their training. One recent survey of 61 physicians reported that only 14% of physicians felt that they themselves were adequately trained to provide nutrition counseling.[4] In another, 90% of cardiologists reported receiving no or minimal nutrition education during fellowship training,[5] despite nutritional factors accounting for approximately 40% of all cardiovascular disease.[6] And a 2019 systematic review of nutrition education in medical training found that, globally, "nutrition is insufficiently incorporated into medical education, regardless of country, setting, or year of medical education."[3]

There is an urgent need to address the relative absence of nutrition education in medical school curricula. Fortunately, efforts are being made. Perhaps the most public of these has been the McGovern Resolution, an act passed in the U.S. House of Representatives on May 17, 2022, that calls for all medical schools to provide nutrition education.[7] However, integration of nutrition education into medical school curricula ostensibly presents a zero-sum game. Quoting Dr. Stephen Devries, a preventative cardiologist who was instrumental in the development of the McGovern Resolution: *"[P]hysicians typically haven't played a meaningful role in helping to guide patients to better nutrition because they haven't received the nutrition education they need. Medical educators often report that there isn't time in the curriculum to teach nutrition, but somehow time is always found to educate physicians about the latest drugs and procedures."*[7] Medical school curricula have been intentionally designed and undergone iteration to maximize transmission of clinical knowledge to students. To some extent, then, medical education is a zero-sum game, with prioritization of nutrition education necessitating a de-prioritization of other topics. However, there is also room for creative solutions.

A unique aspect of nutrition is that students have the opportunity to naturally engage with nutrition science daily by virtue of being human. To that end, we report on a group of Harvard medical and dental students who organized the Metabolic Health Immersion for Medical Education pilot program, centered on wearing Dexcom G6 continuous glucose monitors (CGMs) for 10–40 days. The notion of using CGMs for medical education has been proposed but, as far as we are aware, has never been formally pursued.[8]

The primary study aims were to create an opportunity for students to develop a deeper mechanistic understanding of the role of diet and metabolism on health and disease, and to reflect on how the lessons learned from this immersive experience reinforce lessons learned in the classroom and how they relate to patient care as measured by structured surveys conducted before and after the immersive experience. We provide proof-of-principle that hands-on, nutrition learning outside the classroom was perceived as fun, engaging, and educationally valuable to medical students, and thus may be complementary to in-class or in-clinic medical school coursework. Many students also felt encouraged to improve their own health practices, raising the possibility that metabolic health immersion programs could improve health care trainee or provider self-health with potential beneficial effects on patient care.

Methods

Study Conception and Ethical Approval

The original study protocol was designed by study implementation leader and co-author (NGN) following on interest expressed by a self-selected group of first-year students at Harvard Medical School (HMS) and Harvard School of Dental Medicine (HSDM). Input was solicited from peers and faculty. Approval was sought from the Institutional Review Board (IRB) of Harvard T.H. Chan School of Public Health (IRB21-1698) and the Educational Scholarship for the Program in Medical Education at HMS. On January 13, 2022, the IRB granted a waiver after determining that the protocol did not constitute human subject research. Thereafter, the Educational Scholarship Review Committee of HMS approved the final clinical protocol. All members of the core cohort provided written informed consent prior to enrollment in the study.

Core Cohort Protocol

A core cohort of 13 first-year medical (n = 10) and dental (n = 3) students volunteered to participate in the initial study set, which included five primary components:

(i) *Blood work:* Broad spectrum bloodwork was drawn for all participants after a 12 hour overnight fast for the purposes of safety screening and to provide students with the opportunity to relate content learned in the classroom to their own health states. A summary of student data is provided in Supplemental Table 1, and the complete set of markers in *Supplemental metabolic markers*. All students underwent a health screening interview with team physician, Dr. Robert Cywes, to discuss their medical histories and concerns.

(ii) *Continuous glucose monitoring*: Students were provided training on the safe application Dexcom G6 CGM and use of the Dexcom G6 phone application by Dr. Cywes and the study implementation leader (NGN), and were encouraged to ask clarification questions about tool use throughout the study. Training included a discussion of appropriate interpretation of glycemic data, including emphasis of the point that normal, adaptive glycemic excursions may be expected in healthy persons as a function of exercise, circadian rhythm, cortisol awakening response, and following carbohydrate-rich meals. Following instructions and training, students wore Dexcom G6 or Dexcom G6 Pro CGMs (Dexcom Inc.) for 30–40 days. 10-day variation amongst some students was due to several opting to donate their final sensors to classmates, so more peers could benefit from the experience (see "study expansion," below). Continuous glucose data were available directly to students via the Dexcom G6 iPhone app for personal use and real-time biofeedback. Group data from the core cohort were collected, with permission, in the Dexcom Clarity Clinical portal for research purposes.

(iii) *Dietary tracking*: Students each kept dietary records. Students were encouraged to choose whatever recording system worked best for them, including hand-written diaries, photo journals, or various diet tracking apps, That is, dietary tracking was not standardized for this pilot. Individual dietary records were not collected and intended for student personal use in facilitating interpretation of their CGM data.

(iv) *Weekly meetings*: Students met weekly for 8 weeks to debrief, reflect on experiences and self-experiments performed with their CGMs, discuss primary literature on diet and human metabolism, and/or engage with patients living with diet-related chronic diseases. Each meeting lasted 1 hour and occurred at a set time. When primarily literature was discussed, manuscript selection was student-directed and determined by popular vote. Specifically, the study implementation leader provided a list of 3–5 recently published primary literature manuscripts that he thought would be of interest to peers from across a range of topics, and voting was carried out over group text message, and all other students were encouraged to propose manuscripts for the vote. Topics were varied and included the use of CGM in diet personalization,[9] the impacts of artificial sweeteners[10] and fermented foods[11] on the microbiome, and the impact of mindset on metabolic response.[12] Patient panels included patients with a variety of conditions that had been treated with lifestyle change, including those with obesity, type 1 and type 2 diabetes, mental health conditions, pulmonary disease, and cancer. All patient panels included at least one physician panelist.

(v) *Student surveys*: At the initiation and completion of the study, students were asked to complete surveys including both qualitative and quantitative questions aimed at how the study activities impacted their understanding and perspective on nutrition and metabolism, as well as their personal dietary habits, and general feedback on the pilot protocol. The survey was generated with input from the core cohort and received feedback from faculty and was approved by the Educational Scholarship Review Committee of HMS. Themes were extracted from survey responses by two of the co-authors (NGN, RC) and are reported below.

Prior Nutrition Education Exposure

There were no requirements for prior exposure to nutrition education for the purposes of this study. By virtue of students having completed at least one full semester of medical school, students had some exposure to foundational principles of human metabolism that intersect with diet and lifestyle, although the core curriculum itself provided no significant classroom time specifically devoted to nutrition. All students also had weekly involvement in some form of primary care clinic, where they may have observed the nutrition counseling of patients; and all students were exposed to publicly disseminated fliers, handouts, and infographics (such as MyPlate) widely available at medical school and hospital cafeterias.

Study Expansion

Shortly after study commencement and following positive experiences of the initial core cohort shared across the HMS and HSDM classes, a broader group of first-year Harvard medical and dental students requested access to CGMs. Although demand exceeded availability, Dexcom Inc. provided an additional 20 Dexcom G6 for student use to include an expanded pool of students. While the expanded pool was not asked to engage in the core cohort protocol, members were asked to complete a brief questionnaire on the quality and impact of the experience after wearing a CGM for 10 days.

Results

To preserve identities and given that demographic comparisons were not of interest in this pilot program, comprehensive demographic characterization of study participants was not pursued outside of the confidential health screening performed by the study physician.

Impact of Wearing CGMs on Student Eating Patterns in the Core Cohort

Although the impact of wearing CGMs on student behavior was heterogeneous, the most common responses were reduction in carbohydrate intake and implementation of time-restricted feeding protocols. The motivation for these dietary adjustments may have included positive biofeedback from reducing glycemic variability, improved feelings of physical wellbeing (see below), pre-existing interest in carbohydrate restriction or intermittent fasting, and/or peer-to-peer influence. Of the 10 students who quantified carbohydrate intake of grains and starches on both intake and completion questionnaires at the beginning and completion of the study, 7 reported reductions in intake of bread, bagels, pastas, potatoes, and/or rice. Several students self-reported voluntarily increasing emphasis on protein at mealtimes; and the single food item for which intake increased most consistently across the group was eggs, followed by chicken. Six participants reported the implementation of some form of time-restricted feeding protocol, such as eating on a 16:8 pattern, which limits intake of foods and calorie-containing beverages to a set window of 8 hours per day. Most students also reported feeling some version of "more in control" or "more cognizant" of their diet (Table 1).

Beyond dietary change, some students felt inspired to improve other health practices, such as getting more sleep or exercise. For instance, a student reported *"When I eat better, I am healthier all-around. I exercise more consistently and prioritize sleep."* Others reported desired weight loss and enhanced athletic performance (running and cycling). Furthermore, students who became aware of potential health risk factors revealed by their screening blood work, primarily vitamin D insufficiency, were inspired to address these issues. 9/13 (69%) members of the core cohort had 25-OH vitamin D3 levels < 30 ng/dl, with 4 (31%) having levels below 20 ng/dl (Supplemental Figure 1). All but one of these students began supplementing with 1000—5000 IU of vitamin D3 of their own volition, with one reporting a substantial subjective improvement in feeling of well-being and mood.

Students express a general sentiment of disappointment with respect to the state of their formal nutrition education and the state of nutrition in healthcare

In the completion survey, student reported a near-universal sense of disappointment with respect to the state of nutrition in healthcare (Table 1). The source(s) of these opinions are outside the scope of this study but can be presumed to be derived from some combination of the minimal nutrition education integrated into the core curriculum, exposure to the nutrition counseling of patients in clinics, and publicly disseminated standard handouts and infographics (such as MyPlate) widely available in hospital public spaces. Themes that arose broadly fit into the categories of informational inadequacy and lack of personalization. Drawing from students' open responses, students reported that dietary advice provided to patients is typically "crude," "cookie-cutter," "surface level," "inadequate," and "prescriptive and not individualized," and that current standard of advice focused on energy balance and "calories in – calories out" is "oversimplified" and "misleading," for patients. No students reported satisfaction for the state of nutrition in healthcare.

Students in the core and expanded cohorts report positive experiences with CGMs and that it enhanced their understanding of metabolic health and disease

Overall, members of the core cohort were enthusiastic about their experience with the CGMs, with a majority strongly agreeing with the statements that the immersive experience "enhance[d] [their] understanding of metabolic health and disease," and "will influence the way [they] practice medicine" (Table 1).

In the expanded cohort of students, all agreed or strongly agreed that wearing a CGM for 10 days gave them insights into their body's response to food, enhanced their medical education, and will help them better serve patients in the future. Moreover, 65% felt encouraged to change their own eating behaviors, and all agreed that future medical students should be provided with the opportunity to

Table 1.

Student quotes. Students quotes from the core cohort (n = 13) drawn from completion questionnaires.

Impact of wearing continuous glucose monitors on student eating patterns
• I'm more cognizant of reducing snacking and drinking sugary drinks like boba during the night as it causes huge spikes and variability throughout my day.
• [I] stopped eating rice [and] cut out most processed foods. [I] Feel more in control of my diet.
• I'm trying to snack less and eat more protein in meals to keep myself satiated for a longer period and have more stable glucose levels.
• I have also sought to decrease by simple carb intake, as I found that I had dramatic glucose spikes, and subsequent fatigue, when consuming large amounts of simple carbs.
• One of the most important, lasting impacts of this study on my diet, however, is my ability to resist binge eating when I feel "hypoglycemic." Prior to this study, I often felt spells of strongly craving carbs, which I interpreted as being hypoglycemic. However, I learned from the CGMs that these feelings were not actually correlated with low blood sugar. I have since been able to resist the urge to eat quickly and in high volumes during these time periods.
• The experiment made me more conscious of what I was consuming.
• This experience has definitely changed my eating habits—after seeing how avoiding rice and carbs in general curbed my glucose response, I was more inclined to eat low-carb meals for lunch and dinner… I think my definition of "healthy eating" now includes a sense of foods' glycemic indices and their associated glucose spikes in a way that it didn't before.
• I tried to eat a low-carb diet and maintain an 11am-7pm time-restricted feeding pattern; I adhered to this only modestly. However, on the chunks of days that I did manage to maintain this, I definitely noticed a boost in my energy/mood and was pleased to see a much more stable/flat glucose trace.
• Before my CGM experience, I would most likely eat some sort of snack or breakfast in the morning. I would have a banana with peanut butter, or a bagel with cream cheese if I am hungrier. But after the CGM experience, I stopped feeling like I "have to" have something because my blood sugar is very leveled, and I feel the most focused. I realized that I feel the least focused and productive when my blood sugar is high. When my blood sugar is level between 70-90, I feel and function my best.
• [My] habits have changed since starting this experience in 2 ways. The major change has been to avoid high-glycemic load carbohydrates… I have been paying more attention to the times at which I consume food.
• When I eat better, I am healthier all-around. I exercise more consistently and prioritize sleep and sleep regularity.
Student attitudes to dietary advice given by the medical system to patients
• I believe that the dietary advice given by the medical system is misleading.
• I am shocked at how current dietary guidelines seem to totally miss the mark and have not caught up with the simple idea that high glycemic index foods should be largely avoided. I don't think that most people think in terms of how what they eat affects their blood glucose, but this seems foundational to me now.
• I feel like the counseling is often prescriptive and not individualized.
• I am still disappointed, at best, with the standard medical dietary advice. This experience has highlighted how much improvement needs to be made.
• I already knew before I started this experience that we are giving extremely flawed advice to patients. The dietary guidelines are cookie-cutter, high carb, and low fat. This does not work for most people. When it fails, many times, the clinician would blame the patient instead of the guidelines. It's simple and convincing to believe in calorie in and calorie out, but like many aspects in medicine, that is just too surface-level.
• While I have become aware that the advice we give is largely incomplete, and may be based too dogmatically in CICO [calories in - calories out], I have also begun to perceive that the medical system does not really have faith in patients to adhere to a diet plan, which likely leads to

(continued)

Table 1. (continued)

complacency in the quality of advice that is given. Ironically, it may be the incomplete advice itself that generates some of the failure to adhere to diet plans.
• I think the dietary advice given to patients still has a long way to go in terms of providing effective interventions and knowledge. Given that our own curriculum currently states that hypocaloric diets are the only proven effective method for weight loss makes me feel that there is still a large gap in understanding within the link between nutrition and health. Additionally, I'm skeptical about weight loss being used as the primary goal to health and find that there could be more accurate metrics to document and quantify health goals.
• I think that the current guidelines revolve around MyPlate and eat less and move more. I believe this to be an oversimplified form of talking about nutrition and wellness.
Impact of wearing a glucose monitor on the way students will practice medicine
• I never would have understood what patient's experience with a CGM without having gone through it myself.
• I think this experience has made me more mindful about the connection between diet and health and I hope to use this knowledge to help my patients.
• I will definitely be thinking about the ways that a CGM could help my patients. Especially those that are struggling with weight or energy throughout the day. [Observing] the graph of what my sugars were doing when I was feeling tired was very informative for what I was consuming and think that it could help my patients too!
• I have become more aware of the role that food selection has in creating health, and will more strongly incorporate lifestyle interventions into my future recommendations.
• This experience has given me a first-hand look at what being more mindful and data-driven about one's eating habits [can do for health]; I'll be better able to communicate and educate my patients from this experience.
• I definitely think [having worn a glucose monitor] will impact the way I practice medicine. I learned that nutrition is not a cookie cutter science (is any part of medicine, really?) and it needs to be extremely individualized. I would not hesitate to recommend the CGM to my patients so they can learn how their body reacts to different foods.
• Participating in this project undoubtedly enhanced my learning experience in the classroom, and my ability to relate to patients in clinic… Moreover, it reinforced my belief that we ought to educate patients and provide opportunities for learning *before* they are diagnosed with a condition like type 2 diabetes.

wear CGMs as an immersive experience in metabolic medicine. (Figure 1).

Student Feedback Provides Direction for Future Immersion

In the completion survey, students were asked how the immersion experience could be improved. Themes that emerged included (i) deeper and/or guided group analysis of the CGM data and (ii) implementation of group interventions. With respect to the latter, different students independently suggested engaging in a group sleep study, stress test, exercise class, or dietary intervention.

There was a clear appreciation for the community aspect of the experience. As articulated by one student, *"I enjoyed being in the study with my friends so that we can talk about the experiences we have had together. I think that it could have been an isolating time to have done it all alone."* And students overall felt that similar experiences should be provided to fellow healthcare practitioners. As stated by another, *"I loved this experience! I wish it could be available for more people and doctors who are practicing now. Many doctors are giving patients advice that won't benefit their metabolic health, and I think the healthcare system needs to use the CGM more. I would like to engage in similar experiences in the future."*

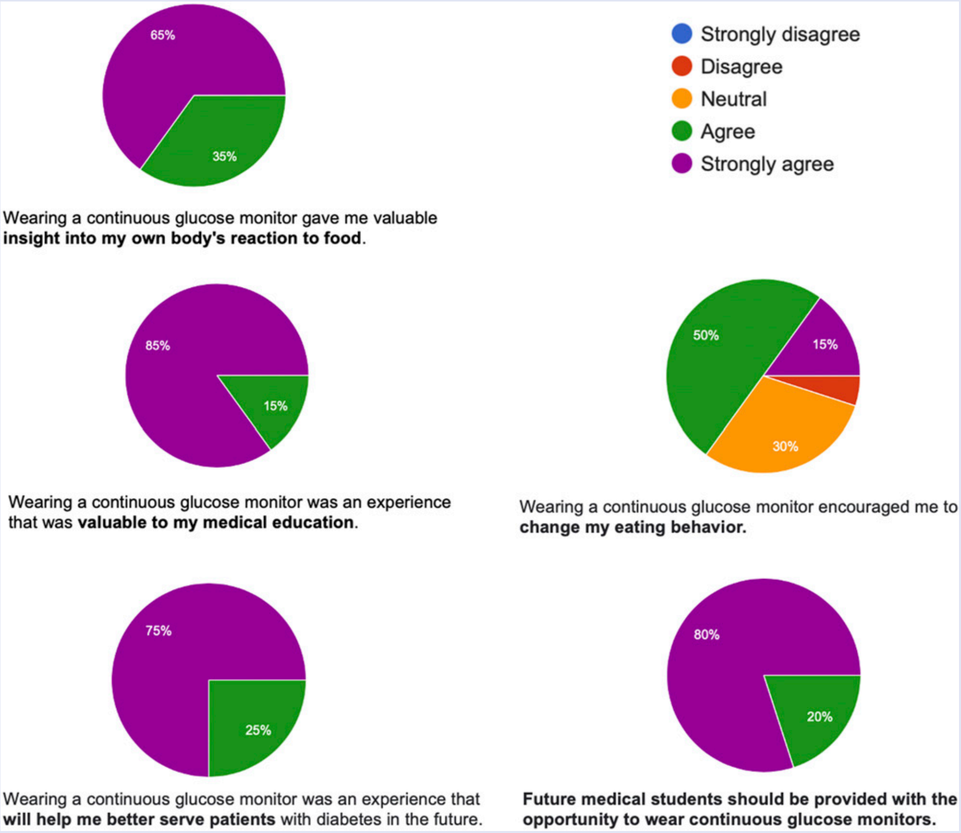
Thus, future metabolic health immersion programs may consider emphasizing the community aspect of the project, including small group analyses of personal CGM data or shared experimental lifestyle interventions.

Discussion

In this Metabolic Health Immersion for Medical Education pilot program, conducted with a core cohort of 13

Figure 1.

Expanded cohort student survey. All student members of the expanded cohort who responded to the survey (n = 20) agreed or strongly agreed that wearing a continuous glucose monitor provided them with insights into their body's reactions to foods, was valuable to their medical education, will help them better serve their patients, and that future students should have access to similar opportunities, when possible. The majority felt wearing a monitor encouraged them to change their eating behavior.



medical and dental students at Harvard Medical School during the first half of 2022, participants wore CGMs for approximately one month and engaged in weekly discussion sessions. Overall, students endorsed the student-designed, student-led extracurricular program as considerably enhancing their understanding of nutrition within medical education, and an experience that will lead to their more intentional incorporation of nutritional health into patient care. Additionally, most students reported being more cognizant of and engaged in taking care of their personal health. Some altered their eating behavior to stabilize blood glucose and noted enhanced mental performance. Others were inspired to sleep better or exercise more as a result either of forced reflection on their health or perceived impact on their glycemic response (Table 1). Together, these student reflections the potential for immersive metabolic health experiences to both inspire self-health and enhance medical education for future physicians and dentists.

There is a strong body of literature demonstrating that physicians who care for themselves are better equipped to care for patients. Physicians or trainees who engage in health practices in their own lives, such as exercise, healthy eating, avoiding tobacco or alcohol, seatbelt use, are more likely to counsel patients on these topics.[13-15] And, physicians who are perceived by patients to be healthy and/or who disclose their own health practices are more successful at counseling patients to adopt lifestyle change.[16] The converse is also true. For example, physicians who identify as overweight report four-fold greater difficulty counseling compared to average weight physicians.[17] (An aside, but important caveat here, is that it is unlikely the case a physician's body habitus impacts the quality of advice they provide, but rather that pervasive weight stigma, buoyed by a poor understanding about nutrition and metabolic health, negatively impacts physician self-image and biases patients against what may be sound advice. This only further highlights the need for better tools for evaluating health status beyond the scale, including CGMs). Thus, it is important for physicians and medical students to take care of themselves, not only because it can help them operate with a greater degree of physical and mental efficiency, but also because of the knock-on behavioral impact it can have on the effectiveness of patient care.

However, as stated by a recent review article in the *American Journal of Lifestyle Medicine: "[h]ealth care professionals represent a population at high risk for poor health."*[18] The combination of chronically high-stress, long work hours, circadian rhythm disruption, and limited food environment pose an obstacle to physicians achieving better health. Perhaps, part of this is unavoidable. For instance, if training demands shifts lasting 24 hours, some sleep deprivation is inevitable. However, one could fairly argue that there is culture of "health martyrship" within medicine that also makes achieving good health more difficult for health care workers.

Addressing "health martyrship" within medicine will require major cultural change; however, compelling medical students (or healthcare professionals at any career stage) to reflect deeply on their own health through health wearables, like CGMs, and metabolic immersion provides a means for encouraging the next generation of doctors to practice preventative medicine on themselves. As a result, they may be more likely to counsel patients on lifestyle interventions, and serve as examples themselves. While currently a speculative and non-quantifiable benefit of metabolic immersion programs for medical students, it may nonetheless prove invaluable in helping to attenuate the rising tide of diet-related diseases.

Strengths and Limitations

This pilot study has several strengths and limitations. Strengths include that (i) This immersive program took advantage of wearable technology to engage students in nutrition education outside the classroom, thus providing a means of integrating nutrition education without the need to sacrifice current classroom material; (ii) Students had the opportunity to use their teachings to improve their own health via real-time biofeedback, and many did so; (iii) Students appreciated the community aspect of the project; and (iv) The project was initiated and led by medical students, demonstrating the degree of enthusiasm for further incorporation of nutrition education into medical school curricula that exists amongst current students and is complementary to efforts being made by faculty.

Limitations include that (i) CGM devices are expensive and, thus, may limit the scalability of this project if not provided by donation or funded through institutions, although the use of more affordable monitor options may attenuate this issue; (ii) Qualitative data collecting methods were limited to student self-report without objective measures of trainee counseling frequency or efficacy, which were beyond the scope of this project; (iii) The group of students was self-selected and therefore might not be generalizable to the larger student body; and (iv) CGM were chosen as the primary tool for the metabolic health immersion program. As such, glycemic variability was the de facto primary operationalized variable by which students could self-assess "metabolic health" and adjust dietary/lifestyle patterns on a daily basis. Thus, students may have been led to alter dietary/lifestyle pattern under the perception that reducing glycemic variability is intrinsically healthier, which may not necessarily be the case, particularly in a population of young persons without obesity or pre-diabetes.

Conclusions

Trends in population health and opinions amongst practicing doctors and medical trainees highlight a clear requirement for and consensus that enhancing the quantity and quality of nutrition teachings in medical education is a necessity. While this should include a re-prioritization of core curricula, immersive group experiences among trainees provide another way to educate on diet and metabolism. In this student designed and led pilot study centered around the use of CGMs, we provide first proof-of-principle that metabolic immersive experiences can engage students and enhance medical school education in nutrition. With continued innovations in health wearables, the possibilities for innovation in metabolic immersion are becoming increasing expansive. Programs today could include, not only CGMs, but heart rate variability monitors, sleep trackers, or continuous ketone monitors. Studies tomorrow might include continuous cortisol measures or day-to-day microbiome composition analyses. Devoting resources to developing similar metabolic health immersive experiences could help the next generation of doctors better serve their patients, with the ultimate aim of addressing the worsening epidemic of diet-related chronic diseases.

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Author Contributions

NN served as study lead and coordinator, drafted study design, recruited participants, distributed CGM, and organized study meetings, and led writing, analysis, and figure and table creation. MC supported NN in organizing study meetings and editing the manuscript. HD served as principal investigator, providing oversight and counsel. MH served as a director of the core curricula for medical and dental students through during the study period and provided edits on the manuscript. RC was chiefly responsible for ordering lab work and acquiring glucose monitors for students, as well as for providing safety screening and medical safety oversight throughout the study. All authors provide input to and approved the final version of the manuscript.

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Supplemental Material

Supplemental material for this article is available online. AJLM

References

1. *Type 2 Diabetes*. Centers for Disease Control and Prevention. 2021. https://www.cdc.gov/diabetes/basics/type2.html
2. Boyle JP, Thompson TJ, Gregg EW, Barker LE, Williamson DF. Projection of the year 2050 burden of diabetes in the US adult population: Dynamic modeling of incidence, mortality, and prediabetes prevalence. *Popul Health Metr*. 2010;8:29. doi:10.1186/1478-7954-8-29
3. Crowley J, Ball L, Hiddink GJ. Nutrition in medical education: A systematic review. *Lancet Planet Health*. 2019;3(9):e379-e389. doi:10.1016/S2542-5196(19)30171-8
4. Vetter ML, Herring SJ, Sood M, Shah NR, Kalet AL. What do resident physicians know about nutrition? An evaluation of attitudes, self-perceived proficiency and knowledge. *J Am Coll Nutr*. 2008;27(2):287-298. doi:10.1080/07315724.2008.10719702
5. Devries S, Agatston A, Aggarwal M, et al. A deficiency of nutrition education and practice in cardiology. *Am J Med*. 2017;130(11):1298-1305. doi:10.1016/j.amjmed.2017.04.043
6. Tappia PS, Blewett H. Nutrition and cardiovascular health. *Int J Mol Sci*. 2020;21(7). doi:10.3390/ijms21072284
7. *McGovern Resolution on Nutrition Education in Medical Schools Passes House*. 2022, mcgovern.house.gov
8. Eisenberg DM, Burgess JD. Nutrition education in an era of global obesity and diabetes: thinking outside the box. *Acad Med*. 2015;90(7):854-860. doi:10.1097/ACM.0000000000000682
9. Zeevi D, Korem T, Zmora N, et al. Personalized nutrition by prediction of glycemic responses. *Cell*. 2015;163(5):1079-1094. doi:10.1016/j.cell.2015.11.001
10. Suez J, Korem T, Zeevi D, et al. Artificial sweeteners induce glucose intolerance by altering the gut microbiota. *Nature*. 2014;514(7521):181-186. doi:10.1038/nature13793
11. Wastyk HC, Fragiadakis GK, Perelman D, et al. Gut-microbiota-targeted diets modulate human immune status. *Cell*. 2021;184(16):4137-4153.e14. doi:10.1016/j.cell.2021.06.019
12. Crum AJ, Corbin WR, Brownell KD, Salovey P. Mind over milkshakes: mindsets, not just nutrients, determine ghrelin response. *Health Psychol*. 2011;30(4):424-429; discussion 30-1. doi:10.1037/a0023467
13. Rogers LQ, Gutin B, Humphries MC, et al. Evaluation of internal medicine residents as exercise role models and associations with self-reported counseling behavior, confidence, and perceived success. *Teach Learn Med*. 2006;18(3):215-221. doi:10.1207/s15328015tlm1803_5
14. Frank E, Galuska DA, Elon LK, Wright EH. Personal and clinical exercise-related attitudes and behaviors of freshmen U.S. medical students. *Res Q Exerc Sport*. 2004;75(2):112-121. doi:10.1080/02701367.2004.10609142
15. Lewis CE, Clancy C, Leake B, Schwartz JS. The counseling practices of internists. *Ann Intern Med*. 1991;114(1):54-58. doi:10.7326/0003-4819-114-1-54
16. Oberg EB, Frank E. Physicians' health practices strongly influence patient health practices. *J R Coll Physicians Edinb*. 2009;39(4):290-291. doi:10.4997/JRCPE.2009.422
17. Perrin EM, Flower KB, Ammerman AS. Pediatricians' own weight: Self-perception, misclassification, and ease of counseling. *Obes Res*. 2005;13(2):326-332. doi:10.1038/oby.2005.44
18. Holtzclaw L, Arlinghaus KR, Johnston CA. The health of health care professionals. *Am J Lifestyle Med*. 2021;15(2):130-132. doi:10.1177/1559827620977065