

Sleep and Health in Student Athletes:

Next Steps Toward Developing a Technology Platform for Dissemination and Implementation

Problem Statement

Poor sleep health among student athletes continues to be an under-addressed problem. This may arise through a broad range of physiologic, social, and environmental pressures, including long hours, additional stress, travel burden, and other sources. These can lead to changes in sleep health that can impair current and future physical and mental health and quality of life. In the general population, insufficient sleep duration and poor sleep quality are strongly associated with the development of cardiometabolic disease risk factors¹⁻⁴, obesity⁵⁻¹⁰, depression¹¹⁻²¹, anxiety disorders²²⁻²⁵, alcohol use²⁶⁻²⁹, other substance use^{27, 30-32}, poorer academic performance³³⁻³⁶, and reduced mental well-being^{37, 38}, in addition to poorer athletic performance³⁹⁻⁴⁶.

In data from student athletes in the American College Health Association from 2011-2014, when asked about access to health-related information, sleep was one of the most infrequently-provided domains of information,⁴⁷. Yet, more than half of the student athletes reported that they wanted more information about sleep, more than nearly all other categories of information. In addition, sleep problems were common, such that 19.8% reported that sleep difficulties had been “traumatic or very difficult,” 21.8% reported “extreme difficulty” falling asleep ≥ 3 nights/week, and 57.0% indicated that they got enough sleep to feel rested on ≤ 3 nights/week (20.4% ≤ 1 day/week). Regarding daytime consequences, 60.9% reported extreme tiredness ≥ 3 days/week and 17.7% reported that sleep difficulties interfered with academics. Additional data from this cohort shows that poor sleep was also associated with lower academic performance⁴⁸, worse mental health⁴⁹, increased substance use⁵⁰, and increased risky behaviors while drinking⁵¹.

For this reason, we developed Project REST (Recovery Enhancement and Sleep Training) to be a program that can improve sleep among student athletes, despite the many situational constraints. The original Project REST study pilot study included educational, tracking, support, and motivational enhancement. This combination produced strong results, including 77 minutes increased sleep duration, 10% increased

sleep efficiency, 55% improvement in sleep latency, 40% improvement in insomnia symptoms, 80% reduction in drowsy driving, and 21% improved overall energy level^{52, 53}.

Following the original Project REST study, we conducted a thorough program evaluation to determine what elements of the original program should be retained and which could be improved⁵⁴. We then surveyed additional student athletes, coaches, and staff to determine what content, and in what format, the new version should include. There was a strong preference an online platform of on-demand videos that can be watched at any time, rather than an in-person class session. Feedback noted that these videos should be accompanied by handouts and specific exercises to practice. Based on iterative focus groups, we arrived at a core set of 30 brief (<5 minutes) videos (including 10 core videos that all students should watch), 20 handouts, and 20 exercises to improve sleep and promote relaxation. Thus, based on this extensive qualitative assessment, a clear plan for content development was presented.

Accordingly, the proposed project aims to build on the successful Project REST program that was successful in a small group of student athletes and build it into a platform that can reach a much wider audience. Further, this proposal aims to test the new platform in N=50 student athletes in order to evaluate the utility of this approach and prepare it for wider dissemination.

AIM 1: Develop an online, disseminable sleep health education program.

The initial Project REST intervention would be difficult to disseminate across a large number of students or institutions. This Aim will facilitate increasing access by creating an online system of on-demand videos, worksheets, and exercises for promoting healthy sleep, based on the content of the previous version of the program and extensive feedback.

AIM 2: Determine whether this new online sleep health intervention is associated with improvements in mental and physical well-being, compared to information only.

HYPOTHESIS 2A: An online sleep health program including videos, handouts, and exercises will demonstrate high acceptability and feasibility.

HYPOTHESIS 2B: A sleep health intervention delivered using online educational tools will result in improved sleep quality over the course of 6 weeks, compared to information only.

HYPOTHESIS 2C: Improvements in sleep will be correlated with improvements in mental well-being, physical well-being, social functioning, stress, and mood.

Description of Campus-Level Pilot Program

This project had two phases: Phase 1 was the development of the materials for the online Project REST platform, and Phase 2 was an initial pilot study testing the new online platform.

The materials for Phase 1 were developed based on the prior version of the Project REST

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content. There were some limitations of the original protocol. In particular, since educational content was delivered in a one-time in-person workshop setting, and the materials were not continually available to student athletes. Thus, the main goal of this project is to use the experience of the original Project REST study and translate it into an online platform that can be disseminable to a much wider group, and across institutions.

The activities during Phase 1 of the project included partnering with University of Arizona Biocommunications to develop the website platform and record the online videos to be made available to student athletes. The structure and function of the website and the content of the educational materials will be driven by our preliminary qualitative program evaluation data. This will allow for the development of an online-based program that can be widely disseminable across institutions.

Phase 2 included a pilot study of this newly-developed online intervention, with additional assessments for data collection purposes. Recruitment of N=50 student athletes was attempted. These participants would be randomized to either the Project REST website or informational handouts about sleep (N=25), based on the information presented in the videos. They will be asked to complete questionnaires at the start and end of the study to evaluate outcomes, and they will participate in the online program for 4-6 weeks. During this time, they will collect daily sleep diary data. At the end of the study they will complete a final questionnaire to assess outcomes. The questionnaires included:

Demographics,

Health History,

Sleep Duration and Quality (Pittsburgh Sleep Quality Index (PSQI)⁵⁵, Sleep Disorders Questionnaire (SDQ)⁵⁶, Insomnia Severity Index (ISI)⁵⁷, Multivariable Apnea Prediction (MAP) Index⁵⁸, and the sleep items from the National Health and Nutrition Examination Survey (NHANES)⁵⁹),

Mental and Physical Well-Being (CDC Health-Related Quality of Life Scale (HRQOL)⁶⁰),

Social Functioning (Multifactorial Scale of Perceived Social Support (MSPSS)⁶¹),

Mood and Depression (Positive and Negative Affect Scales (PANAS)⁶², Centers for Epidemiological Studies Depression Scale (CESD)⁶³),

Stress (Perceived Stress Scale (PSS)⁶⁴),

Substance Use (Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST)⁶⁵),

Time and Travel Demands (school, practice, and travel schedules), and

Academic Stress (academic performance and anxiety)

Then, they were randomized to either the online condition or an information-only condition. Those in the online condition had access to the website, were asked to view the core educational content within the first week, and were asked to regularly access the supplementary educational content, handouts, and exercises. Those in the information-only condition got a set of handouts on healthy sleep habits. Both groups also completed a daily sleep diary on smartphone or computer.

At the end of the 6-week period, all subjects completed baseline questionnaires again to evaluate pre-post changes and completed an additional survey of feasibility / acceptability / perceived impacts. All participants were paid \$50 for their participation.

Since this was considered a pilot study and is likely underpowered, the primary outcomes were assessed descriptively. Since all students completed the survey at both the beginning and end of the intervention period, exploratory analyses can assess differences in outcomes between those who received the online intervention and those that did not.

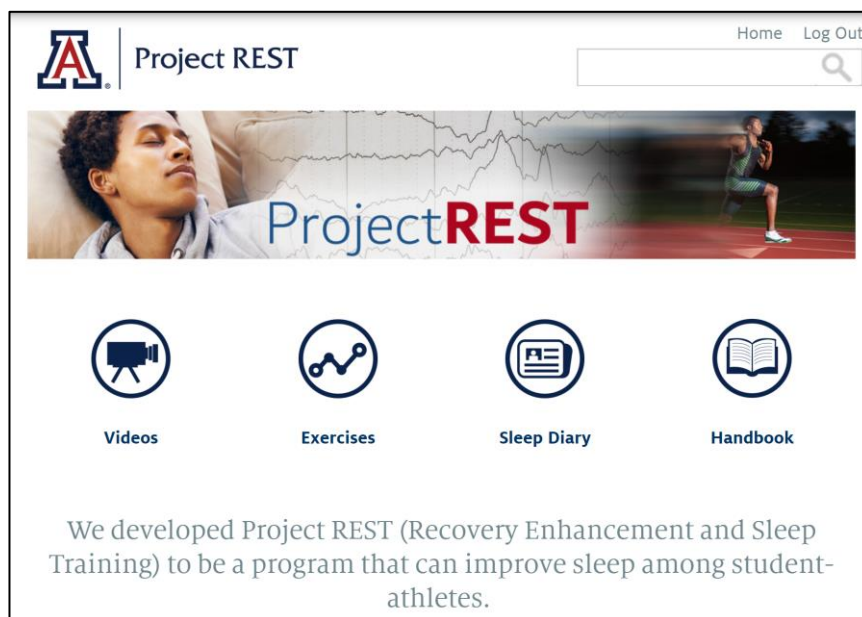
Results of the Program

A total of 38 videos were recorded, totaling 189 minutes and 38 seconds of video content. These videos were recorded with the assistance of the Biocommunications office. The videos (and runtimes) included:

<u>Part</u>	<u>Video</u>	<u>Title</u>	<u>Duration</u>
1	Intro	REST Series Introduction	1:16
	1	What is Sleep	7:21
	2	What are Sleep Stages	7:23
	3	Sleep Wake Regulation	8:58
	4	Biological Rhythms, Health and Performance	8:00
	5	Importance of Sleep	7:10
2	Intro	Identifying Sleep Problems	0:14
	1	Insufficient Sleep and Sleep Deprivation	8:47
	2	Recognizing and Dealing with Insomnia	6:36
	3	Circadian Rhythm Problems	7:40
	4	Sleep Apnea	5:22
	5	Other Sleep Problems	10:42
3	Intro	Sleep Strategies	0:09
	1	Healthy Sleep Habits	8:03
	2	The Power of Stimulus Control	12:01
	3	How to Fall Asleep Faster	8:07
	4	How to Get Out of Bed in the Morning	5:12
	5	Strategic Napping	4:16
	6	Electronic Devices and Sleep	4:47
	7	Travel and Jetlag	6:41
	8	Dealing with Insomnia The Night Before Competition	1:26
	9	Maximizing Sleep Efficiency	3:20
	10	Using Caffeine Effectively	4:31
	11	When and How to Use Melatonin	6:05
	12	Alcohol and Sleep	3:51
	13	Supplements and Sleep	3:32
	14	Taking Control Over Your Sleep	7:26

4	Intro	Sleep in Athletes	0:09
	1	Sleep Deprivation and Athletic Performance	2:19
	2	Sleep Deprivation and Mental Performance	5:39
	3	Sleep Deprivation and Decision Making	3:00
	4	Sleep Deprivation and Pain Management	2:11
	5	Sleep Deprivation and Burnout	1:33
5	Intro	Tracking and optimizing	0:05
	1	Optimizing and Over Optimizing Sleep	2:43
	2	Wearables and Sleep	8:06
	3	Completing Your Sleep Diary	4:14
	4	REST Series Conclusion	0:43

A website was developed to provide online access to video content, exercises, handouts, and other information. The URL for this website was provided to all participants randomized to the website condition. Further, the website was



set up so that only the university credentials of individuals who were in that condition were valid for the website (controlling access and restricting access from other users).

A total of N=44 individuals were recruited to participate in the study, with N=22 randomized to each group. Characteristics of these individuals, stratified by group, are presented as follows:

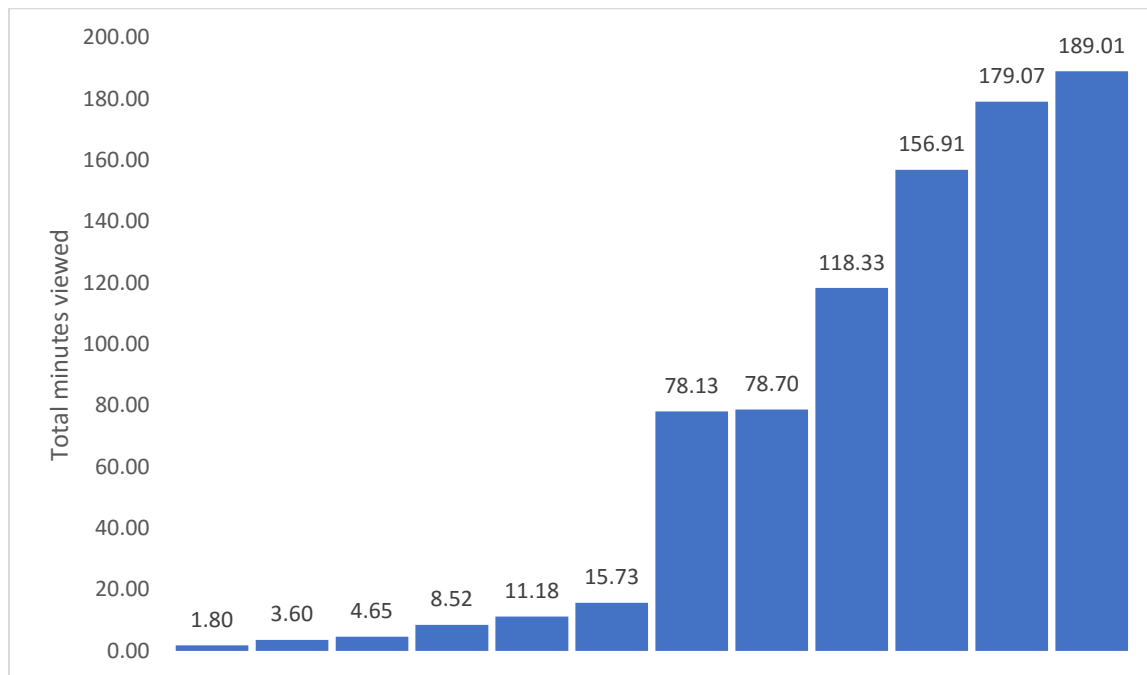
Variable	Category / Units	Complete Sample	Info Only	Online Access	p
Age	Years	20.1±3.3	20.5±1.4	19.7±4.5	0.4089
Sex	Male	38.64%	18.18%	59.09%	0.0053
	Female	61.36%	81.82%	40.91%	
Minority	No	77.27%	90.91%	63.64%	0.0309
	Yes	22.73%	9.09%	36.36%	
Off-Campus Housing	No	27.27%	31.82%	22.73%	0.4984
	Yes	72.73%	68.18%	77.27%	
GPA	A+	4.55%	4.55%	4.55%	0.4734
	A	27.27%	36.36%	18.18%	
	A-	18.18%	9.09%	27.27%	
	B+	18.18%	22.73%	13.64%	
	B	22.73%	18.18%	27.27%	
	B-	6.82%	9.09%	4.55%	
	C-	2.27%	0.00%	4.55%	
Year in School	Freshman	18.18%	18.18%	18.18%	0.9007
	Sophomore	18.18%	18.18%	18.18%	
	Junior	22.73%	22.73%	22.73%	
	Senior	38.64%	36.36%	40.91%	
	Fifth-Year	2.27%	4.55%	0.00%	

There were some differences between the groups in that the information only group had a greater proportion of women and minority students randomized to that group.

A number of different sports were included, including Women's Basketball (N=2), Cross Country / Track and Field (N=3), Golf (N=1), Gymnastics (N=6), Softball (N=3), Swimming (N=7), Tennis (N=1), and Volleyball (N=4), and Men's Baseball (N=5), Cross Country / Track and Field (N=3), Golf (N=1), and Swimming (N=8).

Of the N=22 students given access to the online videos, only N=12 (55%) ever actually logged on to view any video content. And of the N=12 student athletes who accessed the online videos,

the total video viewing time was $M=70.46$ mins ($SD=73.61$), with a range of 1.80mins to 189.01mins. Of those that viewed the video content, one half ($N=6$) were classified as “high-viewers” ($M=133.36$ mins, $SD=49.00$) and half ($N=6$) were classified as “low-viewers” ($M=7.58$ mins, $SD=5.25$). The difference in viewing time was statistically significant between groups ($t(10) = -6.25$, $p=0.0001$).



Regarding how long each video was watched, this was assessed in two ways, unviewed counted as 0 minutes viewed and unviewed counted as missing. The former captures the amount watched across the sample, and the latter captures the amount watched among those that accessed that video.

Video	Unviewed = 0mins		Unviewed = missing		
	Mean	SD	N	Mean	SD
Part 1, Intro	0.96	0.59	9	1.27	1.27
Part 1, Video 1	4.70	3.37	12	4.70	4.70
Part 1, Video 2	4.00	3.45	10	4.79	4.79
Part 1, Video 3	4.94	5.77	8	7.41	7.41

Part 1, Video 4	4.28	5.28	7	7.34	7.34
Part 1, Video 5	3.19	3.54	7	5.48	5.48
Part 2, Intro	0.14	0.11	9	0.19	0.19
Part 2, Video 1	4.01	4.44	7	6.88	6.88
Part 2, Video 2	2.89	3.28	6	5.78	5.78
Part 2, Video 3	3.57	3.84	6	7.13	7.13
Part 2, Video 4	3.29	4.09	7	5.64	5.64
Part 2, Video 5	4.81	5.28	7	8.24	8.24
Part 3, Intro	0.05	0.07	6	0.10	0.10
Part 3, Video 1	9.78	12.49	8	14.67	14.67
Part 3, Video 2	3.43	5.04	6	6.86	6.86
Part 3, Video 3	2.28	3.68	6	4.56	4.56
Part 3, Video 4	1.47	2.29	6	2.94	2.94
Part 3, Video 5	1.20	1.90	4	3.60	3.60
Part 3, Video 6	1.14	1.83	6	2.29	2.29
Part 3, Video 7	1.65	2.61	6	3.31	3.31
Part 3, Video 8	0.30	0.54	0	0.00	0.00
Part 3, Video 9	0.70	1.28	6	0.59	0.59
Part 4, Intro	0.04	0.06	6	1.41	1.41
Part 4, Video 1	0.55	0.87	5	0.11	0.11
Part 4, Video 2	1.10	2.16	6	1.09	1.09
Part 4, Video 3	0.63	1.14	5	2.63	2.63
Part 4, Video 4	0.66	0.99	5	1.50	1.50
Part 4, Video 5	0.47	0.67	5	1.59	1.59
Part 5, Intro	0.04	0.06	6	0.94	0.94
Part 5, Video 1	0.75	1.21	4	0.11	0.11
Part 5, Video 2	1.85	3.17	5	1.81	1.81
Part 5, Video 3	1.40	1.88	6	3.70	3.70

Part 5, Video 4	0.20	0.30	6	2.79	2.79
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Due to the small cell sizes, statistical analyses are underpowered. A summary of change scores for main outcome measures was as follows:

		Info Only		Online (Non-Viewer)		Online (Viewer)	
Variable	Units	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Sleep Latency	Minutes	-7.33	10.82	-9.67	10.71	-5.00	8.10
Sleep Duration	Hours	1.25	3.13	0.38	0.41	0.71	0.58
PSQI Score	Points	-1.33	1.73	-0.83	1.17	-1.00	2.10
ISI Score	Points	-2.00	3.64	-3.50	8.19	-1.17	3.71
MSPSS Score	Points	-6.56	21.10	-3.33	4.41	-5.00	9.74
CESD Score	Points	-0.78	4.71	-1.83	3.13	0.17	2.48
PSS Score	Points	-1.89	3.82	-1.83	2.32	1.83	3.54
ASSIST Score	Points	-1.44	4.03	-1.67	2.88	0.17	2.04

Additional questionnaires were obtained but did not contain enough variability for meaningful analysis.

Overall nominal changes were observed, such that sleep latency decreased in all groups, sleep duration increased in all groups, PSQI score decreased in all groups (indicating that sleep quality improved), and ISI score decreased in all groups (indicating that insomnia severity was lowered). Many of these observed differences met minimal clinically-relevant cutoffs (5 mins for sleep latency, 30 mins for sleep duration, 1 point for PSQI, and 1 point for ISI). Some nominal changes for mental health outcomes were observed, but these were often minimal, except for MSPSS score which nominally decreased for all groups, suggesting decreased social support.

Regarding feedback (1-10 scale), those in the information only group reported that the handouts were helpful (M=7.3), learning about sleep science was helpful (M=8.3), the initial

survey was helpful (M=7.3), and learning about sleep tips was helpful (M=8.6). Those in the website group indicated that the website was helpful (M=5.8 non-viewers, M=7.7 viewers), that the initial survey was somewhat helpful (M=4.7 non-viewers, M=6.3 viewers), learning about sleep science was helpful (M=6.5 non-viewers, M=8.7 viewers), and learning about sleep tips was helpful (M=7.3 non-viewers, M=9.2 viewers).

In describing what they had learned from the program, participants recorded the following:

	Info Only	Videos (Non-Viewers)	Videos (Viewers)
How sleep is important to health	100%	83%	100%
How sleep is important to daytime functioning	100%	83%	100%
How sleep is important to athletic performance	100%	83%	100%
How sleep is important for mental well-being	100%	83%	100%
How to tell if my sleep is good or bad	100%	67%	100%
How I actually sleep	100%	67%	83%
How good or bad sleep affects the next day	100%	67%	100%

In describing whether they report that the program resulted in perceived changes to aspects of their sleep, they reported:

	Info Only	Videos (Non-Viewers)	Videos (Viewers)
My sleep is better	89%	50%	83%
I am more satisfied with my sleep	89%	50%	67%
I fall asleep easier	78%	67%	67%
Awakenings at night are less of a problem	67%	50%	67%
My sleep timing is better	78%	67%	67%
I know what to do if I have trouble sleeping	100%	50%	100%
I know what to do if I am sleepy during the day	89%	33%	100%

I am more energized during the day	89%	33%	67%
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In describing how their participation was perceived to have impacted other areas of functioning, participants reported:

Improvements in:	Info Only	Videos (Non-Viewers)	Videos (Viewers)
Stress	89%	33%	83%
Academic Performance	78%	50%	50%
Athletic Performance	89%	50%	67%
Social Life	78%	33%	67%
Family Life	78%	33%	67%
Mental Health	100%	50%	83%
Physical Health	89%	67%	67%
Energy Level	100%	50%	83%
Ability to Focus	89%	67%	83%

IMPLICATIONS FOR CAMPUS-LEVEL PROGRAMMING

This pilot project included 2 phases: the creation of an online, disseminable version of a sleep education program and the initial testing of that platform. The online platform was eventually created, and included a set of 38 videos that provided more than 3 hours of educational video content, as well as handouts and additional exercises. The comparison condition was a lack of online access but provision of a complete set of educational materials that encompass the details of the online videos.

Overall, several key findings emerge: (1) students who participated in the program perceived overall improvement in their sleep, learned more about sleep, and perceived changes in related areas of functioning – especially in those who either received the complete handout or spent time watching the videos; (2) neither the online nor the information only conditions achieved the

level of success seen in the original ProjectREST study that included additional elements; and (3) approximately half of those provided online access did not watch videos or otherwise access much of the information on their own.

Regarding the first finding, it is important to note that nearly all participants (especially those who received handouts or actually watched videos) reported improvements in nearly all areas queried. The fact that there were many areas that were not endorsed by those who did not watch the videos further supports the notion that the access to the educational content was beneficial. In particular, the program was highly successful at educating participants, produced consistent improvements in perceived aspects of sleep, and was associated with perceived benefits in key areas, including energy level and stress. These benefits were accompanied by clinically significant improvements to sleep-related outcomes.

Regarding the second finding, it is notable that neither the simple handout nor the access to the online information or exercises resulted in improvements to standardized sleep and mental health measures. There are several possible reasons for this. First, the original ProjectREST study included some elements that likely improved outcomes that were not included in either arm of this study, such as: (1) in-person educational sessions, allowing for a personal connection and open questions; (2) 24/7 access to peer support and expert support to address problems as they arose; and (3) objective sleep tracking with a wearable sleep tracker that also provides feedback on sleep. It is possible that any or all of these missing elements might have further increased success of the program.

Regarding the third finding, it is important to note that only about half of those randomized to the online content actually made use of the online educational video content (they may have accessed additional information from handouts and exercises). This suggests that not all student athletes will access educational information, especially when it might take time and effort to access that content.

The results of this pilot study (and the previous study) suggest a relatively clear path forward for a campus-based sleep health educational program. The program should include the educational content, as that was nearly universally helpful. But different students may find different types of

content more helpful (e.g., videos, handouts, in-person) and one form of information is likely insufficient. Although sleep diaries were useful, an objective sleep tracker system may improve adherence and may be a useful supplement to the intervention. Third, focusing on practical sleep-related skills training as well as basic sleep science will address a wide range of problems and better prepare students for the real-world problems they face. Fourth, access to a support system that is actively promoted may provide real-time support when students face challenges.

There are other possible ways forward that neither of these studies have been able to address but might be integrated into future programs. First, the importance of collaboration among training and coaching staff in delivering these messages may be key, especially when there may be conflicting messages. Second, integrating a sleep screening program with a more robust sleep disorders screening program may be helpful. Players with sleep disorders might be inappropriate for a program like this and might be better served through a more traditional path that includes diagnosis and treatment of their disorder, since this program is not designed to accomplish that.

Taken together, the results of this pilot study were very informative in that they (1) allowed for the creation of sleep education materials online and in print that have demonstrated utility and can be widely disseminated, and (2) provided useful information regarding the future dissemination and refinement of the program.

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