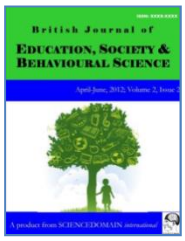

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Effects of Additional Yoga, Meditation and Homework: A Randomized Controlled Trial Evaluating Sleep Problems with a University Student Sample

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AW and SL designed the study and carried out the field work. Author SL managed the analyses of the study. All authors contributed to the literature search, and wrote, read and approved the final manuscript.

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ABSTRACT

Aims: To investigate the effects of a theory-based treatment (active control condition) addressing social-cognitive constructs on healthy lifestyle behaviors, and whether additional effects would occur if additional practical exercises with yoga, meditation, and homework to improve self-regulatory strategies (intervention condition) were added.
Study Design: Pilot study.
Place and Duration: An international university in Germany, four weeks.
Methodology: 23 undergraduate students were allocated either to an active control group (sessions addressing social-cognitive constructs, with no yoga, meditation, or homework) or an intervention group (sessions addressing social-cognitive constructs, with additional practical exercise in yoga and meditation, and homework to increase self-regulation). Students participated in weekly sessions over four weeks. All study participants improved in their self-regulatory skills (pros, subjective norm, self-efficacy, goal setting and cons). Effects on sleep problems transpired as an interaction of time and treatment group

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(Eta²=.13). The intervention increased self-regulatory strategies more than the active control treatment (Eta²=.17).
Conclusion: Results highlight the importance of exercising yoga and meditation, and providing additional material to enhance self-regulatory strategies. By doing so, sleep problems in students can be reduced.

Keywords: Social cognitive theory; self-efficacy; goal-setting; planning.

1. INTRODUCTION

Physical activity, nutrition and sleep are well studied within freshmen college populations (e.g., [1]). In general, many freshmen and other college students report suboptimal health behaviors and sleep problems [2]. Although irregular sleep patterns, such as sleeping and waking late, may in part be due to typical adolescent/young adult circadian rhythms, many previous studies have found that emotional and academic stress negatively impact sleep in freshmen students, causing irregular patterns, and insufficient amounts of sleep. This in turn can negatively influence mental and physical functioning, and hinder students' health, as well as their ability to function in general [3,4,1].

Further, many studies have found links between perceived sleep, physical activity and diet. Namely, more sleep problems often result in higher fat intake and less physical activity (e.g., [5]). On the other hand, proper physical activity may improve sleep and nutrition indirectly, by creating improved individual levels of psychological resources, particularly self-efficacy and better use of self-regulatory strategies [6].

Yoga and meditation have emerged as specific forms of physical activity that have been shown to improve sleep on a subjective and biological level in more healthy [7,5] and less healthy individuals [8]. Yoga and meditation, similar to other stress management techniques, can increase detachment from stressors during the day, thereby improving sleep. It is not solely physical activity that is connected to sleep, however, nutrition also has a strong connection [9,10]. The relationship direction could be circular, in that too little sleep can negatively impact physical activity and diet, and in turn, improved diet and physical activity may positively impact sleep. Furthermore, yoga specifically has been shown to have positive effects on regulating stress and negative emotions, and thereby plays a role in improving nutrition by decreasing the likelihood of emotional eating and stress induced sugar cravings [11].

Therefore, conscious improvement of physical activity is an important approach to enhance health and sleep [12]. Achieving such improvement depends on different social-cognitive factors, such as *self-efficacy.* Self-efficacy is one of the most crucial factors in making a change in health behaviors (in this case, a person's belief in his/her ability to stick to an activity program). Studies examining physical activity in college freshmen have found a bidirectional relationship between activity self-efficacy, and students' level of activity [13], indicating self-efficacy is not only improved by physical activity, but can itself play a role in improving physical activity and health behaviors.

Self-efficacy beliefs are key components of many social cognitive theories (such as *Social Cognitive Theory*, SCT, [14]; *Protection Motivation Theory*, PMT, [15], and the *Health Action Process Approach*, HAPA, [16]), which describe factors that affect and determine behavior. SCT also specifies mechanisms through which behavioral determinants work, and how such

mechanisms may be translated into effective health practice [14,16]. Aside from perceived self-efficacy, the core constructs of this theory are goal setting, outcome expectancies (pros and cons), and sociostructural facilitators (i.e., subjective norm). These self-regulatory strategies (i.e. pros, subjective norm, self-efficacy, goal setting and cons), and the overall structure of the SCT theory, have been tested and reviewed across numerous populations and domains of human behavior and health promotion such as self-efficacy [17], outcome expectancies [18], goal setting [19], and testing of the model structure [20].

Interventions that are well constructed have been found to positively improve various health behaviors [21,22], thus, to address sleep problems and the resulting health issues of students, the aim of this study was to design an effective intervention. Because of its established structure, SCT was used as the foundation [23]. Theories are an essential component of a practical focus for a number of reasons. For example, they state which variables (and when) are important, and which variables should exhibit a certain effect from an intervention (for instance, a planning intervention should produce more precise plans and increased health behavior, but show no effect on goal setting (cf. [24,16]). From a more theoretical viewpoint, practically applying theories is imperative for testing their effectiveness in real world settings. To date, however, relatively few interventions have been based on social-cognitive theories (as, for example, the intervention study by [9]).

While *physical activity* has generally been found to increase sleep duration and quality [25,26], results are inconsistent among studies, making it difficult to determine exactly how physical activity impacts sleep [27,28]. Thus, the *current study* aimed to increase self-efficacy and change self-regulatory strategies, thereby improving physical activity and reducing sleep problems of the participants by means of a treatment based on Bandura's SCT [14]. To make the treatment more effective, based on previous findings of the effectiveness of yoga, meditation and self-regulation, physical activity with a focus on yoga and meditation, as well as material to work on intensively between sessions as homework, were included. With this addition to the *active control treatment* (which addressed SCT constructs only), the *intervention treatment* was formed, which was expected to be more effective than the active control treatment.

The major goal of the study was to improve sleep in undergraduate students through a theory-based intervention that aimed at increasing healthy lifestyle behaviors (e.g., sufficient physical activity), and self-regulatory strategies (i.e. pros, subjective norm, self-efficacy, goal setting and cons) towards these behaviors. Thus, Hypothesis 1 assumed that both treatments provided to the active control group (ACG) and the intervention group (IG) would produce significant time effects, indicating significant improvements in self-regulatory strategies (pros, subjective norm, self-efficacy, goal setting and cons; Hypothesis 1a), behavior (Hypothesis 1b), and reduction of sleeping troubles (Hypothesis 1c).

Testing an additional intervention, practical exercise in yoga and meditation, and additional homework to improve self-regulatory strategies was added, and it was tested whether the intervention group (yoga and meditation, and additional homework) would outperform the active control group (theory-based intervention addressing self-regulatory strategies). Based on this, Hypothesis 2 was formulated: The intervention would improve self-regulatory strategies (pros, subjective norm, self-efficacy, goal setting and cons; Hypothesis 2a) and behavior (Hypothesis 2b), and reduce subjective sleeping troubles (Hypothesis 2c) more than the active control group.

2. METHODOLOGY

2.1 Participants

Participants were 23 undergraduate university students (see characteristics in Table 1). Study majors varied among sciences and arts, with no particular discipline being disproportionately represented. Students signed up for a class in response to being approached and invited to take part in a four week workshop for sleep management by means of yoga and meditation, including lifestyle behaviors (physical activity and nutrition). Invitation was via mass email, flyers distributed to residence rooms on campus, word of mouth, and recommendations from the university counseling department. Participants received credits (part of their university degree completion requirements) if they participated in all sessions.

Inclusion criteria required only that individuals were studying at the regarding university. Aside from this, they were expected to be experiencing sleep difficulties related to their studies, and willing to make a commitment to attend all weekly sessions over a four week period to improve these difficulties. None of the students reported any prior experiences with yoga and/or meditation.

Table 1. Baseline characteristics of students in the active control group (N=12) and the intervention group (N=11), as well as the correlational sample

	Active control group (N=12)	Intervention group (N=11)
Variable	*n* (%) or mean (*SD*)	*n* (%) or Mean (*SD)*
Age (years)	20.42 (1.56)	19.70 (1.64)
Gender	5 men (42%), 7 women (58%)	6 men (55%) 5 women (45%)
Sleeping troubles[1]	3.25 (1.22)	3.55 (1.04)
Sleepy during the day[1]	3.92 (0.67)	4.09 (0.94)
Unwanted behaviors when sleeping[1]	2.58 (1.38)	2.30 (0.82)
Stress[1]	2.93 (0.92)	3.26 (0.53)
Pros[2]	4.50 (1.38)	5.27 (0.79)
Subjective norm[2]	4.33 (1.23)	5.09 (1.05)
Self-efficacy[2]	4.17 (1.70)	3.73 (1.27)
Goal setting[2]	4.50 (1.57)	5.00 (1.00)
Cons[2]	2.92 (1.68)	2.73 (1.19)

Note: No significant differences between the Active Control Group and the Intervention Group.[1] Answering options range from never (1) to very often (5)[2] Answering options range from not at all true (1) to absolutely true (6)

2.2 Procedure and Research Design

This pilot study was an experimental 2-factors design with eight repeated measurement points (t1, t3, t5, and t7 at the beginning of weekly sessions, and t2, t4, t6, and t8 at the end of weekly sessions) was chosen. The same questionnaire was used at all measurement points, but some constructs were not measured at t2, t4, t6 and t8 to avoid unnecessary repetition. Both the intervention group and the active control group participated in all measurement points. Survey questions were validated items for measuring social-cognitive

factors related to healthy lifestyle behaviors (physical activity, nutrition and stress management), subjective sleep problems, and current health behavior (see below).

Participants were randomly assigned to an active control group (n=12), or an intervention group (n=11). Individuals in the two groups did not differ with regard to gender and age, physical activity, self-regulatory strategies, or sleep problems, prior to the intervention (all p>.12, see Table 1). The randomization process was done by numbering students alternately as one (intervention group) or two (active control group) prior to the first session. The active control group and the intervention group took place at the same time at two different locations on campus. Both groups were led by previously schooled instructors.

2.2.1 Active control group

The active control group (ACG) discussed tips on managing stress and improving sleep through selected health behaviors for the entire session each week, without any practical exercise in yoga and meditation during the session.

2.2.2 Intervention group

The intervention group (IG) received the same tips, but with less time to discuss the topics, as they spent most time learning practical techniques in yoga and meditation. Additionally, the intervention group received homework: a weekly physical activity task to be completed between sessions, weekly handouts, and weekly forms to record details of their weekly task, with the aim to increase their self-regulatory skills (cf. Appendix: Table 1). Identities were kept anonymous by using a code instead of names on the questionnaires. The entire treatment (intervention vs. active control condition) took place over four weeks.

2.3 Measures

*Self-efficac*y was assessed by the item “I am certain I can maintain regular physical activity, healthy nutrition, and stress management, even if it is difficult.” Retest-reliability was .63-.89 for adjacent measurement points, and .61-.92 for measurement points with more distance. Answers for all self-regulatory strategies were assessed using six-point scales, ranging from *not at all true* (1) to *absolutely true* (6).

Physical activity behavior was assessed asking study participants to indicate whether the statement “Within the last month I performed physical activity at least 3 times per week for 30 minutes or more” would be true or false (indicated by no or yes).Retest-reliability was .74-.79 for adjacent measurement points, and .64-.84 for measurement points further apart.

Subjective sleep problems were measured with the single item “I have trouble sleeping at night”. Responses were given on five-point scales, anchored between never (1), almost never (2), sometimes (3), fairly often (4), very often (5). Retest-reliability was .76-.80 for adjacent measurement points, and .55-.82 for measurement points further apart.

If students did not participate in a measurement point, or did not answer specific items, their answers were replaced by their answers of the last measurement point (last observation carried forward method; [29,30]. All students participated in the sessions; however, some students came late or had to leave before filling in their questionnaire at the end of the session. Consequently, five out of the twenty-three students missed the t2 measurement point (the end of the first session), eight missed t3 (the beginning of the second session),

eight missed t4 (the end of the second session), and 10 missed t5 (the beginning of the third session), t6 (the end of the third session), t7 (the beginning of the fourth session) and t8 (the end of the fourth session). These were always different students, with no clear patterns of missing sessions. Of those students filling in their questionnaires, missing values occurred with a low percentage (5% or less produced missing values on selected variables).

3. RESULTS AND DISCUSSION

To test time and *intervention effects*, a repeated measure MANOVA was run with *pros, subjective norm, self-efficacy, goal setting and cons*as the dependent variable at eight points in time and treatment groups as the between-factor. The MANOVA revealed a significant time effect ($F_{\text{Roy's Largest Root}}(7,16)=4.45$, $p=.01$; $\text{Eta}^2=.18$). The interaction between time and treatment ($F_{\text{Roy's Largest Root}}(7,16)=4.21$, $p=.03$; $\text{Eta}^2=.17$) was also revealed to be significant. Fig. 1 displays the means of the self-regulatory strategies for the two groups over time (Panel a pros, Panel b subjective norm, Panel c self-efficacy, Panel d goal setting and Panel e cons).

Secondly, a Chi^2-test with percentages of students being physically active on a sufficient level was run. However, no significant differences between the groups occurred. Thirdly, it was tested whether the intervention affected *subjective sleep problems* of participants. A repeated measures ANCOVA was run with sleep problems as the dependent variable at three points in time, sleep problems at t1 as a covariate, and groups as the between-factor. There was no overall time effect (F (1,22)=1.29, $p=.28$), however, a quadratic interaction of time and treatment group transpired ($F(5,18)= 3,11$, $p=.05$, $\text{Eta}^2=.13$). (Table 2) displays the means in sleep problems for the two groups over time.

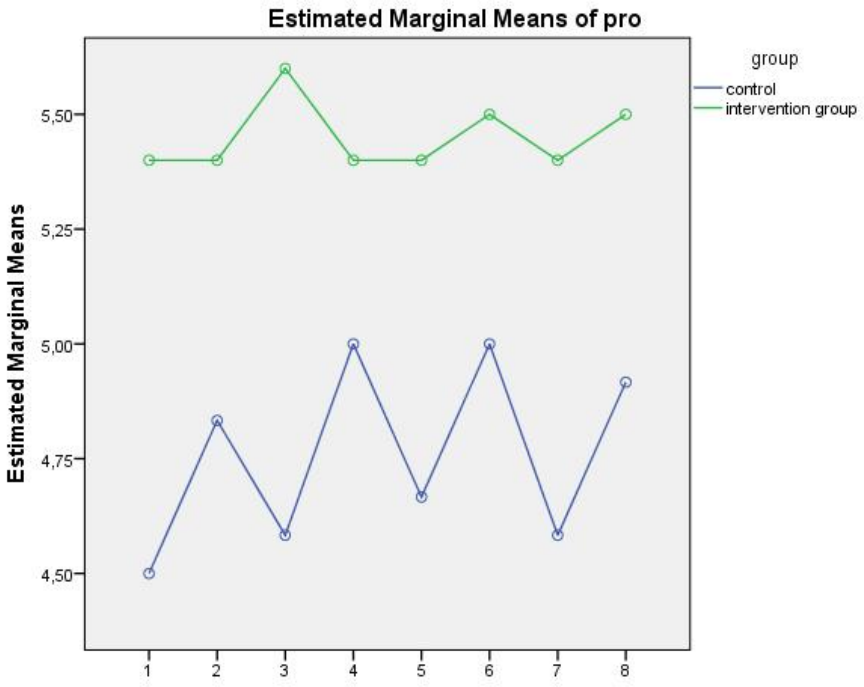
Table 2. Means (M), standard deviations (SD, in parentheses) of sleeping troubles in university students (time 1 [T1], time 3 [T3], time 5 [T5] and time 7 [T7]) (N = 23), divided into groups

	T1	T3	T5	T7
Active control group (*N*=12)	3.25 (1.22)	3.00 (1.41)	2.67 (1.16)	3.08 (1.08)
Intervention group (*N*=11)	3.55 (1.04)	3.27 (1.01)	3.09 (1.05)	2.91 (1.14)

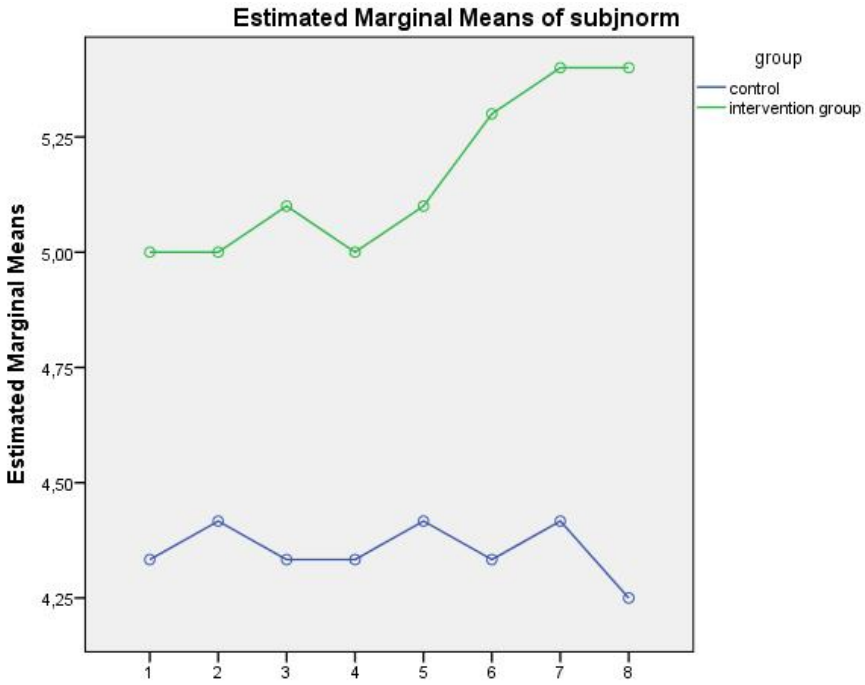
The main difference between the two groups was that the active control group decreased in their sleeping problems from T1 to T3 and T5 but increased at T7 to a higher level than T3. In contrast, the intervention group decreased their sleeping problems equally from T1 to T3 and T5, and that this trend was maintained to a further decrease at T7.

In this pilot study, a theory-based sleep improvement intervention was tested on a sample of 23 undergraduate students experiencing sleep problems. This is the first study to address different healthy lifestyle behaviors by means of a theory-based treatment. In addition to this treatment (which both the active control and intervention conditions received), the intervention group was also trained in yoga and meditation, and provided with additional material to work on between sessions, to increase self-regulatory strategies (a weekly task, weekly handouts, and weekly forms for the intervention group to record details of their weekly task).

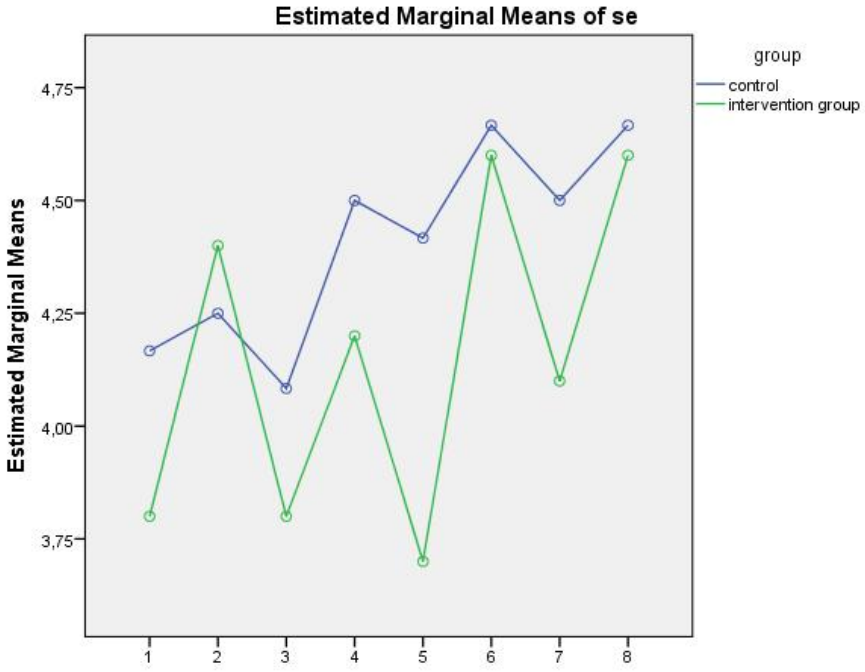
Panel a: Pros



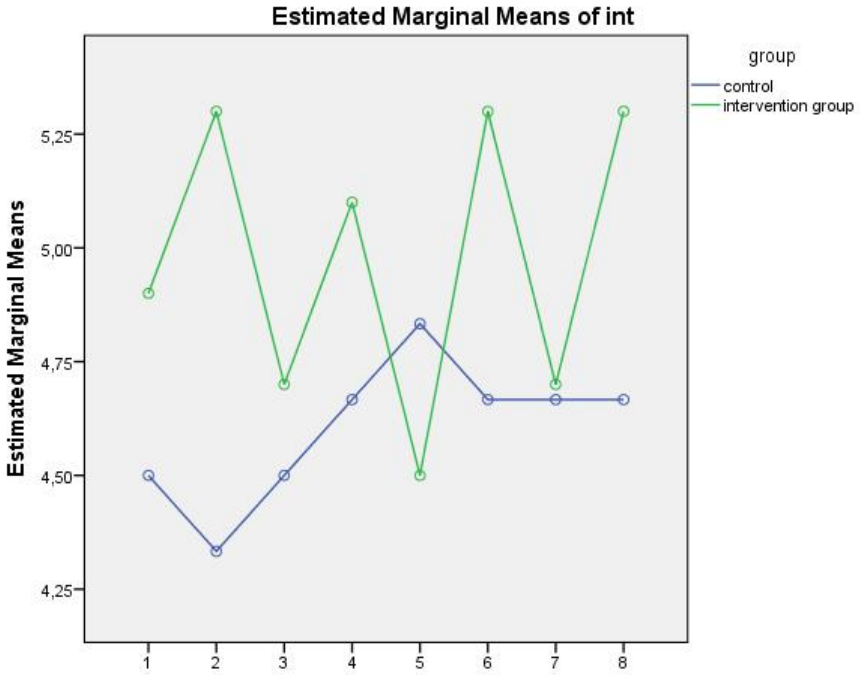
Panel b: Subjective norm



Panel c: Self-efficacy



Panel d: Goal setting



Panel e: Cons

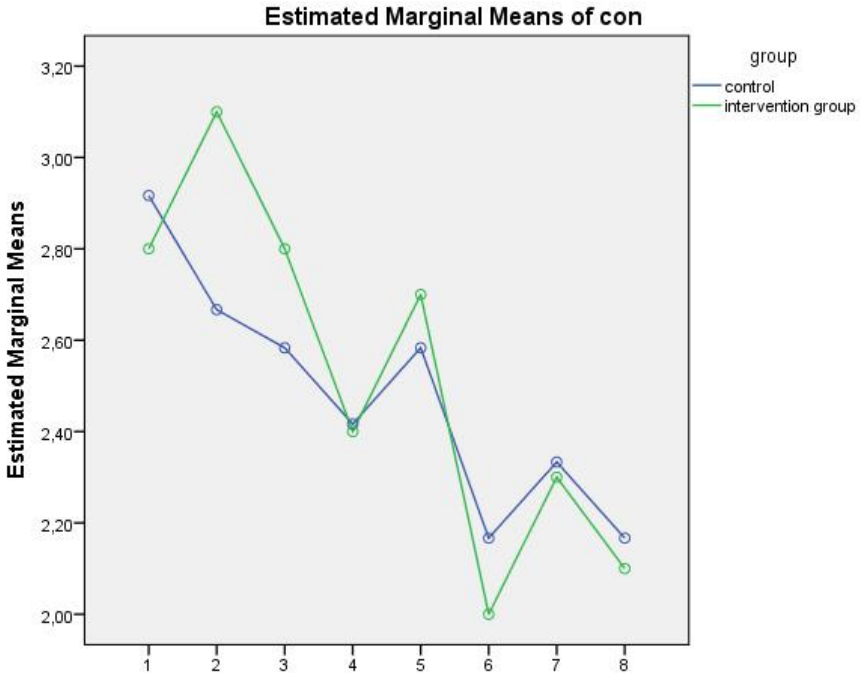


Fig. 1. Social-cognitive levels among university students (N = 23): Means of the two groups at eight points in time, panel a pros, panel b subjective norm, panel c self-efficacy, panel d goal setting and panel e cons

Hypothesis 1 addressed changes over time, which were found in self-regulatory strategies (supporting Hypothesis 1a). This is not surprising, as the intervention condition had a strong focus on self-regulatory strategies. However, it was expected that such changes would also produce changes in behavior and sleeping troubles, which was not the case on the overall level (not confirming Hypothesis 1b and 1c). Still, at least hypothesis 1a could be supported, showing that self-regulatory strategies to adopt and maintain a healthy lifestyle were successfully improved by the intervention. This is in line with previous studies finding that self-regulatory strategies can be increased with cognitive-behavioral interventions (e.g., targeting enjoyment in the study by [9], for self-efficacy in insomnia patients [31]). Hypothesis 2 a/b/c addressed whether the intervention group was more effective in changing these self-regulatory strategies, behavior, and sleep troubles than the active control group. This assumption was supported by the results regarding self-regulatory strategies (supporting Hypothesis 2a) and sleep problems (supporting Hypothesis 2c), but not by those regarding behavior (not confirming Hypothesis 2b). We further assumed that the intervention group would decrease in their sleep problems, which was supported in terms of an interaction of time and group (Eta^2=.13).

In future studies, psychological mechanisms should be tested. It could then be tested whether changes in self-regulatory strategies mediate the intervention effect in terms of changing behavior (as it was found for goal setting in previous studies, such as [32]), and thereby improving sleep problems.

These are important findings not only for addressing students' health, but also to help them prevent absence due to illness later in their student and working life, by adopting effective self-regulatory strategies [3]. However, although Roy's Largest Root is the most powerful of all test-statistics [33], it tends to come to optimistic approximations – especially when all other test-statistics are not significant. Replicating this study with a bigger sample size might provide more robust results on the current hypotheses.

In future studies, some improvements should be realized: First, in this pilot study, only single indicators were used due to time constraints. In further studies, more study participants should be included and multiple indicators to measure constructs more accurately should be utilized, as well as differentiated, and objective measures of lifestyle behaviors (especially physical activity) could be used. Second, a manipulation check should be used to test whether participants in either condition actually adopted yoga or meditation into their lifestyle. Third, some measures should be taken to prevent experimenter bias. The rationale was to run both the ACG and IG at the same time to prevent variation in that sense. However, two or more groups using the ACG or IG treatment should be offered, with a random permutation of instructors to each condition (both instructors teaching both ACG and IG) to reduce an experimenter effect. Further analyses regarding the mechanisms could also shed light on the processes, such as the outlined mechanisms in (Appendix: Fig.1), regarding whether improved self-regulatory strategies actually lead to improvements in behavior, and whether these are promoting better sleep and perhaps also academic performance.

4. CONCLUSION

This was the first study testing a theory-based sleep improvement treatment in a student sample with four treatment sessions, and additional physical activity including yoga and meditation, as well as self-regulatory material constituting the intervention condition. Three out of six hypotheses were confirmed by the data. Unfortunately, the hypothesized behavioral effects could not be confirmed, which might also be a power problem. As only a small number of study participants were included, effects require replication with larger sample sizes, which could therefore have larger power. The mechanisms outlined in Appendix Fig. 1 could guide such a study and the regarding analyses. Further, effects could also be replicated in samples from the workforce, as sleep problems have been found to be related to health and absence due to illness [3].

Nonetheless, trends found from this study indicate the potential of (a) a theory-based treatment (the session received by both the intervention group and the active control group), and (b) additional physical activity including yoga and meditation in particular, as well as self-regulatory material to enhance and reinforce the effects of the session. Attempts to support students' ability to cope with sleep problems during their study time can make use of these findings, by working on self-regulatory strategies such as goal setting, pros and action plans. Early prevention of sleep problems through health behaviors is imperative, which the current study provides some evidence for. Yoga, meditation, and self regulatory strategies can play a key role in this.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

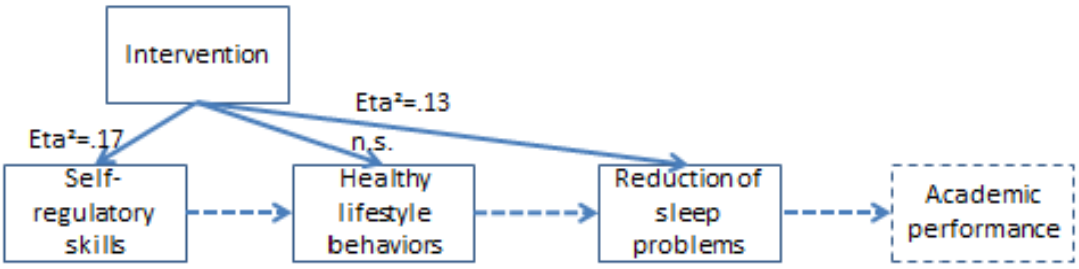
Appendix Table 1. Overview of the 4 week intervention delineating constructs, topics and tasks for the intervention group

Week	Targeted social-cognitive constructs	Session topics	Behavior change strategies used during the sessions	Additional self-regulatory strategies (homework received by intervention group at end of the session)
1 Goal setting	All: goal setting, physical activity experiences Intervention group: self-efficacy[1], positive experience with physical activity, self-efficacy, mastery experience	Education and facts regarding the relationship between physical activity and nutrition on sleep and stress, model learning	Information about sleep, stress, studying, physical activity and nutrition, and their relationships to each other, to enhance personal risk perception Beneficial effects of physical activity on sleep and stress pointed out to increase anticipation of positive outcome expectations Current experiences with physical activity, sleep, and stress discussed Focused on positive aspects of physical activity and nutrition to reduce negative anticipations on future physical activity initiation	Brisk walking for at least ½ hour per day. Monitor experiences on provided forms
2 Transitioning from knowledge to improving resources	All: outcome expectations, physical activity experiences Intervention group: self-efficacy[1], positive experience with physical activity, self-efficacy, mastery experience, action and coping planning	Positive/negative expectations and experiences of rest and physical activity during work: learning the benefits of working with body signals and making the time for breaks	Positive effects of 'body breaks', brief periods of rest or physical activity between working Increase the anticipated positive effects of rest and physical activity on sleep and stress management Tips on increasing body awareness, listening to signals, ways to incorporate physical activity into the day, and learned how to identify	Yoga and/or meditation for at least ½ hour per day, or some kind of physically vigorous physical activity of choice (e.g. Running, sports, swimming, etc.) For at least ½ per day

			resources which would help them to realize behavior change. Education regarding impact of nutrition on sleep, the impact of physical activity on sleep, and how to realistically incorporate healthy eating, physical activity, and sleep management techniques into already existing schedules, using action planning and coping planning Think of concrete areas that could be targeted as problem nutrition or physical activity, and realistic improvements that could be made	dditionally: experiences with the previous week's task was discussed. The feedback was provided by the instructor orally and promptly. Subsequently, the instructor opened the stage for the entire group to provide feedback and discuss in general on what worked, what did not, and strategies to improve.
3 Concrete steps and managing obstacles	All: impediments Intervention group: self-efficacy[1] positive experience action and coping planning	Dealing with impediments, self-monitoring: focus on management strategies of inevitable impediments in incorporating altered physical activity/nutrition routines into schedules	Time management strategies to tackle impediments Discussion of personal obstacles Hints and tips on how to adjust personal schedules to include relaxation or activities Formation of action and coping plans including when, where and how they wanted to do relaxation or physical activity, as well as anticipate possible obstacles and counter-strategies	ga and meditation for at least ½ hour per day, or some kind of physically vigorous physical activity of choice (e.g. running, sports, swimming, etc.) for at least ½ per day. Include specific action and coping plans dditionally: relayed current experiences and received practical tips according to the previous content
4 Staying on track and feeling good about it	All: facilitators Intervention group: self-efficacy[1], social support	Social support, continuing lessons on a regular basis	Activating social support to increase adherence, especially to physical activity behavior	ontinued use of action and coping plans to incorporate and

	Tips on how to incorporate friends and partners into activities Generating various ideas regarding who could be asked to physical activity with them Review of the previous lessons, discussion about how to go forward and incorporate the learned strategies into daily life	maintain healthy nutrition and physical activity into routines, with suggestions to include social support in form of an physical activity partner

Note: [1]The major objective of the tasks within the IG was to create positive mastery experiences to increase self-efficacy



Appendix Fig. 1. Effects of the theory-based intervention: hypotheses and aggregated findings

Note. Dotted parts not tested in this study. However, such mechanisms could be assumed and should be tested in future studies

Peer-review history:
The peer review history for this paper can be accessed here:
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