Long-Term Links between Physical Activity and Sleep Quality

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ABSTRACT

SEMPLONIUS, T., and T. WILLOUGHBY. Long-Term Links between Physical Activity and Sleep Quality. *Med. Sci. Sports Exerc.*, Vol. 50, No. 12, pp. 2418–2424, 2018. **Purpose**: Findings from cross-sectional research indicate that the relationship between sleep quality and physical activity is mixed. For research that *does* indicate a significant association, the interpretation of the finding most often is that physical activity leads to better sleep, or less frequently, that better sleep leads to more involvement in physical activity (see sleep deprivation studies). Cross-sectional studies, however, are not able to assess the direction of these effects, and experimental studies have tested only one direction of the effects. Longitudinal studies, with their focus on temporal order, are needed to specifically examine the link between sleep and physical activity as well as the direction of effects. The current study had three goals: to examine 1) the longitudinal relationship between sleep and physical activity, 2) the direction of effects, and 3) whether emotion regulation mediates the relationship between sleep and physical activity. **Methods**: Participants included a sample of 827 ($M_{\text{age at baseline}} =$ 19.04 yr, SD = 0.92 yr, 73.88% female) students at a university in Southwestern Ontario, who took part in a larger longitudinal survey that started in their first year of university. Participants were surveyed annually for 3 yr (2011, 2012, 2013; retention, 83.9%). Measures assessed sleep quality, physical activity, emotion regulation, and involvement in sports clubs. **Results**: A cross-lagged autoregressive path analysis revealed that sleep quality indirectly predicted increased high-, moderate-, and low-intensity physical activity over time through its positive effect on emotion regulation. Moderate levels of physical activity indirectly predicted sleep quality over time through emotion regulation. **Conclusions**: Overall, there appears to be support for a bidirectional relationship between sleep and physical activity over time (at least for moderate physical activity) but *only* indirectly through emotion regulation. **Key Words:** EMOTION REGULATION, EXERCISE, SLEEP, SPORTS

Sleep experts (1,2) and popular culture (3) have inundated us with the idea that engaging in physical activity can promote better sleep. In fact, a quick Google search with the question, "Can exercise make you sleep better?" leads to many sites that tell us that, yes, it can. Findings from research examining this relationship, however, are mixed, with some studies finding a significant association and others not (4). For example, Youngstedt et al. (5) measured sleep and physical activity in undergraduates (using self-reported exercise and sleep diaries) and adults (using actigraphy and diaries) and found that there were no significant correlations between sleep and physical activity (see also Mitchell et al. [6]). Reasons for the mixed results may be the manner in which the studies are conducted and how the research question is framed. The majority of studies examining the associations between sleep and physical activity are cross-sectional, quasi-experimental or experimental, with researchers examining only *one* direction of associations. For example, researchers examine either 1) the effect of physical activity on sleep (7–14), or 2) the effect of poor sleep/sleep deprivation on exercise (15–18).

Findings from research examining the effects of physical activity on sleep are mixed. Myllymäki et al. (13) had 11 participants engage in 1 d with late-night exercise and another day with no late-night exercise, and observed their sleep those nights in a laboratory. Participants' reported sleep quality did not differ, depending on whether they had exercised (the only finding was that there was less REM sleep after exercising). Similarly, Myllymäki et al. (14) found no effect of varying intensity of physical activity on 14 male participants' sleep quality compared with days with no physical activity. In contrast, others *have* found significant effects of physical activity on sleep. Group comparison

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research with adolescents (nonrandom group assignment) revealed that 258 athletes reported better sleep quality than 176 nonathletes (7), and 17 adolescents who exercised for ~8 $h \cdot wk^{-1}$ had better objective sleep quality (measured through EEG) than 21 adolescents who exercised ~2 $h \cdot wk^{-1}$ (although these nonrandomized groups did not differ on subjective sleep quality) (8). Furthermore, in a study of 862 undergraduates, students who thought they were less active or less in shape concurrently reported poorer perceived sleep quality than students who perceived themselves as being more active and more in shape (12). An experimental/longitudinal study by Kalak et al. (19), using random assignment, examined whether 27 adolescents who ran for 30 min in the morning for 3 wk showed more improvements in sleep than 24 individuals who did not run in the morning. Kalak et al. (19) found that both objective (EEG measurement) and subjective sleep quality improved only for those who ran for 30 min during weekday mornings.

There has been less research specifically examining the alternate direction of effects, that is, whether sleep influences subsequent physical activity (18). Generally, research examining this direction of effects has used experimental designs. For example, Martin (16) twice had eight participants walk on treadmills until they were exhausted—once after a normal night of sleep and once after 36 h of sleep deprivation. Martin (16) found that physiological differences (e.g., heart rate) were minimal but participants' perceptions of how hard they had exercised were higher after sleep deprivation than after normal sleep, and they also exercised for less time after sleep deprivation. Schmid et al. (17) found similar results such that 15 males who were sleep restricted engaged in less physical activity and less strenuous physical activity than when they had regular sleep. Furthermore, adolescents who reported sleeping less than 8 h a night engaged in more sedentary behaviors than those who reported sleeping for longer periods of time (however, there were no differences in their moderate/vigorous physical activity levels; (15). A meta-analysis indicated that both short-term exercising (i.e., under 1 wk of physical activity) and longer-term exercise (i.e., over 1 wk of physical activity) were associated with increases in indicators of good sleep [e.g., shorter time to fall asleep and better sleep efficiency; (20)].

A recent research review has indicated that the relationship likely is bidirectional. Specifically, Chennaoui et al. (21) indicated that many studies support the hypothesis of a bidirectional relationship between sleep and physical activity in both clinical and nonclinical samples. Conclusions about the direction of effects in the association between sleep and physical activity, however, require the use of a longitudinal design in which *both* temporal order and bidirectionality can be assessed. Only two studies have directly assessed the bidirectional association between sleep and physical activity, and they were conducted with older adults. In a 2-yr longitudinal study of 489 older adults (M_{age} = 72 yr; 87% retention), Holfeld and Ruthig (22) found that sleep quality predicted more frequent physical activity over time, but physical activity did not predict better sleep quality over time. In contrast, Dzierzewski et al. (23) found a bidirectional relationship between sleep quality and exercise in an 18-wk, daily diary study of 79 older adults (M_{age} = 63 yr). Given these conflicting results and the focus only on older adults, the first goal of the present study was to investigate the bidirectional association between sleep and physical activity in a longitudinal study with university students. The transition from high school to university often is associated with decreased physical activity (24,25) and changes in sleep (e.g., more wake time variability in university than high school; (26,27) making studies of this age period important for health promotion.

As not all studies have found a direct association between sleep and physical activity, there is some speculation that the effect between sleep and physical activity may be indirect [see also (22)]. For example, physical activity has been hypothesized to promote better psychosocial adjustment (8), such as emotion regulation, which in turn is thought to lead to better sleep; alternatively, exercise could promote sleep and, therefore, well-being (28). Importantly, previous research has indicated that emotion regulation is tied to both physical activity (29) and sleep (30). The second goal of the current study, therefore, was to examine whether emotion regulation mediates the relationship between physical activity and sleep quality over time (i.e., does physical activity promote better emotion regulation over time, and in turn, better sleep quality over time, and *vice versa*).

METHODS

Participants

The participants were 827 students enrolled at a mid-sized university in southern Ontario, Canada, who took part in a larger longitudinal study that started when they were in their first year of university. SES data indicated that mean levels of education for mothers and fathers fell between "some college, university, or apprenticeship program" and "completed a college/apprenticeship and/or technical diploma." Students were surveyed annually. Only data for the second, third, and fourth waves are included in this study as sports team involvement was not assessed in the first wave. However, for clarity, these time points will be referred to as time 1 (wave 2), time 2 (wave 3) and time 3 (wave 4) in the present study.

Procedure

University students from various academic disciplines were invited to complete a survey examining factors related to stress, coping, and adjustment to university and were given course credit or monetary compensation for their participation at each time point. All students who participated in the first assessment were invited to participate again at each subsequent time point by way of e-mails, posters, and classroom announcements. At all assessments, the surveys were completed during the winter term. The university ethics board approved the study, and all participants provided informed consent before participation.

Missing Data Analyses

Missing data occurred within each assessment time point because some students did not answer every question (average missing data at times 1, 2, and 3 were 1.971%, 1.914%, and 1.935%, respectively) and because some students did not complete all three waves of the survey (retention rate, 83.9%; time 1, 827; time 2, 714; time 3, 694). At time 1, missingness was associated with sex ($F[2, 765] = 7.372$, $P = 0.001$, $\eta^2 = 0.019$); participants who completed three versus were more likely to be female than those who completed two waves ($M_{\text{diff}} = 0.172$ [95% CI, 0.057–0.278]; SE = 0.049; $P = 0.002$, or one wave, $M_{\text{diff}} = 0.157$ [95% CI, 0.004–0.310]; SE = 0.064, $P = 0.043$). Missingness also was associated with moderate physical activity ($F[2, 765] = 3.6720$ $P = 0.027$, $\eta^2 = 0.009$); participants who completed one wave reported less frequent moderate exercise than individuals who completed three waves ($M_{\text{diff}} = 0.377$ [95% CI, 0.003–0.750], SE = 0.156, $P = 0.048$. Missingness was not associated with time 2 or time 3 study variables, Ps > 0.230. Missing data were imputed using the EM (expectation–maximization) algorithm with all study measures included in the imputation process (31). Methodological research has demonstrated that this method of dealing with missing data is preferable to more common methods, such as pairwise deletion, listwise deletion, or mean substitution (32).

Measures

All measures with the exception of demographics were assessed across 3 yr of university. Sports club involvement also was assessed to control for any specific team benefits beyond physical activity.

Demographics. Self-reported sex, parental education (one item per parent, averaged for participants reporting on both parents), and whether participants were born in Canada were assessed at baseline and used as covariates in all analyses.

Emotion regulation. Emotion regulation was assessed using six items from the Difficulties in Emotion Regulation Scale (33). The responses were based on a five-point Likert scale ranging from 1 (almost never) to 5 (almost always). Cronbach's alpha at times 1, 2, and 3 were 0.74, 0.77, and 0.79, respectively. Higher scores indicated poorer emotion regulation.

Sleep quality. Sleep quality was assessed using an adapted version of the Insomnia Severity Index (34). As response options for items 1 to 5 ranged from 1 to 5 and item six response options ranged from 1 to 4, item 6 was recoded to have a range of 1 to 5 so a composite sleep variable could be created. Cronbach's alpha for the sleep items at times 1, 2, and 3 were 0.76, 0.79, and 0.79, respectively. Higher scores indicated poorer sleep quality.

Physical activity. Physical activity was assessed using three items. The items assessed how many times in the last month participants were involved in physical activity on their own or with a team, that was either 1) high-intensity physical activity, 2) moderate-intensity physical activity, or 3) low-intensity physical activity. These categories are consistent with the Borg Rating of Perceived Exertion (35) and target heart rate for monitoring physical activity (36). The responses were based on a five-point Likert scale ranging from 1 (*everyday*) to 5 (*not at all*). Higher scores indicated lower levels of high-intensity, moderate-intensity, and low-intensity physical activity.

Sport club involvement. Sport club involvement was assessed with one item examining how often participants participated in sports clubs since the start of the academic year. The responses were based on a five-point Likert scale ranging from 1 (*never*) to 6 (*several times a week*). Higher scores indicate higher involvement in sport clubs.

Plan of analysis. An autoregressive cross-lag analysis examining the associations among sleep quality, emotion regulation, physical activity (high, moderate, and low intensities), and sport club involvement across times 1, 2, and 3 was conducted using MPlus version 7.4 (37) (see Fig. 1). Significance level was set at $P = 0.05$.

RESULTS

Preliminary Analysis

On average, during the first wave of data collection, participants were 19.04 yr old (SD, 0.92 yr; range, 17.75–25.51 yr). The sample comprised 611 (73.88%) females, and 703 (85.01%) were born in Canada. Descriptive statistics are listed in Table 1. There were significant differences between males and females on sleep quality (time 1 only), emotion regulation (times 1, 2, and 3), moderate-intensity physical activity (times 1 and 2), high-intensity physical activity (times 1, 2, and 3), and sports club engagement (times 1, 2, and 3) (Ps < 0.035), such that females reported lower sleep quality, emotion regulation, moderate and high-intensity physical activity, and sports club engagement than did males.

Primary Analyses

The primary model used to analyze these data was an autoregressive cross-lag path analysis. Two assumptions important to the models are as follows [see Kearney (38) for a discussion]: 1) *synchronicity* (e.g., that all measurements were taken at the same time), and 2) *timeframe of effect* (e.g., the measurements were conducted annually at the same time). Both of these assumptions were met as the data were obtained simultaneously using the same questionnaire and were collected annually between February/March of each year. Overall model fit for the autoregressive cross-lag path analysis was determined using the comparative fit index (CFI) and the root mean square error of approximation (RMSEA) indicators (39). The cutoff criteria recommended

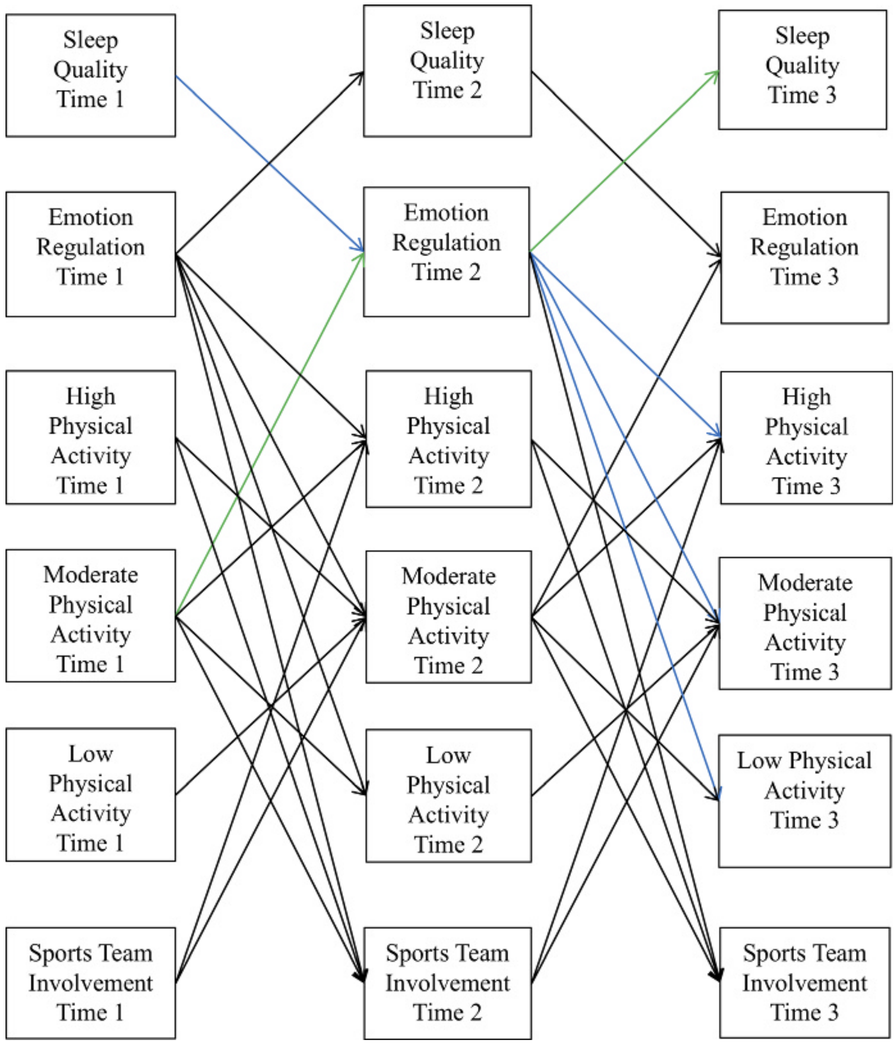

FIGURE 1—Significant cross-lag paths between study variables; the colored paths indicate the significant indirect effects.

for a well-specified model are a CFI > 0.95 and a RMSEA < 0.06, simultaneously (39). Across the three periods, lag-1 cross-lag paths among all six variables, lag-1, and lag-2 autoregressive paths, and concurrent associations among all six variables within each wave were included. Sex, parental education, and whether or not the participant was born in Canada were included as covariates, with correlations specified between the covariates and each variable at time 1, and paths estimated between the covariates and each variable at times 2 and 3. Any statistically significant paths, therefore, would be accounting for the correlations among the variables within a wave and controlling for previous scores on the outcome variables, covariates, as well as the other predictors in the model.

The results of a χ^2 Difference Test of Relative Fit indicated that the patterns of association among the variables were invariant across time (χ^2_{diff} (30) = 42.634, $P > 0.05$). Thus, subsequent analyses were based on the model that was constrained over time. The constrained model fit was well specified (χ^2[60] = 120.714; $P < 0.001$; CFI, 0.990; RMSEA,

TABLE 1. Descriptive statistics for study variables.

Measure	Time 1, M (SD)	Time 2, M (SD)	Time 3, M (SD)
Sleep quality	2.462 (0.748)	2.377 (0.764)	2.323 (0.763)
Emotion regulation	2.853 (0.759)	2.850 (0.766)	2.798 (0.773)
High physical activity	2.967 (1.229)	3.110 (1.301)	2.963 (1.276)
Moderate physical activity	2.789 (1.118)	2.808 (1.188)	2.736 (1.142)
Low physical activity	2.138 (1.193)	2.201 (1.182)	2.005 (1.091)
Sports team involvement	2.238 (1.790)	2.237 (1.801)	2.297 (1.805)
Covariates			
Sex	611 (73.88%) female		
Parent education	3.71 (1.30)		
Born in Canada	703 (85.01%) born in Canada		

TABLE 2. Beta weights of study variables from time 1 to time 2.

Time 1		Time 2	*b*	β	*SE*	*P*
EmoReg1	→	Sleep2	0.095	0.098	0.019	<0.001
EmoReg1	→	HighPA2	0.086	0.054	0.022	0.013
EmoReg1	→	ModPA2	0.098	0.067	0.022	0.002
EmoReg1	→	LowPA2	0.136	0.094	0.023	<0.001
EmoReg1	→	Sports2	−0.090	−0.040	0.020	0.048
Sleep1	→	EmoReg2	0.071	0.073	0.019	<0.001
Sleep1	→	HighPA2	0.021	0.012	0.021	0.547
Sleep1	→	ModPA2	0.041	0.027	0.022	0.205
Sleep1	→	LowPA2	0.012	0.008	0.023	0.722
Sleep1	→	Sports2	−0.004	−0.002	0.020	0.922
HighPA1	→	Sleep2	−0.018	−0.030	0.026	0.246
HighPA1	→	EmoReg2	−0.031	−0.052	0.027	0.050
HighPA1	→	ModPA2	0.107	0.118	0.030	<0.001
HighPA1	→	LowPA2	−0.016	−0.018	0.031	0.577
HighPA1	→	Sports2	−0.125	−0.090	0.028	0.001
ModPA1	→	Sleep2	0.017	0.026	0.026	0.326
ModPA1	→	EmoReg2	0.044	0.066	0.027	0.014
ModPA1	→	HighPA2	0.175	0.161	0.030	<0.001
ModPA1	→	LowPA2	0.083	0.084	0.032	0.008
ModPA1	→	Sports2	−0.111	−0.073	0.028	0.008
LowPA1	→	Sleep2	−0.010	−0.016	0.020	0.431
LowPA1	→	EmoReg2	0.004	0.006	0.021	0.756
LowPA1	→	HighPA2	0.026	0.026	0.023	0.257
LowPA1	→	ModPA2	0.074	0.079	0.023	0.001
LowPA1	→	Sports2	0.050	0.035	0.021	0.099
Sports1	→	Sleep2	<0.001	0.000	0.020	0.983
Sports1	→	EmoReg2	0.002	0.004	0.021	0.829
Sports1	→	HighPA2	−0.072	−0.106	0.023	<0.001
Sports1	→	ModPA2	−0.053	−0.086	0.023	<0.001
Sports1	→	Low PA2	−0.008	−0.013	0.024	0.598

Only the results from time 1 to time 2 are shown as results were constrained across time. Covariate results can be obtained from the author.
b, unstandardized betas; β, standardized betas; SE, standard error for β; *P*, significance value for β; EmoReg, emotion regulation; Sleep, sleep quality; HighPA, high physical activity; ModPA, moderate physical activity; LowPA, low physical activity; 1, time 1; 2, time 2.

0.035; 90% CI, 0.026–0.044; P = 0.998). Table 2 shows beta weights for all paths in the model for all six key study variables (model results are displayed in Fig. 1; only paths from times 1 to 2 are shown as the results are invariant across time).

Results revealed statistically significant indirect effects of time 1 sleep quality on time 3 high-intensity physical activity (β = 0.004; 90% CI, 0.001–0.007; SE = 0.002; P = 0.036), moderate-intensity physical activity (β = 0.005; 90% CI, 0.002–0.008; SE = 0.002; P = 0.017), and low-intensity physical activity (β = 0.007; 90% CI, 0.003–0.012; SE = 0.003; P = 0.006), all through time 2 emotion regulation. These results indicate that better sleep quality predicted greater emotion regulation over time, and in turn, greater emotion regulation predicted more frequent engagement in high, moderate and low physical activity over time. Of interest, the effects only were indirect, as there were no direct effects between sleep and physical activity over time (Ps > 0.200).

There also was an indirect effect from time 1 moderate physical activity to time 3 sleep quality via emotion regulation at time 2 (β = 0.006; 90% CI, 0.002–0.011; SE = 0.003; P = 0.026). See Figure 1 and Table 2 for other statistically significant results.[1]

[1]Note that although the results indicate that the path from time 1 high-intensity physical activity to time 2 emotion regulation was nonsignificant, the beta is negative, which is the opposite of their bivariate correlation. This is most likely due to suppression, as the correlation between the physical activity measures were fairly high (see Table 3).

DISCUSSION

The results of the current study indicate that there is support for a relationship between sleep and physical activity over time but *only through* emotion regulation. There was no evidence for direct links between physical activity and sleep over time, which may speak to the mixed results found previously in the literature. The present study provides the first longitudinal evidence for a link between sleep and physical activity in a young adult sample. These results are consistent with past cross-sectional work that has found direct measures of physical activity are not related to some indicators of sleep quality, but cognitive factors, such as thinking one is in shape are related (12). Of note, sleep only indirectly predicted high, moderate and low levels of physical activity over time via emotion regulation, and only moderate levels of physical activity indirectly predicted lower sleep problems over time via emotion regulation. Thus, engaging in low- and high-intensity physical activity was not enough to improve emotion regulation and subsequently sleep quality over time which has important implications for health recommendations. These results, however, fall in line with recommendations of the Center for Disease Control that indicate engaging in moderate- and high-intensity exercises will provide substantial health benefits (40). It is surprising that the results for high-intensity physical activity were not significant; perhaps, as indicated previously, the moderately high correlation between high and moderate physical activity suppressed its effects. At the

TABLE 3. Correlation matrix.

Measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Sleep1	**1.00**																	
2. Sleep2	**0.66**	**1.00**																
3. Sleep3	**0.60**	**0.70**	**1.00**															
4. EmoReg1	**0.35**	**0.29**	**0.28**	**1.00**														
5. EmoReg2	**0.32**	**0.36**	**0.37**	**0.64**	**1.00**													
6. EmoReg3	**0.29**	**0.31**	**0.39**	**0.62**	**0.68**	**1.00**												
7. HighPA1	**0.07**	0.04	0.05	**0.13**	**0.11**	**0.09**	**1.00**											
8. HighPA2	**0.14**	**0.11**	**0.10**	**0.17**	**0.19**	**0.14**	**0.55**	**1.00**										
9. HighPA3	**0.15**	**0.07**	**0.11**	**0.14**	**0.15**	**0.14**	**0.52**	**0.57**	**1.00**									
10. ModPA1	**0.10**	**0.09**	**0.11**	**0.08**	**0.13**	**0.10**	**0.69**	**0.49**	**0.42**	**1.00**								
11. ModPA2	**0.15**	**0.14**	**0.11**	**0.15**	**0.17**	**0.15**	**0.48**	**0.73**	**0.50**	**0.55**	**1.00**							
12. ModPA3	**0.13**	**0.10**	**0.11**	**0.16**	**0.17**	**0.15**	**0.45**	**0.45**	**0.72**	**0.44**	**0.52**	**1.00**						
13. LowPA1	0.07	0.05	0.05	0.05	0.06	0.05	**0.28**	**0.22**	**0.20**	**0.41**	**0.32**	**0.26**	**1.00**					
14. LowPA2	**0.09**	**0.15**	**0.09**	**0.08**	**0.09**	**0.09**	**0.15**	**0.28**	**0.19**	**0.24**	**0.44**	**0.26**	**0.36**	**1.00**				
15. LowPA3	0.03	**0.08**	0.06	**0.09**	**0.17**	**0.12**	**0.19**	**0.19**	**0.29**	**0.23**	**0.27**	**0.46**	**0.40**	**0.37**	**1.00**			
16. Sports1	**−0.16**	**−0.07**	**−0.11**	**−0.13**	**−0.09**	**−0.11**	**−0.41**	**−0.36**	**−0.29**	**−0.33**	**−0.29**	**−0.21**	**−0.10**	−0.06	−0.06	**1.00**		
17. Sports2	**−0.15**	**−0.09**	**−0.12**	**−0.19**	**−0.15**	**−0.14**	**−0.40**	**−0.46**	**−0.36**	**−0.34**	**−0.36**	**−0.31**	**−0.09**	**−0.10**	**−0.11**	**0.60**	**1.00**	
18. Sports3	**−0.13**	−0.06	**−0.12**	**−0.22**	**−0.11**	**−0.14**	**−0.35**	**−0.41**	**−0.40**	**−0.31**	**−0.34**	**−0.35**	**−0.10**	**−0.08**	**−0.11**	**0.52**	**0.68**	**1.00**

Correlations not in bold emphasis are not significant.

Sleep, sleep quality; EmoReg, emotion regulation; HighPA, high intensity physical activity; ModPA, moderate intensity physical activity; Low PA, low intensity physical activity; 1, Time 1; 2, Time 2; 3, Time 3.

same time, however, medium-intensity physical activity was predicted by high and low physical activity. Perhaps low-intensity physical activity (e.g., going for walks) is a starting point for the initiation of medium-intensity physical activity, at least for young adults, which would subsequently promote better emotion regulation and sleep quality over time.

Although these results provide support and add to what was previously assumed about the relationship between physical activity and sleep, limitations of the current study must be addressed. The first limitation is that these data are based on self-report information. It would be beneficial to examine more objective measures of individuals' sleep quality (e.g., through actigraphy or EEG). However, self-report allows us to examine participants' *perception* about their sleep, which provides important information. A second limitation is that our sample was comprised only of undergraduate students. It would be worthwhile to examine these questions with young adults who are not attending university as well as adolescents. It may be that similar patterns of results would be found as the findings of the current study parallel Holfeld and Ruthig's study (22) conducted with older adults (although note that our results found an association from sleep to physical activity *only* through emotion regulation).

Overall, the results of the current study add support to previous research that has suggested associations between sleep and physical activity, and sheds some light on research that has failed to find significant associations between these two factors (4,6). Although there were no significant *direct* effects between sleep and physical activity over time, these two factors were associated longitudinally *via* emotion regulation—that is, better sleep predicted better emotion regulation over time, which in turn predicted more frequent high-, moderate-, and low-intensity physical activities over time. Further, moderate physical activity predicted fewer sleep problems over time via emotion regulation. Clearly, sleep and moderate physical activity play important roles in improving emotion regulation over time.

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The authors declare no conflicts of interests. The results of the present study do not constitute endorsement by ACSM, and these results are presented clearly, honestly and without fabrication, falsification, or inappropriate data manipulation.

EPIDEMIOLOGY

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