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Original Article

Examining the Effects of Strength Training with Load Progression on Sleep Parameters and Mental Health in College Students

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Sleep Sci

Abstract

Objective To compare the effects of strength training with load progression after 4 weeks on sleep parameters and mental health in college students.

Methods A total of 17 university students (11 women, 6 men), ranging from 18 to 21 years old, were randomized into a strength training group (STG) and a control group (CG). The Pittsburgh sleep quality index (PSQI), insomnia severity questionnaire, hospital anxiety and depression (HAD) scale, profile of mood states (POMS), and chronotype were used to evaluate the main outcomes. Training consisted of 60 minute·d^{-1} (2 times/week, for 4-weeks), with 3 sets of 10 to 12 repetitions, and a 1-minute rest interval between sets and exercises. Baseline and postintervention differences were analyzed using generalized estimating equations (GEE).

Results After 4 weeks of ST, a significant time effect on the chronotype (β: 1.33; $p < 0.05$) was observed in the STG. Additionally, there was a significant time and group effect in the reduction of tension (β: 5.00; $p < 0.05$), depression (β: 15.41; $p < 0.05$), anger (β: 8.00; $p < 0.05$), and confusion (β: 6.50; $p < 0.05$). For fatigue (β: 2.66; $p < 0.05$), there was a significant time effect difference in its reduction. Vigor was meaningfully increased in the STG group (β: −1.75; $p < 0.05$). Furthermore, a significant positive relationship was observed between sleep quality and anxiety ($r = 0.54$; $p = 0.03$). Finally, insomnia was positively related with an increase in confusion ($r = 0.70$; $p = 0.04$) and anxiety ($r = 0.52$; $p = 0.04$), as well as with a decrease in vigor ($r = -0.71$; $p = 0.03$).

Keywords
- anxiety
- depression
- sleep
- resistance training

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Discussion Short-term strength training for 4 weeks was effective for improving mental health, helping achieve characteristics of a positive mood profile, that is, low values for negative factors and a high value for the positive factor.

Introduction

Sleep-related problems are common among college students,[1,2] and more than half of this population suffer from poor sleep quality.[3,4] This poor quality, for the most part, stems from irregular hours of sleep, excessive use of screen-based technologies, and low physical activity, making students susceptible and vulnerable to sleep disturbances and deprivation.[4,5]

In a study which analyzed sleep perception, performed with 290 university students (17–29 years old), it was revealed that 67.2% of the students reported poor sleep quality, while among the students who never missed any classes, 62% reported good sleep. Additionally, poor sleep quality was strongly associated with negative moods,[6] increased stress reactivity, higher levels of anxiety, and more absences from morning classes.[4]

Anxiety and depression represent personal, social, and economic burdens, and are considered international[7] and national public health problems.[8] These mental disorders were meaningfully associated with poor sleep quality in various studies.[4,9–11]

Furthermore, poor sleep quality can have mental and physiological consequences in the student population,[9] and lifestyle-related unhealthy behaviors have been linked to increased depressive symptoms among college students in the past.[12]

In addition to these aspects, studies have demonstrated the relationship between sleep problems and chronotype, where people with an evening chronotype have a higher sleep debt, more subjective sleepiness, and poorer sleep quality compared with morning chronotypes.[5,13] According to Halson,[14] a reduction in the number of sleep hours, whether naturally or experimentally, impairs cognitive performance and mood, also being associated with decreased muscle mass and loss of strength.[15–17] Until now, studies investigating the effects of exercise on mood have not taken into account the issue of diurnal rhythms or preferences.[18]

Loprinzi and Loenneke[19] showed that involvement in muscle-strengthening activities is associated with a 19% greater chance of meeting sleep duration recommendations (7–8 hours/night) in adults. Furthermore, Santiago et al.[20] examined the effects of performing a 12-week strength training (ST) program on sleep quality and daytime sleepiness in adolescents. The authors observed that training reduced the sleep quality score and increased total sleep time, with decreased daytime sleepiness. However, Kovacevic et al.[21] in a systematic review study, highlighted that data on the efficacy of ST are limited, requiring further studies to determine whether there is a dose-response effect for ST and sleep, similar to what was observed with aerobic exercise.

Moreover, there are limitations in studies regarding standardization of ST prescription (i.e., intensity, frequency, and duration), especially when considering results of neuropsychological parameters (i.e., depression, anxiety, and stress) among university students.[22,23] Therefore, the aim of this study was to compare the effects of strength training with a progressive increase in training load on sleep parameters, chronotype, and mental health in university students.

Material and Methods

Participants

The following inclusion criteria were used: (a) university students aged between 17 and 21 years, (b) presenting complaints of nonrestorative sleep (poor quality or disturbance of sleep) and daytime sleepiness, (c) not being currently involved in any exercise program, (d) having no physical problem that hinders exercise performance, and (e) without use of sleep drugs.

The sample was recruited through advertisement performed among students of the University of Pernambuco. Initially, a total of 31 students (men: 21; women: 10) agreed to participate in the study. The university students were divided into 2 groups: strength training (STG) and control (CG), through simple randomization via the website www.randomizer.org. Thus, 16 students were initially allocated to the STG and 15 to the CG. However, 8 individuals dropped out of the CG during the interventions, due to living too far away from the location of the training sessions ($n=2$); lack of motivation ($n=3$); and lack of time due to school schedules ($n=3$).

In the STG, 2 students left voluntarily, one of them having suffered an unrelated accident with a fracture in one of the lower limbs, which left him unable to exercise, and another having been excluded due to not following the guidelines of the study stating that no structured physical exercises should be performed outside of the proposed protocol. Thus, the final sample consisted of 21 volunteers (STG: $n=14$; 19.09 ± 0.9 years of age. CG: $n=7$; 20.0 ± 0.7 years of age).

Experimental Approach to the Problem

This is an observational study with the objective of analyzing the effect of strength training (ST) with increased weekly load on sleep quality and psychobiological parameters in university students. The volunteers who met the inclusion criteria were invited to participate, and written informed consent was obtained.

The students were divided into 2 experimental groups: control (CG) and strength training (STG). There were no changes in daily routine activities during the study period and none of the participants (control and training) had played sports for at least 6 months before the intervention. The STG happened for 4 weeks, with 2 training sessions per week on nonconsecutive days, lasting 60 minutes, with a weekly increase in load intensity. In each training session, 8 exercises were performed, as follows: bench press, pulled forward, barbell curl, triceps pulley, leg press 45°, extensor, adductor, and abductor. The resistance training session consisted of 3 sets of 10 repetitions, with rest intervals between sets and exercises of one and two minutes, respectively.

The following evaluation procedures were performed in both groups: anthropometric measurement, analysis of sleep quality and efficiency with the Pittsburgh sleep quality index (PSQI), insomnia through the insomnia severity index questionnaire (ISIQ), daytime sleepiness with the Epworth sleepiness scale (ESS), chronotype, anxiety and depression with the hospital anxiety and depression (HAD) scale, and mood with the profile of mood states (POMS). All variables were evaluated in both groups before and after the intervention.

Outcomes

Anthropometrics and Body Composition

Body mass was measured to the nearest 0.1kg with a digital scale (Filizola, São Paulo, Brazil), and stature was measured to the nearest 0.5cm using a portable Welmy 160/300 stadiometer (Welmy, Santa Bárbara d'Oeste, SP, Brazil), with the participants barefoot, with feet together, and head in the Frankfurt horizontal plane, wearing light clothing. This procedure was performed by a single evaluator following the recommendations described by the International Society for Advancement in Kinanthropometry.[24] The body mass index (BMI) was calculated using the standard formula (BMI: weight [kg]/height [m]).[2]

Sleep Quality, Duration, and Efficiency

Sleep quality was assessed using the PSQI, which has previously been validated for Brazilian adolescents.[25] The PSQI measures sleep habits in the previous month and is composed of 19 questions, divided into 7 domains (i.e., subjective sleep quality, latency, duration, habitual efficiency, disturbance, use of sleeping drugs, and daytime dysfunction). The final score ranges from 0 to 21 points, with higher values indicating poor sleep quality (5–10 points) or a disorder (11–21 points).

Total sleep duration was assessed by the fourth question of the PSQI "how many hours of actual sleep do you get at night?". Efficiency is defined by the percentage of time spent asleep while in bed, calculated by dividing the amount of time spent asleep (in minutes) by the total amount of time in bed (in minutes).[26]

Daytime Sleepiness

The ESS was used to assess daytime sleepiness of the university students.[27] This is a self-administered questionnaire that quantifies the propensity of the individual to fall asleep during 8 routine situations: (a) sitting and reading; (b) watching TV; (c) sitting, inactive in a public place (e.g., a theater or a meeting); (d) as a passenger in a car for an hour without a break; (e) lying down to rest in the afternoon when circumstances permit; (f) sitting and talking to someone; (g) sitting quietly after lunch without alcohol consumption; and (h) inside the car, while stopped for a few minutes in traffic. The final score ranges from 0 to 24 points, with higher values (> 10) indicating excessive daytime sleepiness.

Insomnia Severity Index

To assess insomnia, the insomnia severity index (ISI) questionnaire was applied, consisting of 7 objective questions[28] concerning sleep, including difficulty falling asleep, difficulty staying asleep, problems waking up early, and too much sleep, among others. The scores awarded for each question are added up and analyzed. A score from 0 to 7 points indicates no significant clinical insomnia, 8 to 14 points subliminal, 15 and 21 points moderately severe clinical insomnia, and 22 to 28 points severe clinical insomnia.

Chronotype (Morning-Evening)

A person's chronotype refers to their propensity to sleep at a specific time of a 24-hours-day. Chronotype was evaluated through the questionnaire developed by Horne and Östberg[29] and validated by Ceolim and Menna-Barreto,[30] being used to classify the participants into morning, afternoon, and indifferent. The chronotype varies from 16 to 86 points. The subjects were classified into five different chronotypes as follows: evening (16 to 30 points), moderately evening (31 to 41 points), indifferent or intermediate (42 to 58 points), relatively morning (59 to 69 points), and morning (70 to 86 points).

Anxiety and Depression

To assess anxiety and depression, we used the HAD scale by Zigmond and Snaith,[31] translated into Portuguese and validated by Botega et al..[32] This scale contains 14 multiple-choice questions, consisting of two subscales, anxiety and depression, with seven items each. A higher score means an increase in symptoms. The global score on each subscale ranges from 0 to 21. All items are categorized on a 4-point scale ranging from 0 to 3. A score between 0 and 7 means no depressive or anxious symptoms; scores between 8 and 11 mean possible symptoms; and from 12 to 21 probable symptoms.

The concept of depression is centered on the notion of anhedonia, intended to detect mild degrees of affective disorders in nonpsychiatric settings. It is short and can be quickly completed. The patient is asked to respond based on how they felt during the previous week.

Mood

To assess mood, we used the profile of mod states (POMS). This questionnaire assesses 6 transient mood states: tension, depression, anger, vigor, fatigue, and mental confusion, named after the profile of mood states, which was adapted, translated, and validated for Brazilian Portuguese.[33] The POMS consists of 65 items, to which individuals respond according to 5 alternatives: 0 (not at all), 1 (a little), 2 (more or less), 3 (a lot), and 4 (extremely). Another way of looking at the results is through the total mood (TM), calculated by adding the negative factors (NF), minus the positive factor (PF), plus one hundred. Thus, total mood was calculated using the standard formula: TM = (tension + depression + anger + fatigue + mental confusion) – stamina + 100. As such, a higher score represents worse symptoms of mood.

Interventions and Load Increments

For this study, the STG performed the training twice a week, over 4 weeks. The training was performed in 2 training sessions on nonconsecutive days, lasting 60 minutes, with a weekly increase in load intensity. In each training session, 8 exercises were performed, as follows; bench press, pulled front, direct curl, triceps pulley, leg press 45°, leg extension, adductor, and abductor. The session of resistance training was composed of 3 sets of 10 repetitions, with rest intervals between sets and exercises of 1 and 2 minutes, respectively.

The training sessions used exercises with a load corresponding to 50% in the 1st week, 60 in the 2nd, 70 in the 3rd, and 80% in the 4th, according to the subjective perception of effort (PSE). Thus, to determine the load for the first week, all subjects chose the load at which they could comfortably perform 10 to 12 repetitions in the following exercises: bench press, pulled front, direct curl, triceps pulley, leg press 45°, leg extension, adductor, and abductor. The OMNI-resistance exercise scale (OMNI-RES) was applied immediately after the exercise to identify the subjective perception of effort (PSE), which was considered for the load increments.

In this way, the weekly load was established as PSE 5 at week 1; 6 at week 2; 7 at week 3; and 8 at week 4. Adaptation and familiarization with the OMNI-RES scale were performed during the 1-RM assessment. If the individual reported a PSE outside of the established numerical value, the increase or decrease in the load was adjusted by 5%. During the intervention, the STG trained with a load corresponding to that planned for each week, while the CG did not carry out any type of structured physical exercise.

Statistical Analysis

The data were stored and analyzed using the Statistical Package for the Social Sciences (SPSS, IBM Corp., Armonk, NY, USA). Normality and homogeneity of variances were checked by the Shapiro-Wilk and Levene tests, respectively. Descriptive statistics are presented as mean and standard deviation (SD). Intergroup (STG vs. CG) differences in the anthropometric, sleep parameter, and mental health variables were evaluated using independent sample *t*-tests. To compare the effects of the intervention on sleep parameters, anxiety, depression, and mood, the GEE were used, followed by post-hoc pairwise comparisons using the Bonferroni correction for multiple comparisons. Additionally, the Pearson moment-product correlation was used to verify the

Table 1 Baseline descriptive characteristics and comparisons between adolescents in the control and strength training groups.

Variables (mean ± SD)	Total (*N* = 21)	CG (*N* = 7)	STG (*N* = 14)	*t*-value
Anthropometric				
Age (years)	(19.3 ± 0.7)	(20.0 ± 0.7)	(19.08 ± 0.6)	2.474
Stature (m)	(1.6 ± 0.1)	(1.6 ± 0.0)	(1.6 ± 0.0)	−2.324
BMI (kg/m^2)	(22.3 ± 3.8)	(22.1 ± 3.6)	(22.4 ± 4.1)	−0,155
Sleep parameters				
PSQI (score)	(7.7 ± 2.3)	(8.0 ± 2.1)	(7.6 ± 2.4)	0.280
ESS (score)	(10.1 ± 4.7)	(9.2 ± 4.4)	(10.5 ± 5.0)	−0.529
Sleep efficiency (score)	(84.3 ± 10.9)	(83.9 ± 8.1)	(84.5 ± 12.3)	−0.105
Sleep duration (hours)	(7.3 ± 1.0)	(7.8 ± 0.8)	(7.2 ± 1.1)	1.198
Insomnia (score)	(8.8 ± 4.5)	(8.8 ± 5.3)	(8.8 ± 4.4)	−0.012
Morning-evening	(45.7 ± 7.0)	(45.6 ± 2.3)	(45.7 ± 8.3)	−0.057
Mood (POMS)				
Tension	(8.2 ± 3.2)	(11.2 ± 0.2)	(7.2 ± 0.8)	2.847*
Depression (POMS)	(9.0 ± 9.2)	(17.2 ± 2.09)	(6.3 ± 2.4)	3.117**
Anger	(9.3 ± 5.6)	(17.0 ± 0.6)	(6.8 ± 1.0)	7.845**
Fatigue	(13.5 ± 4.0)	(14.5 ± 1.3)	(13.2 ± 1.2)	0.622
Confusion	(8.2 ± 4.6)	(12.0 ± 2.0)	(7.0 ± 1.1)	1.882
Vigor	(13.8 ± 4.1)	(10.2 ± 1.6)	(15.0 ± 1.0)	−2.200
HAD scale				
Anxiety	(6.3 ± 3.4)	(8.5 ± 1.5)	(5.5 ± 0.8)	1.642
Depression (HS)	(7.26.3 ± 2.8)	(8.7 ± 1.4)	(6.7 ± 0.7)	1.100

Abbreviations: BMI, body mass index; CG, control group; ESS, Epworth sleepiness scale; STG, strength training group; SD, standard deviation; HAD, hospital anxiety and depression; PSQI, Pittsburgh sleep quality index; POMS, profile of mood states. **Notes:** Student *t*-test. *$p < 0.05$. **$p < 0.001$.

relationship between sleep parameters and mental health. The significance level was set at p-value < 0.05 (two-tailed testing) for all analyses.

Results

Descriptive analyses and baseline comparisons of the university students are provided in ►**Table 1**. Tension ($p < 0.05$), depression ($p < 0.001$), and anger ($p < 0.001$) were significantly reduced in STG in comparison with CG at baseline. Additionally, both groups showed an indication of poor sleep quality and subliminal insomnia.

Sleep parameters showed no significant changes after 4 weeks of strength training between groups. However, there was a significant time effect on the chronotype ($p < 0.05$; ►**Table 2**).

The comparisons of the effects of ST on mood and the HAD scale collected after 4 weeks showed significant differences between the groups (►**Table 3**). There was a significant time and group effect in tension reduction ($p < 0.05$), demonstrating that this effect occurred in both groups. However, the magnitude of the effect varied between them. Additionally, there was a significant group effect in the reduction of depression, anger, and confusion variables ($p < 0.05$). Furthermore, there was a significant time effect difference in the reduction of fatigue ($p < 0.05$). Vigor was meaningfully increased in STG group ($p < 0.05$).

Although the effects of the 4 weeks of training were not enough to promote changes in sleep parameters, we opted to examine the existence of relationships between sleep variables and mental health (►**Table 4**). Moreover, a significant positive relationship was observed between sleep quality and anxiety (r = 0.54; $p = 0.03$). Finally, insomnia was positively related to an increase in confusion (r = 0.70; $p = 0.04$), and anxiety (r = 0.52; $p = 0.04$), and to a decrease in vigor (r = −0.71; $p = 0.03$).

Discussion

The aim of this study was to explore the effects of strength training with a progressive increase in training load on sleep parameters, chronotype, and mental health in university students. First, we observed that ST promoted a slight and significant time effect on the chronotype score. The

Table 2 Dependent measures of control and strength training groups in pre- and post-training evaluations and main and interaction effects.

Variables (Mean ± SD)	Baseline	4 weeks ST	Groups		Time		GxT	
			β	95%CI	β	95%CI	β	95%CI
Sleep parameters								
Sleep quality – PSQI (score)								
CG	(8.0 ± 2.1)	(7.6 ± 1.8)	0,93	−0.87–2.74	1.00	−0.13–2.13	−0.69	−2.24–1.04
ST	(7.6 ± 2.4)	(6.6 ± 2.0)						
ESS (score)								
CG	(9.2 ± 4.4)	(8.8 ± 2.6)	−1,61	−4.63–1.39	0.08	−8.25–0.99	0.31	−2.11–2.75
ST	(10.5 ± 5.0)	(9.9 ± 3.7)						
Sleep efficiency (score)								
CG	(83.9 ± 8.1	(84.5 ± 12.3)	1,86	−8.46–12.18	3,97	−3.15–11.09	−2.39	−10.45–5.66
ST	(82.4 ± 10.5)	(80.5 ± 11.4)						
Sleep duration (hours)								
CG	(7.8 ± 0.8)	(8.0 ± 1.0)	0,54	−0.43–1.51	−0.25	−0.71–0.21	0.05	−0.53–0.63
ST	(7.2 ± 1.0)	(7.4 ± 1.0)						
Insomnia (score)								
CG	(8.8 ± 5.35)	(11.0 ± 2.0)	0,85	−3.71–5.41	−1.08	−0.03–2.20	−0.88	−2.05–0.28
ST	(8.8 ± 4.40)	(7.7 ± 3.8)						
Chronotype (morning-evening)								
CG	(45.6 ± 2.3)	(44.2 ± 0.8)	−0.35	−4.32–3.61	1.33	0.02–2.64*	0.20	−1.64–2.05
ST	(45.7 ± 8.3)	(44.4 ± 7.1)						

Abbreviations: CI, confidence interval; CG, control group; ESS, Epworth sleepiness scale; ST, strength training; SD, standard deviation; PSQI, Pittsburgh sleep quality index; POMS, profile of mood states. **Notes:** $^{*}p < 0.05$. $^{**}p < 0.001$.

Table 3 Dependent measures Mood and HAD Scale of control and strength training groups in the pre- and post-training evaluations and main and interaction effects.

Variables (mean ± SD)	Baseline	4 weeks	Groups		Time		GxT	
			β	95%CI	β	95%CI	β	95%CI
Mood (POMS)								
Tension								
CG	(11.2 ± 0.9)	(9.6 ± 1.4)	5.00	1.98–8.01*	2.58	0.97–4.19*	−1.00	−5.80–3.80
STG	(7.2 ± 0.8)	(4.6 ± 0.5)						
Depression (POMS)								
CG	(17.2 ± 2.0)	(20.6 ± 6.5)	15.41	2.47–28.35*	1.08	−3.63–5.80	−4.50	−17.48–8.48
STG	(6.3 ± 2.4)	(5.2 ± 1.1)						
Anger								
CG	(17.0 ± 0.6)	(13.6 ± 25)	8.00	2.59–13.40*	1.16	−0.85–3.13	2.16	4.27–8.60
STG	(6.8 ± 1.0)	(5.6 ± 0.9)						
Fatigue								
CG	(14.5 ± 1.3)	(11.6 ± 0.5)	1.08	−0.81–2.98	2.66	0.42–4.19*	0.16	−3.63–3.96
STG	(13.2 ± 1.2)	(10.5 ± 0.8)						
Confusion								
CG	(12.0 ± 2.0)	(12.6 ± 1.6)	6.50	2.92–10.0*	0.83	−1.46–3.13	−1.50	−4.78–1.78
STG	(7.0 ± 1.1)	(6.1 ± 0.7)						
Vigor								
CG	(10.2 ± 1.6)	(14.3 ± 0.2)	−2.50	−5.18–0.18	−1.75	−3.17–−0.32*	−2.33	−5.54–0.87
STG	(15.0 ± 1.0)	(16.8 ± 1.3)						
HAD scale (HS)								
Anxiety								
CG	(8.5 ± 1.5)	(7.0 ± 0.8)	1.41	−0.48–3.31	−0.08	−1.45–1.29	1.83	−1.13–4.79
STG	(5.5 ± 0.8)	(5.5 ± 0.5)						
Depression (HS)								
CG	(8.7 ± 1.4)	(7.3 ± 1.1)	1.58	−1.12–4.29	1.00	−0.38–2.38	0.41	−3.07–3.91
STG	(6.7 ± 0.7)	(5.7 ± 0.7)						

Abbreviations: CI, confidence interval; CG, control group; HAD, hospital anxiety and depression; SD, standard deviation; STG, strength training group; POMS, profile of mood states. **Notes:** $^{*}p < 0.05$. $^{**}p < 0.001$.

chronotype distribution estimates depend on the population and classification method. Furthermore, chronotype is related to age and sex,[35] as well as other factors such as lifestyle and profession.[36] However, we could not affirm that the changes in the chronotype score were modulated by the ST because we did not work with the individual score.

On the other hand, Siviero et al.[37] demonstrated that individuals who had an afternoon chronotype presented greater adherence to carrying out their training in the period corresponding to their chronotype. Küüsmaa et al.[38] found that, in young men, evening training appeared to lead to greater adaptations in evening endurance performance, when compared with morning training.

Although there is still no consensual definition, the mood state measured by the POMS can be understood as a psychological state composed of positive and negative feelings, which vary in intensity and duration, being an indicator of psychological wellbeing.[39] In the present study, positive psychological changes were observed in the STG, demonstrated by reductions in different scores. For instance, the effects in tension reduction were observed in both groups; nevertheless, with different magnitudes (i.e., group and time effect) and fatigue (i.e., time effect), and an increase in the vigor score regarding time effect in both groups (i.e., positive mood). Additionally, significant effects on depression (POMS), anger, and confusion (i.e., group effect) were observed in the STG, without significant changes in anxiety and depression (HAD scale).

In general, physically active and more physically fit people have a better mood state than those who are sedentary and less fit. Crossectional studies that compared psychological variables of active and sedentary individuals and among

Table 4 Bivariate correlations among sleep parameters and metal health.

Variables	Sleep quality –PSQI (score)	ESS (score)	Insomnia (score)	Sleep efficiency (score)	Sleep duration (hours/min)	Chronotype (morning/ evening)
Mood (POMS)						
Tension	0.370 (0.175)	−0.336 (0.221)	0.381 (0.161)	−0.220 (0.430)	0.297 (0.283)	−0.035 (0.903)
Depression (POMS)	0.144 (0.594)	−0.116 (0.670)	0.000 (0.999)	0.063 (0.825)	0.111 (0.694)	−0.146 (0.589)
Anger	−0.264 (0.342)	−0.365 (0.181)	0.046 (0.871)	0.236 (0.396)	0.176 (0.530)	0.162 (0.564)
Fatigue	0.252 (0.366)	0.284 (0.305)	0.469 (0.078)	−0.261 (0.186)	0.339 (0.217)	0.466 (0.080)
Confusion	0.190 (0.497)	0.070 (0.806)	0.701 (0.004)*	0.166 (0.555)	−0.026 (0.927)	0.153 (0.587)
Vigor	−0.372 (0.172)	−0.142 (0.613)	−0.719 (0.003)*	−0.131 (0.640)	0.064 (0.821)	−0.031 (0.914)
HAD scale						
Anxiety	0.540 (0.038)*	0.315 (0.254)	0.527 (0.043)*	−0.124 (0.659)	−0.067 (0.811)	0.125 (0.657)
Depression (HD)	−0.151 (0.590)	−0.381 (0.157)	0.275 (0.321)	0.297 (0.283)	−0.282 (0.308)	−0.037 (0.895)

Abbreviations: ESS, Epworth sleepiness scale; PSQI, Pittsburgh sleep quality index; POMS, profile of mood states. **Notes:** $^{*}p < 0.05$. $^{**}p < 0.001$.

those with different levels of activity and physical fitness corroborate this premise.[40,41]

For instance, Werneck et al.[42] evaluated the profile of mood states (POMS) in seven different training situations, consisting of resistance exercises and running on a treadmill, with different intensities and on alternate days. The results demonstrated that acute exercise sessions promoted changes in posteffort mood, regardless of the type of exercise and intensity. It is interesting to observe that variables such as depression, anger, and mental confusion were not statistically different, revealing that these variables seem to be less sensitive to acute exercise.[42]

In another study, de Melo et al.[43] demonstrated improvement in mental health after just one session of strength training (ST), resulting in a profile of positive mood state, with low values of negative scores and a high value of the positive score (vigor). A possible explanation for these effects is that the psychological benefits of exercise occur both as a result of physiological factors, such as increased physical fitness, and increased levels of neurotransmitters in the brain, such as endorphins, serotonin, and α brain waves that act to improve the quality of sleep,[44] and of psychological and social factors, such as increased self-esteem, self-efficacy, feelings of pleasure, and contact with people.[42] Therefore, the control of acute variables, such as volume and intensity, will positively add to the exercise prescription process for the prevention and treatment of anxiety and mood disorders, especially among university students.

In the present study, when we examined the relationships between sleep parameters and mental health, a positive correlation was observed between insomnia, confusion (POMS), and anxiety (HAD scale), while a negative correlation was found between insomnia and vigor (POMS), indicating that the more severe the insomnia complaints, the worse the participant's levels of confusion and anxiety. Additionally, the lower level of insomnia, the better the level of vigor (POMS). Furthermore, the correlation between sleep quality and anxiety was positive, demonstrating that higher poor sleep quality scores resulted in higher anxiety levels.

The metanalyses of correlational and experimental studies revealed positive effects of exercise in healthy people and in clinical populations (also in patients with emotional and sleep disorders) regardless of sex and age. The benefits are significant, especially in subjects with an elevated level of anxiety and depression, because of the wider possibility for change. The greatest improvements are caused by rhythmic and aerobic exercises using large muscle groups, of moderate and low intensity.[45]

In this context, Ji et al.[46] investigated the effects of intensity and frequency of 6 weeks of exercise (cardiorespiratory training and resistance training) on anxiety, depression, and sleep quality in college students, and found that exercise intensity reduced anxiety, decreased symptoms of depression, and raised quality of sleep. This last variable was most closely related to intensity, indicating that exercise intensity and frequency have different effects on anxiety, depression, and sleep quality in college students.

It is important to mention that low psychological distress was frequently found in aged adults with a high cognition profile and low functional disability, while increasing psychological distress was commonly found in worsening cognition and high functional disability, demonstrating districting trajectory profiles in older age.[47] It emphasizes the fundamental role of preventing the increase of psychological distress and, consequently, functional disabilities from an early age, which probably will reflect in older ages. The present study showed the benefits of ST on chronotype, tension, depression, anger, fatigue, confusion, and vigor in university students, which indicates the importance of preventing unfavorable psychological stress, maintaining good physical functioning, and avoiding future functional alterations.

Anxiety and depression are serious public health problems; even recently, the symptoms of these mental disorders have been associated with suicidal ideation,[48–50] representing an economic burden for countries. Their reduction will also reflect on public health economics. Furthermore, the promotion of the mental health of Latin American youth is extremely necessary due to the increased prevalence of psychological distress in this age and regional group.[51]

This study has some limitations that should be pointed out. The first is that the measurement methods used are all of self-assessment, which can be influenced by subjective emotions when completing the questionnaire, leading to biases in the research results. The second is the small sample size.

Conclusion

From a practical point of view, it can be said that ST contributes to mental health improvement, since it contributes to the achievement of characteristics of a positive mood profile, that is, low values for negative factors and a high value for the positive factor. This positive profile can influence the daily performance of university students.

Ethical Considerations

This study was approved by the Research Ethics Committee of the University of Pernambuco (UPE, CAAE: 91840618.6.0000.5192). All procedures followed the guidelines of the Declaration of Helsinki (www.wma.net/e/policy/b3.htm). Prior to starting the experimental protocol, all participants were informed about the study, including an explanation of the research objective, and signed an informed consent form. They were also assured of their right to refuse participation and to voluntarily withdraw from the study. Moreover, they were informed that the intervention would not be harmful to them and their data would be managed confidentially.

Conflict of Interests

The authors have no conflict of interests to declare.

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References

1 Zhang M, Qin L, Zhang D, et al. Prevalence and factors associated with insomnia among medical students in China during the COVID-19 pandemic: characterization and associated factors. BMC Psychiatry 2023;23(01):140
2 Becker SP, Jarrett MA, Luebbe AM, Garner AA, Burns GL, Kofler MJ. Sleep in a large, multi-university sample of college students: sleep problem prevalence, sex differences, and mental health correlates. Sleep Health 2018;4(02):174–181
3 Cavalcanti LMLG, Lima RA, Silva CRM, Barros MVG, Soares FC. Constructs of poor sleep quality in adolescents: associated factors. Cad Saude Publica 2021;37(08):e00207420
4 Afandi O, Hawi H, Mohammed L, et al. Sleep quality among university students: Evaluating the impact of smoking, social media use, and energy drink consumption on sleep quality and anxiety. Inq Journal. 2013;5
5 Wang F, Bíró É Determinants of sleep quality in college students: A literature review. Explore (NY) 2021;17(02):170–177
6 Ablin JN, Clauw DJ, Lyden AK, et al. Effects of sleep restriction and exercise deprivation on somatic symptoms and mood in healthy adults. Clin Exp Rheumatol 2013;31(6, Suppl 79)S53–S59
7 GBD 2019 Mental Disorders Collaborators. Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet Psychiatry 2022;9(02): 137–150
8 Orellana JDY, Ribeiro MRC, Barbieri MA, et al. Mental disorders in adolescents, youth, and adults in the RPS Birth Cohort Consortium (Ribeirão Preto, Pelotas and São Luís), Brazil. Cad Saude Publica 2020;36(02):e00154319
9 Sadeh A, Tikotzky L, Kahn M. Sleep in infancy and childhood: implications for emotional and behavioral difficulties in adolescence and beyond. Curr Opin Psychiatry 2014;27(06):453–459
10 de Zambotti M, Goldstone A, Colrain IM, Baker FC. Insomnia disorder in adolescence: Diagnosis, impact, and treatment. Sleep Med Rev 2018;39:12–24
11 Goldstone A, Javitz HS, Claudatos SA, et al. Sleep Disturbance Predicts Depression Symptoms in Early Adolescence: Initial Findings From the Adolescent Brain Cognitive Development Study. J Adolesc Health 2020;66(05):567–574
12 Vieira FDST, Muraro AP, Rodrigues PRM, Sichieri R, Pereira RA, Ferreira MG. Lifestyle-related behaviors and depressive symptoms in college students. Cad Saude Publica 2021;37(10): e00202920
13 Bavarsad MB, Azimi N, Moradbeigi K, Latifi M. Associations between morningness-eveningness and sleep quality among female dormitory residents. Thrita. 2015;4
14 Halson SL. Monitoring training load to understand fatigue in athletes. Sports Med 2014;44(Suppl 2, Suppl 2)S139–S147
15 Leproult R, Van Cauter E. Role of sleep and sleep loss in hormonal release and metabolism. Endocr Dev 2010;17:11–21
16 Nedeltcheva AV, Kilkus JM, Imperial J, Schoeller DA, Penev PD. Insufficient sleep undermines dietary efforts to reduce adiposity. Ann Intern Med 2010;153(07):435–441
17 Knowles OE, Drinkwater EJ, Urwin CS, Lamon S, Aisbett B. Inadequate sleep and muscle strength: Implications for resistance training. J Sci Med Sport 2018;21(09):959–968
18 Sławińska M, Stolarski M, Jankowski KS. Effects of chronotype and time of day on mood responses to CrossFit training. Chronobiol Int 2019;36(02):237–249
19 Loprinzi PD, Loenneke JP. Engagement in muscular strengthening activities is associated with better sleep. Prev Med Rep 2015; 2:927–929
20 Santiago LCS, Lyra MJ, Germano-Soares AH, et al. Effects of Strength Training on Sleep Parameters of Adolescents: A Randomized Controlled Trial. J Strength Cond Res 2022;36(05): 1222–1227
21 Kovacevic A, Mavros Y, Heisz JJ, Fiatarone Singh MA. The effect of resistance exercise on sleep: A systematic review of randomized controlled trials. Sleep Med Rev 2018;39:52–68
22 Singh NA, Stavrinos TM, Scarbek Y, Galambos G, Liber C, Fiatarone Singh MA. A randomized controlled trial of high versus low intensity weight training versus general practitioner care for clinical depression in older adults. J Gerontol A Biol Sci Med Sci 2005;60(06):768–776

23 Gerber M, Brand S, Herrmann C, Colledge F, Holsboer-Trachsler E, Pühse U. Increased objectively assessed vigorous-intensity exercise is associated with reduced stress, increased mental health and good objective and subjective sleep in young adults. Physiol Behav 2014;135:17–24

24 Marfell-Jones MJ, Stewart AD, de Ridder JH. International standards for anthropometric assessment. Wellington, New Zealand: International Society for the Advancement of Kinanthropometry; 2012

25 Bertolazi AN, Fagondes SC, Hoff LS, et al. Validation of the Brazilian Portuguese version of the Pittsburgh Sleep Quality Index. Sleep Med 2011;12(01):70–75

26 Reed DL, Sacco WP. Measuring Sleep Efficiency: What Should the Denominator Be? J Clin Sleep Med 2016;12(02):263–266

27 Bertolazi AN, Fagondes SC, Hoff LS, Pedro VD, Barreto SSM, Johns MW. Validação da escala de sonolência de Epworth em português para uso no Brasil. J Bras Pneumol 2009;35(09):877–883

28 Morin CM, Belleville G, Bélanger L, Ivers H. The Insomnia Severity Index: psychometric indicators to detect insomnia cases and evaluate treatment response. Sleep 2011;34(05):601–608

29 Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol 1976;4(02):97–110

30 Ceolim MF, Menna-Barreto L. Sleep/wake cycle and physical activity in healthy elderly people. Sleep Res Online 2000;3(03): 87–95

31 Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983;67(06):361–370

32 Castro MM, Quarantini L, Batista-Neves S, Kraychete DC, Daltro C, Miranda-Scippa A. [Validity of the hospital anxiety and depression scale in patients with chronic pain.]. Rev Bras Anestesiol 2006;56(05):470–477

33 Peluso MA, Guerra de Andrade LH. Physical activity and mental health: the association between exercise and mood. Clinics (São Paulo) 2005;60(01):61–70

34 Lack L, Bailey M, Lovato N, Wright H. Chronotype differences in circadian rhythms of temperature, melatonin, and sleepiness as measured in a modified constant routine protocol. Nat Sci Sleep 2009;1:1–8

35 Roenneberg T, Kuehnle T, Juda M, et al. Epidemiology of the human circadian clock. Sleep Med Rev 2007;11(06):429–438

36 Adan A, Archer SN, Hidalgo MP, Di Milia L, Natale V, Randler C. Circadian typology: a comprehensive review. Chronobiol Int 2012;29(09):1153–1175

37 Siviero RB, Braga GF, Esteves A. A influência do cronotipo e da qualidade do sono na frequência de treinamento na academia. Rev Bras Ativ Fís Saúde. 2015;20:262–269

38 Küüsmaa M, Schumann M, Sedliak M, et al. Effects of morning versus evening combined strength and endurance training on physical performance, muscle hypertrophy, and serum hormone concentrations. Appl Physiol Nutr Metab 2016;41(12): 1285–1294

39 Werneck FZ, Navarro CM. Nível de atividade física e estado de humor em adolescentes. Psicol, Teor Pesqui 2011;27:189–193

40 Steinberg H, Nicholls BR, Sykes EA, et al. Weekly exercise consistently reinstates positive mood. Eur Psychol 1998;3:271–280

41 Hassmén P, Koivula N, Uutela A. Physical exercise and psychological well-being: a population study in Finland. Prev Med 2000;30 (01):17–25

42 Werneck FZ, Bara Filho MG, Coelho EF, Ribeiro LS. Efeito agudo do tipo e da intensidade do exercício sobre os estados de humor. Rev Bras Ativ Fís Saúde. 2012;15:211–217

43 de Melo CC, Boletini TL, Bicalho CCF, da Costa VT, Noce F. Efeitos da prática de musculação nos estados de humor de jovens aprendizes. RBPE.2018;8

44 Paluska SA, Schwenk TL. Physical activity and mental health: current concepts. Sports Med 2000;29(03):167–180

45 Ruiz-Comellas A, Valmaña GS, Catalina QM, et al. Effects of Physical Activity Interventions in the Elderly with Anxiety, Depression, and Low Social Support: A Clinical Multicentre Randomised Trial. Healthcare (Basel) 2022;10(11):2203

46 Ji C, Yang J, Lin L, Chen S. Physical Exercise Ameliorates Anxiety, Depression and Sleep Quality in College Students: Experimental Evidence from Exercise Intensity and Frequency. Behav Sci (Basel) 2022;12(03):61

47 Vasiliadis HM, Pitrou I, Grenier S, Berbiche D, Hudon C. Psychological Distress, Cognition, and Functional Disability Trajectory Profiles of Aging in Primary Care Older Adults. Clin Gerontol 2023;46(05):819–831

48 Im Y, Oh WO, Suk M. Risk Factors for Suicide Ideation Among Adolescents: Five-Year National Data Analysis. Arch Psychiatr Nurs 2017;31(03):282–286

49 Metts AV, Echiverri-Cohen AM, Yarrington JS, Zinbarg RE, Mineka S, Craske MG. Longitudinal associations among dimensional symptoms of depression and anxiety and first onset suicidal ideation in adolescents. Suicide Life Threat Behav 2023;53(03): 457–469

50 Delgadillo J, Budimir S, Barkham M, Humer E, Pieh C, Probst T. A Bayesian network analysis of psychosocial risk and protective factors for suicidal ideation. Front Public Health 2023;11:1010264

51 Souza TT, Almeida AC, Fernandes ADSA, Cid MFB. Adolescent mental health promotion in Latin American countries: an integrative literature review. Cien Saude Colet 2021;26(07): 2575–2586

