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Increased objectively assessed vigorous-intensity exercise is associated with reduced stress, increased mental health and good objective and subjective sleep in young adults

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HIGHLIGHTS

- Vigorous exercise has mental health benefits beyond moderate physical activity.
- Vigorous exercise is associated with less stress, pain, insomnia and depression.
- Vigorous exercisers have more favorable objective sleep pattern.
- Vigorous exercisers report fewer mental health problems if exposed to high stress.

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ABSTRACT

The role of physical activity as a factor that protects against stress-related mental disorders is well documented. Nevertheless, there is still a dearth of research using objective measures of physical activity. The present study examines whether objectively assessed vigorous physical activity (VPA) is associated with mental health benefits beyond moderate physical activity (MPA). Particularly, this study examines whether young adults who accomplish the American College of Sports Medicine's (ACSM) vigorous-intensity exercise recommendations differ from peers below these standards with regard to their level of perceived stress, depressive symptoms, perceived pain, and subjective and objective sleep. A total of 42 undergraduate students (22 women, 20 men; M = 21.24 years, SD = 2.20) volunteered to take part in the study. Stress, pain, depressive symptoms, and subjective sleep were assessed via questionnaire, objective sleep via sleep-EEG assessment, and VPA via actigraphy. Meeting VPA recommendations had mental health benefits beyond MPA. VPA was associated with less stress, pain, subjective sleep complaints and depressive symptoms. Moreover, vigorous exercisers had more favorable objective sleep pattern. Especially, they had increased total sleep time, more stage 4 and REM sleep, more slow wave sleep and a lower percentage of light sleep. Vigorous exercisers also reported fewer mental health problems if exposed to high stress. This study provides evidence that meeting the VPA standards of the ACSM is associated with improved mental health and more successful coping among young people, even compared to those who are meeting or exceeding the requirements for MPA.

1. Introduction

Stress and stress-related mental disorders are extremely common among young people [1,2]. Studies show that high levels of stress are associated with a plethora of mental health problems including increased depressive symptoms [3], higher burnout rates [4], augmented sleep complaints [5], elevated levels of pain [6], and decreased quality of life [7]. This is critical from a public health perspective because these mental health problems are highly prevalent among young people. For example, a recent review revealed that college students report depressive disorders more often than the general population with a mean occurrence rate of 31% [8]. Similar figures exist for other mental health problems such as sleep complaints with prevalence rates up to 50% [9,10]. Moreover, many of these disorders have a high temporal stability and persist over several years [11,12], leading to long-term bio-

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physiological changes [13] that may increase the risk for cardiovascular diseases [14]. Finally, mental health problems are associated with decreased professional success [15], which is especially problematic for young people who are at the beginning or their careers.

Meanwhile, the role of physical activity as a factor that protects against stress-related mental disorders is well documented [16,17]. Previous studies have shown that young people who regularly engage in physical activity perceive less stress [18], report lower depressive symptoms [19], experience fewer sleep complaints [20,21], and perceive fewer symptoms of pain [6]. Researchers have also shown that regular physical activity can prevent mental health problems among people with high stress exposures [22,23].

Despite this body of evidence, there is still a dearth of research using objective measures of physical activity. With few exceptions [24,25], current knowledge is based on self-reported levels of physical activity. The present study goes beyond the existing literature in that (i) accelerometer data are used to examine the relationship between objectively measured physical activity, stress, depressive symptoms, pain and sleep complaints, (ii) current physical activity guidelines of the American College of Sports Medicine (ACSM) [26,27] are referenced to categorize participants into groups who do/do not accomplish vigorous physical activity (VPA) recommendations [26], (iii) subjective and objective measures are combined to assess sleep [28], and (iv) interactions between stress and physical activity are tested to investigate whether participants who accomplish current vigorous-intensity exercise guidelines cope more successfully with high levels of stress [23].

Importantly, this study does not compare active versus inactive individuals because all participants in this sample meet the ACSM's moderate physical activity (MPA) standards ($\geq$150 min of MPA). Rather, it compares those who engage only in MPA with those who engage in MPA and VPA. Thus, the specific focus of this study is whether – beyond basic MPA recommendations – meeting the ACSM's vigorous-intensity exercise guidelines ($\geq 3 \times 20$ min of VPA per week) is associated with additional mental health benefits among young people.

This specific focus is important because some scientists have argued that VPA might have greater health benefits than MPA [29–31] given that VPA is more effective in increasing aerobic fitness, and that energy expenditure rates are higher for VPA. These assumptions were supported in several investigations using mortality and physical disease indicators [32–38]. For example, Lee and Paffenbarger [39] found in a 15 year longitudinal study with 13,485 men (M_{age} = 58 years) that VPA clearly predicted lower mortality, whereas light physical activity (LPA: <4 METs) did not result in reduced mortality rates. Comparable results were observed in younger populations. For instance, in a 24-year longitudinal study van de Laar et al. [37] showed that individuals with the highest arterial stiffness scores engaged significantly less in VPA during adolescence and young adulthood, whereas no significant effects were observed for light-to-moderate physical activity.

Despite these promising results, insights regarding the potential of VPA to protect against mental health complaints are still limited. In a longitudinal study with middle-aged women, Pavey et al. [31] found that odds ratios for depressive symptoms were similar for VPA compared to moderate-to-vigorous physical activity (MVPA), except at very high levels of physical activity exceeding 2000 MET·min·wk^{-1}. Similarly, Lindwall et al. [40] observed that adults who regularly engage in LPA or MVPA have comparably reduced odds for anxiety, depression and burnout if compared to inactive individuals. This is in line with the prospective findings of Jonsdottir et al. [41] who found that the risks of depression, burnout, and high stress are significantly lower among individuals who regularly engaged in either LPA or MVPA.

Taken together, these findings support the idea that health benefits of VPA may go beyond those of LPA or MPA, both as physical and mental are concerned. Nevertheless, some methodological limitations warn against an overgeneralization of the existing findings. First, few studies have applied objective measurements to assess levels of physical activity. Second, several studies used arbitrarily set benchmarks to distinguish sufficient versus insufficient levels of VPA without referring to contemporary physical activity recommendations. Third, few studies controlled for LPA or MPA when studying the relationship between VPA and health. Fourth, there is still relatively little research regarding mental health outcomes although mental health problems are on the increase world-wide [42]. Finally, most studies have looked at direct relationships between VPA and mental health, whereas few have considered the potential of VPA as a stress buffer.

Given this background, the following three study questions will be addressed in the present paper:

(1) Do young adults who accomplish the ACSM's vigorous-intensity exercise recommendations differ from peers below these standards with regard to their level of perceived stress, depressive symptoms, perceived pain, and subjective sleep complaints?
(2) Do young adults below and above the ACSM's vigorous-intensity exercise recommendations differ with regard to their objectively assessed sleep patterns?
(3) Do young adults below and above the ACSM's vigorous-intensity exercise recommendations differ with regard to their depressive symptoms, perceived pain, and subjective sleep complaints particularly if they perceive high stress?

Based on previous research with physical health outcomes [32–38], which suggested improved outcomes for individuals engaging in VPA as compared to those engaging in MPA, our hypotheses are that participants who meet vigorous-intensity exercise standards perceive less stress [18], report fewer depressive symptoms [43], less pain [44], fewer subjective sleep complaints [45] and a more favorable objective sleep pattern [28]. Ultimately, we expect that participants who meet vigorous-intensity exercise guidelines cope more successfully with high levels of subjective stress [22,23].

2. Methods

2.1. Participants and procedure

Participants were 42 undergraduate students from the University of Basel, Switzerland (22 women, 20 men; total sample: M_{age} = 21.24 years, SD = 2.20; women: M_{age} = 20.65 years, SD = 1.39; men: M_{age} = 21.77 years, SD = 2.65) who were recruited via word-of-mouth recommendation. These voluntary participants received detailed information about the purpose of the study. Participants were assured confidentiality, and they gave written informed consent before providing their demographic background and subjective assessments of stress, depressive symptoms, pain and subjective sleep complaints. Additionally, they wore an accelerometer device for seven consecutive days. All participants were instructed on how to handle the accelerometer. Twenty-two participants volunteered to take part in a supplementary sleep-EEG assessment. T-tests showed that these students did not differ in any of the study variables from students who did not participate in the sleep-EEG recordings (all $p > .05$). Sleep-EEG devices were applied via in-home conditions on a Tuesday or Thursday night. Objective physical activity and sleep-EEG recordings were carried out shortly after the participants had completed the psychological questionnaires. All participants received a food voucher (worth 12 Swiss Francs) as incentive. The local ethics committee approved the study protocol and the study was conducted in accordance with the Declaration of Helsinki.

2.2. Measures

2.2.1. Physical activity

Physical activity was assessed with an accelerometer (GTIM, Actigraph, Shalimar, FL, USA) worn around the hip. Seven consecutive days of measurement were included to assess a full weekly period. The sampling epoch was set at 15 sec [46]. Participants were instructed