Human Behavior, Development and Society
E-ISSN 2651-1762, Vol 25 No 2, August 2024

Physical Activity and Sleep Lessons Learned from Disruptions at a Residential University in Thailand: A Basis for Future Health Interventions

Serah Carolyn Clarence Gladstone Solomans, Ministry of Public Health, Thailand
Nattapon Chawla, Ratna Balraj, Wilai Laolee, Maxine Newell, and Elvin Walemba
Asia-Pacific International University, Thailand

Date Received: 28 June 2024 Revised: 22 July 2024 Accepted: 28 July 2024

Abstract

Existing research shows COVID-19 pandemic restrictions led to widespread disruptions in health-related behaviors, including physical activity (PA) and sleep patterns among university students, faculty and staff. The specific impact of pandemic restrictions and the lack of crisis preparedness at educational institutions are not well documented. This cross-sectional pilot study (n = 48) used a self-administered questionnaire to investigate the impact of restrictions on PA and sleep to identify the health impact, possible modifiable behaviors, and policies to target for change in future crises to improve health, academic, and work outcomes, especially for institutions with natural green spaces. It was hypothesized the restrictions reduced adults' PA levels and negatively impacted sleep. Statistical analyses revealed significant differences (p < .05) in the time spent doing medium- and high-intensity PA, walking, length of time to fall asleep, and hours slept before and during the pandemic. Concentration on infection prevention and spread rather than on health maintenance for those not acutely ill inadvertently discouraged using outdoor spaces for exercise while gym and sports facilities remained closed. These findings indicate the negative impact lockdown restrictions may have on general health, and how organizations can promote behaviors to maintain basic physical and sleep health.

Keywords: *Physical activity, sleep, disruption, COVID-19, cross-sectional, walking*

Introduction and Literature Review

The global pandemic due to COVID-19 had widespread implications for people's health. Many aspects of life were impacted, including education. Lui and colleagues (2020) stated that the COVID-19 virus had become a great challenge and was a growing public health concern. As the number of confirmed cases continued to increase, restrictions and other measures were implemented to limit infections and the spread of the virus at the national, local, and institutional levels which included social distancing, quarantines, and lockdowns. Though these measures proved effective in controlling the spread of the disease, they had negative impacts on daily lives including reducing physical activity (López-Valenciano, 2021), increasing sedentary behaviors (Romero-Blanco, 2020), and disrupting sleep (Marelli, 2021).

Physical activity (PA) is one of the most important health factors for human beings (Sygit et al., 2019). According to Dasso (2019), physical activity is defined as "any bodily movement produced by skeletal muscles that require energy expenditure". Adults are encouraged to participate in at least 150 minutes of moderate PA or 75 minutes of vigorous PA every week to maintain general health (Bull et al., 2020). Despite the positive effects associated with PA, in the last 20 years PA has declined significantly among adults during normal circumstances (Marques et al., 2018; Liangruenrom et al., 2019). Recent results from Thailand's National Health and Welfare Survey indicated that only 42.4% of Thai adults met the World Health Organization's recommended levels of PA (Liangruenrom et al., 2017). However, a public awakening of health consciousness has led to increased interest in ways to improve health. One accessible and easy PA is walking. Studies have shown that walking is a suitable activity for people who do not want to engage in vigorous or costly exercise to improve their health (Ungvari et al., 2023) and reduce all-cause mortality, especially for those who engage for the first time (Kelly et al., 2014; Inoue et al., 2023). Studies in the UK also showed that brisk walking was associated

with reduced risk of respiratory disease (Celis-Morales et al., 2019), including chronic obstructive pulmonary disease and pneumonia-related mortality (Ukawa et al., 2019) among elderly people. Walking, particularly in groups, has also been shown to improve mental and behavioral health (Kritz et al., 2021). Walking in forested areas with natural surroundings was shown to help participants gain confidence in coping and acting on planned activities (Freeman et al., 2017). Walking was one of the activities not restricted in Thailand during the pandemic.

Another area significantly impacted by the pandemic and accompanying restrictions was sleep. A minimum of 7 hours of sleep per day is recommended for an adult between the ages of 18-60 (Watson et al., 2015). Canadian guidelines provide evidence-based recommendations in which a healthy 24-hour day includes 7-9 hours of sleep, reallocating more time for moderate-to-vigorous-intensity PA, and also allocating time to light-intensity PA (Ross et al., 2020). Numerous studies have analyzed the impact of COVID-19 on levels of PA and sleep of adults. Maugeri et al. (2020) studied the changes in PA levels during quarantine and how exercise impacted psychological health in Italy; Castañeda-Babarro et al. (2020) studied how self-reported PA and sedentary time changed during lockdown in Spain. Stanton et al. (2020) studied the association between psychological distress and specific health behaviours, including PA and sleep in Australia, during the pandemic-induced restrictions. Didriksen et al. (2021) studied a large national cohort in Denmark looking at sleep among other factors; Stockwell et al. (2021) summarized reported studies on the differences in PA and sedentary behaviour before and during lockdowns. The studies generally found that PA levels decreased, and sleep patterns changed. These results seem to have been widespread, with an international survey from the Americas, Asia, Europe, and North Africa comparing “before” and “after” confinement conditions, revealing that all forms of PA had declined, while the daily sitting time had increased from five to eight hours per day (Ammar et al., 2020).

A cross-sectional study conducted in Russia by Konstevaya et al. (2021) aimed to evaluate the changes in sleep and PA that resulted from pandemic restrictions imposed on adults over the age of 18. Between April 26 and June 6, 2020, the period of tightest restrictions, data were gathered online: participants described their sleep habits, frequency and length of walking, moderate and vigorous-intensity PA, and muscle strengthening exercises before the pandemic and for the previous seven days. Access to outdoor green space and exercise centers, Internet resources, self-isolation advice, and other preventive measures were also self-reported. The findings revealed that the number of individuals getting enough sleep decreased significantly, and policies, such as not being permitted to leave the house for PA and the closing of fitness centers, were linked to lower PA levels. Thus, in comparison to the pre-COVID era, the PA and sleep hygiene were adversely affected during the pandemic restrictions.

Martínez-de-Quel et al. (2020) conducted a longitudinal study in a Spanish sample to find out how obligatory confinement affected PA, the risk of eating disorder, sleep quality, and well-being of the target population. They found confinement significantly decreased the PA levels (p = .001) and sleep quality (p < .001). Physically active participants experienced a greater and significant differential effect with respect to PA, quality of sleep, and wellbeing when compared to the physically inactive participants (p = .05). In a cross-sectional investigation by Luciano et al. (2021), Italian medical students described their behaviors during lockdowns, comparing them to pre-lockdown data and current recommendations by completing the International Physical Activity Questionnaire Short Form and items from the Pittsburgh Sleep Quality Index. During lockdowns, their PA levels decreased while the number of hours sitting and sleeping increased; even those who did report an increase in PA also reported increased sitting time. Sitting time also went up for students who slept less than seven hours each night. Sitting up may also have been due to increased time spent doing schoolwork; however, many developed habits of binge-watching television series and movies on streaming networks such as Netflix®, Disney+ Hotstar®, and unregulated sites. This led to significant changes in sleep patterns (Siraj, 2023).

Educational institutions managed the pandemic’s challenges in different ways. Many closed (Donohue & Miller, 2020) or went completely online. Residential institutions, especially those with

international students who could not return home, faced unique challenges. Reflecting on this time can provide management lessons that promote better health outcomes and consequently better educational outcomes for students and work outcomes for faculty and staff.

The purpose of this study was to examine the impact of the COVID-19 pandemic on PA and sleep among university adults. Furthermore, the study aimed to understand what modifiable behaviors could be targeted as points of intervention and management for future crises to improve health, academic, and work outcomes, especially for institutions that have access to natural green spaces. It was hypothesized that the pandemic reduced adults' level of PA and negatively impacted sleep.

Methodology

This study was a cross-sectional study that included adults of Asia-Pacific International University (a Seventh-day Adventist institution in Muak Lek, Thailand) selected through convenience sampling method who lived on campus, either in the dormitories or faculty housing. The participants were invited to answer a 35-item questionnaire after a consent form had been completed.

Individuals were eligible to participate if they were above 18 years of age and residing on campus during the first semester of the 2021-2022 academic school. While a sample size of 197 participants was recommended (with a confidence level of 95%), 50 participants responded to the questionnaire, of whom 48 provided sufficient answers for use in the data analysis.

The questionnaire used was adapted from the study by Kontsevaya et al. (2021). The first seven items related to demographics; respondents also indicated the extent to which they followed self-isolation recommendations and their access to outdoor space. The next 20 items evaluated the PA of adults before the pandemic and during the seven days immediately preceding the time the survey was completed.

Statistical Analysis

Demographic characteristics were categorized by sex, participant status, and residential type, and summarized using descriptive statistics. To analyze PA and sleeping behaviors, associated with the impact of the pandemic, paired *t*-tests were used. All statistical analyses were computed using a statistical software package, with significance set at the $p < .05$ level.

Results and Discussion

Participants

A total of 48 participants completed the questionnaires; the response rate was low as many people struggled with online learning and the lethargy associated with many assignments. Of the respondents, 26 (54.1%) were female, 38 (79.2%) were students, and 34 (70.8%) lived in a dormitory.

During the lockdown in Thailand, this university had many restrictions in place following the DMHTT acronym–distancing, masking wearing, hand hygiene, and testing for COVID-19. On-campus restrictions rigidly enforced social distancing (especially in closed spaces like classrooms, the cafeteria, and assembly places), wearing masks, hand hygiene and COVID-19 testing; the university tested 15% of students every other week. Community members were encouraged to walk to stay active and healthy, but it was unclear if masks had to be worn while walking. Many people disliked wearing masks because they made breathing difficult, especially for strenuous activities. However, walking at a moderate pace was not so difficult, so people could walk together in groups with masks on, or they could walk alone without masks.

The study revealed the amount of time participants spent walking before and during the pandemic; please see Table 1 below for details.

Table 1 *Comparison of Time Per Day Spent Walking Before and During COVID-19*

Minutes Spent Walking On a Normal Day Before COVID-19	Respondents		
	Pre-COVID-19	Last 7 Days (During COVID-19)	Change
None	5	7	+42%
≤ 30	12	-	-100%
31–60	23	21	-8.7%
61–120	4	17	+325%
≥ 120	2	3	+50%
No response	2	-	-100

The results showed that pre-COVID, more than 60% of respondents spent at least 30 minutes a day walking, and 85% spent some time walking per day. The UK National Health Service recommends walking as a useful form of exercise where pace can replace duration, suggesting that a short (10 minute) brisk walk can count towards the recommended 150 minutes of exercise per week, and provides numerous health benefits (NHS, 2022). A reduction in walking time would be particularly detrimental to general health, and this would be exacerbated by morose attitudes resulting from restrictions and lockdown stress (Sundarasen et al., 2020; Odriozola-González et al., 2020) and online learning (Raj & Fatima, 2020).

The average time the respondents spent walking in the seven days prior to completing the survey was 1.30 hours, or 1 hour and 18 minutes. Respondents who did not walk at all increased from 5 to 7 people (10.4% to 14.6%). However, a general increase in the time spent walking during the lockdown was observed, with 41 people walking more than 30 minutes during the pandemic compared to 29 before it. Walking may have taken the place of meeting up with friends, going to the gym, or playing team sports. There was no difference in the time spent walking when males and females were compared up to one hour; however, more males walked 60–120 minutes (3 versus 1) and more than 120 minutes (2 versus 0) than females. Restrictions on leaving campus and using the gym applied to both students and faculty/staff. Approximately 60% of both groups walked at least 30 minutes per day, but only students walked for more than 120 minutes, suggesting students were more likely to achieve the recommended daily PA goal.

Overall, the restrictions had a significant impact on respondents' PA as shown in Table 2, which summarizes paired a two-tailed *t*-test analysis of questions focusing on the amount of time spent walking before and during COVID-19.

Table 2 *The Impact of COVID-19 on Respondents' Physical Activity and Sleep*

Change from pre-COVID-19 compared to the last seven days prior to taking the survey…	*p* value		
	Combined	***Male***	***Female***
Days not getting enough sleep	.020	.059	.358
Days having trouble falling asleep	.067	.090	.576
Days per week engaged in high-intensity physical activity	.015	.664	.016
Time spent per day doing high-intensity physical activity	.169	.025	.929
Days per week engaged in moderate-intensity physical activity	.030	.417	.055
Time spent per day on moderate-intensity physical activity	.001	.073	.013
Days per week spent strength training	.244	.439	.329
Days per week performing exercises	.330	.328	.330
Days per week spent walking more than 10 minutes	.002	.161	.005
Time spent walking on a normal day	< .001	.067	.017

Note: the *p* value is significant at < .05

Results showed a significant difference between respondents' ability to get enough sleep before and during COVID-19 restrictions (p = .020), days per week spent in high-intensity or moderate

intensity PA (p = .015 and p = .030, respectively), time spent daily on moderate-intensity PA (p = .001), days per week spent walking 10+ minutes (p = .002), and time spent walking on a normal day (p = < .001).

A closer analysis showed that when divided by gender, a significant difference for males was noted in time spent per day doing high-intensity PA (p = .025) before and during COVID-19, though the difference was not significant for the whole group. For females, a significant difference in the time per day doing moderate-intensity PA (p = .013) was noted, along with a significant difference in the days per week spent walking more than 10 minutes (p = .005). These results suggest that the restrictions had a greater impact on the PA of females, while males experienced a greater, though not significant, impact on falling asleep and getting enough sleep. Overall, the number of days that respondents were not getting enough sleep or had trouble falling asleep increased. Decreases were seen in the number of days they engaged in high- or low-intensity PA, the time spend doing moderate PA, and days on which the respondent walked more than 10 minutes Surprisingly, the number of days per week spent on strength training also increased.

A study by Bisson et al. (2019) reported that sleep quality was positively related to number of steps taken, and that women who took more steps reported higher quality sleep than those who were less active. Our study showed no significant difference between males and females with regards to walking before the pandemic restrictions, but significant results when the time spent walking before and after the restrictions were compared (p < .001). Although an increase in the number of days with inadequate sleep was reported, the increase was not significant (p = .067).

In a study of 54 young adults over a 12-week period, Wang and Boros (2021) reported that daily walking had a significant impact on sleep quality and sleep components. Physical activity generally improved sleep quality (Lang et al., 2015). Thus, changes in sleeping patterns and quality may have directly resulted from reduction of PA levels during lockdown restrictions. Recent studies showed that problems falling asleep were more prevalent during, than before the pandemic (Marelli et al., 2021); this may be attributed to less PA. In a report by Watson et al. (2015), The American Academy of Sleep Medicine and Sleep Research Society recommended that adults should sleep seven or more hours per night on a regular basis to help prevent "impaired immune function, increased pain, impaired performance, increased errors, and greater risk of accidents." In encouraging more sleep, it is important to note that studies have shown a U-shaped relationship between all-cause mortality and number of hours of sleep. Following a meta-analysis of sleep studies, Shen et al. (2016) reported that 7 hours/day of sleep were recommended to prevent death among adults. This sleep duration was supported by a large study in the US. Yang et al. (2020) used available data from the National Health Interview Survey (2004-2014), including over 280,000 participants, with a median follow-up period of 5.25 years. They found that sleeping less than 6 hours per day or more than 8 hours per day increased the risk of mortality compared with sleeping 7 hours per day. Alternatively, a study from East Asia with over 300,000 adult participants found sleep duration either longer or shorter than 7 hours was associated with all-cause mortality; the greatest association for all-cause mortality was sleep durations of longer than 10 hours for both women and men (Svensson et al., 2021).

Alternatively, the surge in online gaming (DiFrancisco-Donoghue et al., 2023) and watching online content (Siraj, 2023) may have been an important factor in sleep disruption. Resident hall deans and resident assistants have previously reported widespread use of online gaming sites by male students during the semester even prior to the pandemic lockdown. With the lockdown, it is likely that students spent more time on online games and other forms of entertainment.

When restrictions on other forms of exercise and entertainment are considered, it makes sense that respondents, especially students, would spend more time outside walking rather than cooped up in their rooms for a change of scenery. Pre-pandemic, the university sports grounds were used most evenings for football, volleyball, racket games, and basketball. Many more campus residents used the gym for exercise and the track for aerobic exercises, including running and jogging. Interestingly, this study's data (Table 1) showed an increase in the number of people walking 60–120 minutes. Further study is needed to understand why short walks were replaced by longer walks. This could be because

short walks were in addition to other forms of exercise or entertainment. Since other forms of exercise and entertainment were curtailed, respondents switched to having longer walks. Contrary to a study by Bisson et al. (2019), this study's respondents still reported an increase in days with inadequate sleep (p = .020). However, this result must be viewed cautiously since the sample size was quite small.

Most respondents (75%) used digital or online sources to provide instruction and guidance on physical activities, with females using this resource slightly more (77.3%) than males (73.1%). A study by Pramono et al. (2024) compared fitness and exercise levels of university student users and non-users of fitness apps. They reported a significant difference between the exercise intensity of the two groups, as well as differences by gender. Non-users of the fitness app had significantly higher intensity exercise than users in the Pramono et al. (2024) study, but not in this one; this may have been due to the small sample size.

When asked how the pandemic had affected their PA, common responses were that it had no effect (12 respondents), they could not leave their house for sports, and the gym was closed. These results were interesting because the two highest responses were contradictory. Furthermore, the university did not restrict campus dwellers from leaving their residences to carry out general exercise, and even organized some "new normal" small group activities in harmony with closed spaces regulations, limited time for activities, and the requirement that participants wear an approved face mask.

A greater proportion of females than males indicated that restrictions had no effect on their PA; this supported data which showed that males were generally more active prior to the restrictions. The campus has easy access from housing areas to green spaces; many walking trails and paved roads pass through wooded and landscaped areas. Walking through natural zones has been reported to help improve coping mechanisms and prompt action from those who walk (Freeman et al., 2017).

Exercise improves general health and protects against hospitalization with COVID-19 (Cho et al., 2021; Rahmati et al., 2022). Health outcomes for residents may have been improved by encouraging walking as a form of exercise, even if masks needed to be worn in line with the strict campus regulations. Wearing a mask during moderate to high intensity exercise is suitable for healthy young adults without underlying health conditions (Jones et al., 2023; Shaw et al., 2021). Systemic reviews by Asin-Izquierdo et al. (2022) and Zheng et al. (2023) reported exercising while wearing face masks did not cause significant negative physiological or cardiorespiratory effects. This included wearing cloth face masks, where negative effects were experienced at higher exercise intensities (Driver et al., 2022). Changes in physiological measures (heart rate, respiratory rate, blood pressure, oxygen saturation, and time to exhaustion) were dependent on the intensity of exercise (Epstein et al., 2020). Furthermore, training outside and in less crowded places reduced the perceived negative effects of training while wearing face masks (Das et al., 2023).

Finally, the study revealed that most respondents adhered relatively well to protective measures; common responses to "wash hands more often" and "keep social distance" were 22 (46%) and 19 (40%), respectively. This suggests that signage campaign and regular online reminders helped change residents' behavior. Perhaps the university should have done more to encourage people to walk outdoors, whether leisurely, moderately, or fast-paced. During the lockdown, wearing facemasks was strictly enforced, and many people also wore them outdoors while in small groups. Wearing masks was an important tool in preventing transmission of the virus; however, the masks discouraged physical activity due to their discomfort and awkward breathing, especially while exerting oneself. Walking with a mask may be inconvenient, but walking leisurely or even moderately is possible with a mask and does not cause undue hardship. Therefore, walking should have been more strongly encouraged by the university.

Walking in the sunlight fosters synthesis of Vitamin D; Angelidi et al. (2021) reported that Vitamin D helped reduce COVID-19 mortality and invasive mechanical intervention through its immunomodulatory function. This is another reason for walking, especially during the daylight hours.

Study results indicated that restrictions imposed during the pandemic significantly affected campus residents' sleep and PA. However, data also showed that many respondents maintained their

levels of PA. Recent studies have revealed a strong inverse correlation between exercise and hospitalization with COVID-19 (Ezzatvar et al., 2022; Sallis et al., 2021; Sittichai et al., 2022; Castoldi et al., 2023; Young et al., 2023). Simple changes to campus restrictions may have helped improve PA levels, which in turn could have helped to reduce the impact of the restrictions on residents' sleep habits. In hindsight, the university could have done more to encourage physical activity to boost general health and complement the preventative measures designed to keep the virus from entering the campus community.

Several limitations existed in this study. First, a small sample size (48) compromised statistical power. Second, only a few questions addressed sleep. More questions would have provided greater insight on how inactivity, diet, sleep cycles, bedtime and wake times, and screen time affected sleep. Third, the sample was limited to international students, so findings were not representative of the whole university, nor could they be generalized to general populations. Future studies should be conducted with larger and more representative sample sizes, and includes more questions about sleep to achieve better results.

Conclusion

This study revealed that pandemic restrictions and lockdowns had a significant impact on the PA and sleep habits of campus residents. Since the restrictions faced by respondents were similar to those in many locations, unsurprisingly, negative impacts mirrored findings of other researchers such as Chouchou et al. (2021), Diniz et al. (2022), and Konstevaya et al. (2021). Consequently, some campus residents reduced their physical activities even though walking or jogging were not restricted. The university administration could have encouraged residents to maintain or increase their physical activity through education and announcements about how walking or jogging improves general health and sleep quality.

These findings highlight directions for future interventions. These include reminding the community to remain active, especially by walking along the wooded natural areas where getting Vitamin D improves immune function and protects against infection and disease. Current recommendations by sleep experts of the need for at least seven to nine hours per night should also be pointed out and emphasized.

References

Angelidi, A. M., Belanger, M. J., Lorinsky, M. K., Karamanis, D., Chamorro-Pareja, D., Ognibene, J., Palaiodimos, L., & Mantxoros, C. S. (2021). Vitamin D status is associated with in-hospital mortality and mechanical ventilation: A cohort of COVID-19 hospitalized patients. *Mayo Clinic Proceedings. 96(4),* 875–886. https://doi.org/10.1016/j.mayocp.2021.01.001.

Ammar, A., Brach, M., Trabelsi, K., Chtourou, H., Boukhris, O., Masmoudi, L., Bouaziz, B., Bentlage, E., How, D., Ahmed, M., Müller, P., Müller, N., Aloui, A., Hammouda, O., Paineiras-Domingos, L. L., Braakman-Jansen, A., Wrede, C., Bastoni, S., Pernambuco, C. S., … & Hoekelmann, A. (2020). Effects of COVID-19 home confinement on eating behaviour and physical activity: Results of the ECLB-COVID19 international online survey. *Nutrients*, *12*(6), 1583. https://doi:10.3390/nu12061583

Asín-Izquierdo, I., Ruiz-Ranz, E., & Arévalo-Baeza, M. (2022). The physiological effects of face masks during exercise worn due to COVID-19: A systematic review. *Sports Health: A Multidisciplinary Approach, 14*(5), 648–655. https://doi:10.1177/19417381221084661

Bisson, A. N. S., Robinson, S. A., & Lachman, M. E. (2019). Walk to a better night of sleep: Testing the relationship between physical activity and sleep. *Sleep Health*, *5*(5), 487–494. https://doi.org/10.1016/j.sleh.2019.06.003

Bull, F. C., Al-Ansari, S. S., Biddle, S., Borodulin, K., Buman, M. P., Cardon, G., Carty, C., Chaput, J. P., Chastin, S., Chou, R., Dempsey, P. C., DiPietro, L., Ekelund, U., Firth, J., Friedenreich, C. M., Garcia, L., Gichu, M., Jago, R., Katzmarzyk, P. T., … & Lambert, E., (2020). World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British Journal of Sports Medicine*, *54*(24), 1451–1462. https://bjsm.bmj.com/content/ 54/24/1451

Castañeda-Babarro, A., Arbillaga-Etxarri, A., Gutiérrez-Santamaría, B., & Coca, A. (2020). Physical activity change during COVID-19 confinement. *International Journal of Environmental Research and Public Health*, *17*(18), 6878.

Castoldi, R. C., de Ângelo, J. C., Pereira, T. T., Dias, R. M., & Negrão, F. J. (2023). Relationship between physical exercise and COVID-19 (SARS-CoV-2): Systematic review. *Sport Sciences for Health, 19*(1), 55–67. https://doi.org/10.1007/s11332-022-01028-6

Celis-Morales, C. A., Gray, S., Petermann, F., Iliodromiti, S., Welsh, P., Lyall, D. M., Anderson, J., Pellicori, P., Mackay, D. F., Pell, J. P., Sattar, N., & Gill, J. M. R. (2019). Walking pace is associated with lower risk of all-cause and cause-specific mortality. *Medicine and Science in Sports and Exercise, 51*(3), 472–480. https://doi.org/10.1249/MSS.0000000000001795

Cho, D.-H., Lee, S. J., Jae, S. Y., Kim, W. J., Ha, S. J., Gwon, J. G., Choi, J., Kim, D. W., & Kim, J. Y. (2021). Physical activity and the risk of COVID-19 infection and mortality: A nationwide population-based case-control study. *Journal of Clinical Medicine, 10*(7), 1539. https://doi.org/10.3390/jcm10071539

Chouchou, F., Augustini, M., Caderby, T., Caron, N., Turpin, N. A., & Dalleau, G. (2021). The importance of sleep and physical activity on well-being during COVID-19 lockdown: Reunion Island as a case study. *Sleep Medicine*, *77*, 297–301. https://doi.org/10.1016/j.sleep.2020.09.014

Das, A., Azarudheen, S., Chandrasekaran, B., Fernandes, S., & Davis, F. (2023). The plausible effects of wearing face masks on sports performance—A scoping review. *Science & sports, 38*, (5–6), 474–487. https://doi.org/10.1016/ j.scispo.2022.12.006

Dasso N. A. (2019). How is exercise different from physical activity? A concept analysis. *Nursing Forum*, *54*(1), 45–52. https://doi.org/10.1111/nuf.12296

Didriksen, M., Werge, T., Nissen, J., Schwinn, M., Sørensen, E., Nielsen, K. R., Bruun, M. T., Banasik, K., Hansen, T. F., Erikstrup, C., Ostrowski, S. R., Jennum, P. J., Hjalgrim, H., Ullum, H., & Pedersen, O. B. (2021). Impact of COVID-19 pandemic on sleep quality, stress level and health-related quality of life—A large prospective cohort study on adult Danes. *International Journal of Environmental Research and Public Health*, *18*(14), 7610. https://doi.org/10.3390/ijerph18147610

DiFrancisco-Donoghue, J., De Las Heras, B., Li, O., Middleton, J., & Jung, M. K. (2023). Gaming in pandemic times: An international survey assessing the effects of COVID-19 lockdowns on young video gamers' health. *International Journal of Environmental Research and Public Health*, *20*(19), 6855. https://doi.org/10.3390/ijerph20196855

Diniz, T. A., Christofaro, D. G., Tebar, W. R., Cucato, G. G., Botero, J. P., Correia, M. A., Ritti-Dias, R. M., Prado, M. C. L., & Prado, W. L. (2020). Reduction of physical activity levels during the COVID-19 pandemic might negatively disturb sleep pattern. *Frontiers in Psychology*, *11*, 586157. https:/doi.org/10.3389/fpsyg.2020.586157

Donohue, J. M., & Miller, E. (2020) COVID-19 and school closures. *Journal of the American Medical Association, 324*(9), 845–847. https://doi.org/10.1001/jama.2020.13092

Driver, S., Reynolds, M., Brown, K., Vingren, J. L., Hill, D. W., Bennett, M., Gilliland, T., McShan, E., Callender, L., Reynolds, E., Borunda, N., Mosolf, J., Cates, C., & Jones, A. (2022). Effects of wearing a cloth face mask on performance, physiological and perceptual responses during a graded treadmill running exercise test. *British Journal of Sports Medicine, 56*(2), 107–113. https://bjsm.bmj.com/content/56/2/107

Epstein, D., Korytny, A., Isenberg, Y., Marcusohn, E., Zukermann, R., Bishop, B., Minha, S., Raz, A., & Miller, A. (2020). Return to training in the COVID-19 era: The physiological effects of face masks during exercise. Scandinavian *Journal of Medicine & Science in Sports, 31*(1), 70–75. https://doi.org/10.1111/sms.13832

Ezzatvar, Y., Ramírez-Vélez, R., Izquierdo, M., & Garcia-Hermoso, A. (2022). Physical activity and risk of infection, severity and mortality of COVID-19: A systematic review and non-linear dose-response meta-analysis of data from 1,853,610 adults. *British Journal of Sports Medicine*, *56*(20), 1188–1193. https://doi.org/10.1136/bjsports-2022-105733

Freeman, E., Akhurst, J., Bannigan, K., & James, H. (2017). Benefits of walking and solo experiences in UK wild places. *Health promotion international, 32*(6), 1048–1056. https://doi.org/10.1093/heapro/daw036

Inoue, K., Tsugawa, Y., Mayeda, E. R., & Ritz, B. (2023). Association of daily step patterns with mortality in US adults. JAMA *Network Open, 6*(3), e235174. https://doi.org/10.1001/jamanetworkopen.2023.5174

Jones, N., Oke, J., Marsh, S., Nikbin, K., Bowley, J., Dijkstra, H. P., Hobbs, F. D. R., & Greenhalgh, T. (2023). Face masks while exercising trial (MERIT): A cross-over randomised controlled study. *BMJ Open, 13*, e063014. https://bmjopen.bmj.com/content/13/1/e063014.citation-tools

Kelly, P., Kahlmeier, S., Götschi, T., Orsini, N., Richards, J., Roberts, N., Scarborough, P., & Foster, C. (2014). Systematic review and meta-analysis of reduction in all-cause mortality from walking and cycling and shape of dose response relationship. *International Journal of Behavioral Nutrition and Physical Activity, 11*, 132. https://doi.org/10.1186/s12966-014-0132-x

Kontsevaya, A. V., Mukaneeva, D. K., Myrzamatova, A. O., Okely, A. D., & Drapkina, O. M. (2021). Changes in physical activity and sleep habits among adults in Russian Federation during COVID-19: A cross-sectional study. *BMC Public Health, 21*(1), 1–12. https://doi.org/10.1186/s12889-021-10946-y

Kritz, M., Thøgersen-Ntoumani, C., Mullan, B., Stathi, A., & Ntoumanis, N. (2021). "It's better together": A nested longitudinal study examining the benefits of walking regularly with peers versus primarily alone in older adults. *Journal of Aging and Physical Activity, 29*(3), 455–465. https://doi.org/10.1123/japa.2020-0091

Liangruenrom, N., Topothai, T., Topothai, C., Suriyawongpaisan, W., Limwattananon, S., Limwattananon, C., Tisayatikom, K., Patcharanarumol, W., & Tangcharoensathien, V. (2017). Do Thai people meet recommended physical activity level? The 2015 national health and welfare survey. *Journal of Health Systems Research*, *11*(2), 205–220. https://www.researchgate.net/publication/317416626_Do_Thai_People_Meet_Recommended_ Physical_Activity_Level_The_2015_National_Health_and_Welfare_Survey

Liangruenrom, N., Craike, M., Biddle, S. J., Suttikasem, K., & Pedisic, Z. (2019). Correlates of physical activity and sedentary behaviour in the Thai population: A systematic review. *BMC Public Health*, *19*(1), 1–26. https://doi.org/10.1186/s12889-019-6708-2

López-Valenciano, A., Suárez-Iglesias, D., Sanchez-Lastra, M. A., & Ayán, C. (2021). Impact of COVID-19 pandemic on university students' physical activity levels: An early systematic review. *Frontiers in Psychology, 11*, 624567.

Luciano, F., Cenacchi, V., Vegro, V., & Pavei, G. (2021). COVID-19 lockdown: Physical activity, sedentary behaviour and sleep in Italian medicine students. *European Journal of Sport Science*, *21*(10), 1459–1468. https://doi.org/10.1080/17461391.2020.1842910

Marelli, S., Castelnuovo, A., Somma, A., Castronovo, V., Mombelli, S., Bottoni, D., Leitner, C., Fossati, A., & Ferini-Strambi, L. (2021). Impact of COVID-19 lockdown on sleep quality in university students and administration staff. *Journal of Neurology*, *268*(1), 8–15. https://doi.org/10.1007/s00415-020-10056-6

Marques, A., Santos, T., Martins, J., Matos, M. G. D., & Valeiro, M. G. (2018). The association between physical activity and chronic diseases in European adults. *European Journal of Sport Science*, *18*(1), 140–149. https://doi.org/10.1080/17461391.2017.1400109

Martínez-de-Quel, Ó., Suárez-Iglesias, D., López-Flores, M., & Pérez, C. A. (2021). Physical activity, dietary habits and sleep quality before and during COVID-19 lockdown: A longitudinal study. *Appetite*, *158*, 105019. https://doi.org/10.1016/j.appet.2020.105019

Maugeri, G., Castrogiovanni, P., Battaglia, G., Pippi, R., D'Agata, V., Palma, A., Rosa, M. D., & Musumeci, G. (2020). The impact of physical activity on psychological health during COVID-19 pandemic in Italy. *Heliyon*, *6*(6), e04315.

NHS. (2022, December 15). *Walking for Health*. https://www.nhs.uk/live-well/exercise/walking-for-health/

Odriozola-González, P., Planchuelo-Gómez, Á., Irurtia, M. J., & de Luis-García, R. (2020). Psychological effects of the COVID-19 outbreak and lockdown among students and workers of a Spanish university. *Psychiatry Research, 290*, 113108. https://doi.org/10.1016/j.psychres.2020.113108

Pramono, B. A., Hafidz, A., Fajar, M. K., Wijono, Wulandari, F. Y., Kusuma, I. D. M. A. W., & Hooi, L. B. (2023). Comparison between mobile fitness apps users and gender on exercise intensity in university students. *Journal of Human Sport and Exercise*, *19*(2), 550–559. https://doi.org/10.14198/jhse.2024.192.10

Rahmati, M., Shamsi, M. M., Khoramipour, K., Malakoutinia, F., Woo, W., Park, S., Yon, D. K., Lee, S. W., Shin, J. I., & Smith, L. (2022). Baseline physical activity is associated with reduced mortality and disease outcomes in COVID-19: A systematic review and meta-analysis. *Reviews in Medical Virology, 32*(5), e2349. https://doi.org/10.1002/rmv.2349

Raj, U., & Fatima, A. (2020). *Stress in students after lockdown due to COVID-19 Thereat and the effects of attending online classes* [Research paper]. SSRN Electronic Journal https://ssrn.com/abstract=3584220

Romero-Blanco, C., Rodríguez-Almagro, J., Onieva-Zafra, M. D., Parra-Fernández, M. L., Prado-Laguna, M. D. C., & Hernández-Martínez, A. (2020). Physical activity and sedentary lifestyle in university students: Changes during confinement due to the COVID-19 pandemic. *International Journal of Environmental Research and Public Health*, *17*(18), 6567. https://doi.org/10.3390/ijerph17186567

Ross, R., Chaput, J., Giangregorio, L. M., Janssen, I., Saunders, T. J., Kho, M. E., Poitras, V.J., Tomasone, J. R., El-Kotob, R., McLaughlin, E. C., Duggan, M., Carrier, J., Carson, V., Chastin, S. F., Latimer-Cheung, A. E., Chulak-Bozzer, T., Faulkner, G., Flood, S. M., Gazendam, M. K., & Tremblay, M. S. (2020). Canadian 24-hour movement guidelines for adults aged 18–64 years and adults aged 65 years or older: An integration of physical activity, sedentary behaviour, and sleep. *Applied Physiology, Nutrition, and Metabolism, 45*(10) (Suppl. 2), S57–S102. https://doi.org/10.1139/apnm-2020-0467

Sallis, R., Young, D. R., Tartof, S. Y., Sallis, J. F., Sall, J., Li, Q., Smith, G. N., & Cohen, D. A. (2021). Physical inactivity is associated with a higher risk for severe COVID-19 outcomes: A study in 48 440 adult patients. *British Journal of Sports Medicine, 55*(19), 1099–1105. https://doi.org/10.1136/bjsports-2021-104080

Shaw, K. A., Zello, G. A., Butcher, S. J., Ko, J. B., Bertrand, L., & Chilibeck, P. D. (2021). The impact of face masks on performance and physiological outcomes during exercise: A systematic review and meta-analysis. *Applied Physiology, Nutrition, and Metabolism*, *46*, 693–703. https://doi.org/10.1139/apnm-2021-0143

Shen, X., Wu, Y., & Zhang, D. (2016). Nighttime sleep duration, 24-hour sleep duration and risk of all-cause mortality among adults: A meta-analysis of prospective cohort studies. *Scientific Reports 6*, 21480 (2016). https://doi.org/10.1038/srep21480

Siraj, N. (2023). Binge watching and sleep quality among college students. *International Journal of Indian Psychology, 11*(1), 1228–1237. https://ijip.in/wp-content/uploads/2023/03/18.01.124.20231101.pdf

Sittichai, N., Parasin, N., Saokaew, S., Kanchanasurakit, S., Kayod, N., Praikaew, K., Phisalprapa, P., & Prasannarong, M. (2022). Effects of physical activity on the severity of illness and mortality in COVID-19 patients: A systematic review and meta-analysis. *Frontiers in Physiology, 13*, 1030568. https://doi.org/10.3389/fphys.2022.1030568

Stanton, R., To, Q. G., Khalesi, S., Williams, S. L., Alley, S. J., Thwaite, T. L.,Fenning, A. S., & Vandelanotte, C. (2020). Depression, anxiety and stress during COVID-19: Associations with changes in physical activity, sleep, tobacco and alcohol use in Australian adults. *International Journal of Environmental Research and Public Health*, *17*(11), 4065. https://www.mdpi.com/1660-4601/17/11/4065/htm

Stockwell, S., Trott, M., Tully, M., Shin, J., Barnett, Y., Butler, L., McDermott, D., Schuch, F., & Smith, L. (2021). Changes in physical activity and sedentary behaviours from before to during the COVID-19 pandemic lockdown: A systematic review. *BMJ Open Sport & Exercise Medicine*, *7*(1), e000960. https://bmjopensem.bmj.com/ content/7/1/e000960

Sundarasen, S., Chinna, K., Kamaludin, K., Nurunnabi, M., Baloch, G. M., Khoshaim, H. B., Hossain, S. F. A., & Sukayt, A. (2020). Psychological impact of COVID-19 and lockdown among university students in Malaysia: Implications and policy recommendations. *International Journal of Environmental Research and Public Health*, *17*(17), 6206. https://doi.org/10.3390/ijerph17176206

Svensson T, Saito E, Svensson A. K., Melander, O., Orho-Melander, M., Mimura, M., Rahman, S., Sawada, N. Koh, W., Shu, X., Tsuji, I., Kanemura, S., Park, S. K., Nagata, C., Tsugane, S., Cai, H., Yuan J., Matsuyama, S. Sugawara, Y., Wada, K., . . . & Potter, J. D. (2021). Association of sleep duration with all- and major-cause mortality among adults in Japan, China, Singapore, and Korea. (2021, September 3). *JAMA Network Open, 4*(9): e2122837. https://doi.org/10.1001/jamanetworkopen.2021.22837

Sygit, K., Sygit, M., Wojtyła-Buciora, P., Lubiniec, O., Stelmach, W., & Krakowiak, J. (2019). Physical activity as an important element in organizing and managing the lifestyle of populations in urban and rural environments. *Annals of Agricultural and Environmental Medicine, 26*(1), 8–12. https://doi:10.26444/aaem/99177

Ukawa, S., Zhao, W., Yatsuya, H., Yamagishi, K., Tanabe, N., Iso, H., & Tamakoshi, A. (2019). Associations of daily walking time with pneumonia mortality among elderly individuals with or without a medical history of myocardial infarction or stroke: Findings from the Japan collaborative cohort study. *Journal of Epidemiology, 29*(6), 233–237. https://doi.org/10.2188/jea.JE20170341

Ungvari, Z., Fazekas-Pongor, V., Csiszar, A., & Kunutsor, S. K. (2023). The multifaceted benefits of walking for healthy aging: From Blue Zones to molecular mechanisms. *GeroScience, 45*(6), 3211–3239. https://doi.org/10.1007/s11357-023-00873-8

Wang, F., & Boros, S. (2021). The effect of daily walking exercise on sleep quality in healthy young adults. *Sport Sciences for Health, 17*, 393–401. https://doi.org/10.1007/s11332-020-00702-x

Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S. R., Quan, S. F., & Tasali, E. (2015). Recommended amount of sleep for a healthy adult: A joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society. *Sleep*, *38*(6), 843–844. https://doi.org/10.5665/sleep.4716

Young, D. R., Sallis, J. F., Baecker, A., Cohen, D. A., Nau, C. L., Smith, G. N., & Sallis, R. E. (2023). Associations of physical inactivity and COVID-19 outcomes among subgroups. *American Journal of Preventive Medicine, 64*(4), 492–502. https://doi.org/10.1016/j.amepre.2022.10.007

Zheng, C., Poon, E. T., Wan, K., Dai, Z., & Wong, S. H. (2023). Effects of wearing a mask during exercise on physiological and psychological outcomes in healthy individuals: A systematic review and meta-analysis. *Sports Medicine* (Auckland, N.Z.), *53*(1), 125–150. https://doi.org/10.1007/s40279-022-01746-4