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A cross-sectional study: the impact of extreme weather, sleep quality, and physical activity
Un estudio transversal: el impacto del clima extremo, la calidad del sueño y la actividad física

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Abstract. This study aims to explore the impact of extreme weather condition on sleep quality and physical activity in Gorontalo using a cross-sectional research design. The data were collected from 220 respondents aged 18-25 using the Pittsburgh Sleep Quality Index (PSQI), International Physical Activity Questionnaire (IPAQ), and weather information from BMKG Gorontalo. The results showed that extreme weather, especially high temperatures, significantly reduced physical activity and affected sleep quality. Respondents with higher physical activity levels showed better sleep quality (lower PSQI scores). Extreme weather also reduces motivation to exercise, increasing the risk of health problems such as dehydration and heat stroke. In conclusion, public health interventions that promote physical activity and improved sleep quality during extreme weather conditions are urgently needed to reduce associated health risks. This study emphasises the importance of understanding the specific mechanisms of how extreme weather affects sleep and physical activity, and developing strategies to maintain healthy routines despite adverse weather conditions.
Keywords: extreme weather, sleep quality, physical activity, public health, health interventions.

Resumen. Este estudio tiene como objetivo explorar el impacto de las condiciones meteorológicas extremas en la calidad del sueño y la actividad física en Gorontalo utilizando un diseño de investigación transversal. Se recogieron datos de 220 encuestados de entre 18 y 25 años utilizando el Índice de Calidad del Sueño de Pittsburgh (PSQI), el Cuestionario Internacional de Actividad Física (IPAQ) e información meteorológica de BMKG Gorontalo. Los resultados mostraron que las condiciones meteorológicas extremas, especialmente las altas temperaturas, reducían significativamente la actividad física y afectaban a la calidad del sueño. Los encuestados con mayores niveles de actividad física mostraron una mejor calidad del sueño (puntuaciones más bajas en el PSQI). El tiempo extremo también reduce la motivación para hacer ejercicio, aumentando el riesgo de problemas de salud como la deshidratación y el golpe de calor. En conclusión, se necesitan urgentemente intervenciones de salud pública que promuevan la actividad física y la mejora de la calidad del sueño durante condiciones meteorológicas extremas para reducir los riesgos para la salud asociados. Este estudio subraya la importancia de comprender los mecanismos específicos de cómo el clima extremo afecta al sueño y a la actividad física, y de desarrollar estrategias para mantener rutinas saludables a pesar de las condiciones meteorológicas adversas.
Palabras clave: clima extremo, calidad del sueño, actividad física, salud pública, intervenciones sanitarias.

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Introduction

Extreme weather has become one of the biggest challenges, in the current era of climate change, with phenomena such as heatwaves, floods, and storms becoming more frequent and impacting various aspects of human life (Cruz et al., 2020). One significant area affected is human health, particularly through its influence on sleep quality and physical activity (Nilsson et al., 2021a). Inactivity in Physical Activity (PA) is a behaviour that seriously compromises physical, mental and social health (Gutiérrez-Higuera et al., 2023). Poor sleep quality caused by poor weather and device use and inadequate physical activity can contribute to a range of health problems, including mental disorders, cardiovascular disease and a weakened immune system (Corvalán-Luengo et al., 2023; Mason et al., 2020). This situation underscores the importance of understanding and mitigating the impact of extreme weather on individual health, especially amid the increasing frequency of extreme weather events as a result of climate change (Chan et al., 2019).

Extreme weather impacts not only physical health but also has significant psychological effects. Prolonged heatwaves can cause stress, anxiety, and other mental health issues, which in turn can affect sleep quality. For example, studies show that increasing environmental temperatures can disrupt sleep patterns and reduce motivation for physical activity (Hambrecht et al., 2022; Santos Labrador & Melero Ventola, 2023a). This is further exacerbated by unsafe or uncomfortable environments for outdoor physical activities, especially during extreme weather conditions (Wong et al., 2020). Additionally, vulnerable populations such as the elderly and children are at higher risk of health impacts from extreme weather, requiring special interventions to protect these groups (Kline & Prunicki, 2023).

The primary issue in this research is how extreme weather affects individual sleep quality and physical activity levels and how these impacts contribute to broader public health issues. Prolonged heatwaves, for instance, can disrupt sleep patterns and reduce motivation for physical activity. As (Li & Guo, 2023) pointed out, developing early warning systems specific to extreme weather can help reduce associated health risks and alleviate the burden on public health systems. However, the main challenge is identifying and understanding the complex mechanisms linking extreme weather to behavioral and health changes. Therefore, this study aims to identify and address existing knowledge gaps in the literature, focusing on the impact of extreme weather on sleep health and physical activity.

To address this issue, previous research has shown that interventions focusing on improving sleep quality and physical activity can help mitigate the negative health impacts of

extreme weather. For instance, (Zhang et al., 2020) found that educating the public on maintaining health during heatwaves can reduce the risk of sleep disturbances and improve physical fitness. Furthermore, developing public health programs that include training on relaxation techniques and stress management can help individuals cope with the psychological impacts of extreme weather. Other studies also suggest that integrating interdisciplinary approaches can provide a more comprehensive understanding of the interactions between extreme weather, sleep health, and physical activity (Nilsson et al., 2021). Additionally, this study will review related literature supporting the proposed solutions. Pröbstl-Haider et al., (2021) highlighted the need for further research to assess the impact and costs of heatwaves on health systems and to evaluate the effectiveness of interventions aimed at enhancing health system resilience against extreme heat events. This research will fill those gaps by exploring the complex relationships between extreme weather, sleep quality, and physical activity. In the context of public health, a better understanding of how extreme weather affects individual sleep quality and physical activity levels can help design more effective interventions to maintain overall health and well-being (Greca et al., 2022).

This study aims to explore and analyze the impact of extreme weather on individual sleep quality and physical activity levels and to understand how these factors contribute to broader public health issues. Using a cross-sectional research design, this study will collect data that includes measurements of weather parameters such as temperature, humidity, and rainfall, as well as survey data on respondents' sleep quality and physical activity (Nilsson et al., 2021). With this approach, the study is expected to provide significant contributions to the field of environmental health and offer recommendations for public health policies that are more adaptive to climate change. The scope of this study includes analyzing other factors that may affect the outcomes, such as age, gender, health conditions, and socio-economic factors. By understanding the interactions between these factors and their impact on human health, this research can help design more effective interventions to maintain public health amid extreme weather challenges. This study also aims to develop strategies to raise public awareness about the importance of maintaining sleep quality and physical activity, especially during periods of extreme weather (Sheehan, 2021). Through integrating findings from various relevant studies, this research is expected to provide new insights into how extreme weather affects human health through less recognized pathways and offer recommendations that can be applied in public health policies to address future climate change challenges (Walton et al., 2021).

Thus, this research not only contributes to scientific understanding of the impacts of extreme weather but also offers practical solutions to enhance overall public health and well-being. This study will help design more effective interventions to minimize the impact of extreme weather on sleep health and physical activity, as well as provide recommendations that can be applied in public health policies to face future climate change challenges (Nema & Muthupriya, 2022; Santos Labrador & Melero Ventola, 2023b). With a multidisciplinary approach and holistic research, this study has the potential to make significant contributions to the field of environmental health and offer sustainable solutions to improve public health amid increasingly complex climate change challenges.

Method

This study aims to investigate the relationship between extreme weather, sleep quality and physical activity among Gorontalo residents, using a quantitative approach and cross-sectional research design. This design allows the collection of data on exposure and outcomes at one time, to describe the characteristics of the subjects as well as the relationship between variables. The study was conducted from September to October 2023, with a population of 220 people aged 18-25 years. From this population, a sample of 35 respondents was selected using purposive sampling technique based on the criteria of age, occupation, type of physical activity, and the validity of the answers given.

Data collection techniques were carried out through questionnaires distributed in the form of Google Forms to the respondents. The instrument used to measure physical activity was The International Physical Activity Questionnaire (Craig et al., 2003), while to assess each individual's sleep quality, the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al., 1989) was used. Data related to extreme weather was obtained from the Gorontalo Meteorological, Climatological and Geophysical Agency (BMKG), with a time coverage of one month from September to October 2023.

Data analysis was conducted using Pearson correlation test to determine the relationship between extreme weather variables, sleep quality, and physical activity of Gorontalo residents. Prior to the correlation analysis, a data normality test was conducted using the Shapiro-Wilk method to ensure that the data met the assumption of normality. The results of this correlation analysis are expected to provide a deeper understanding of how extreme weather factors affect sleep quality and physical activity levels, and provide a basis for recommendations for more effective public health interventions in the region. This research makes an important contribution to understanding the impact of climate change on human health, particularly in the local context of the Gorontalo community.

Results

The data in table 1 is a data collection activity carried out by filling out the research instrument that has been provided through filling out the google form given to 220 people with male criteria aged 18-25 years obtained physical activity data as described.

Table 1.
Overview of Pittsburgh Sleep Quality, Physical Activity Questionnaire, and Temperature in Gorontalo.

Category	Mean (SD)	Median (IQ)	% / Temperature
Pittsburgh Sleep Quality Index (PSQI)	5.7 (2.5)	5.0 (3.0)	
Good Sleep Quality			62.85%
Poor Sleep Quality			37.14%
Morningness-Eveningness Questionnaire (MEQ)	41.1 (9.0)	41.1 (13.0)	
Wake up at 05:00-05:59			37.14%
Wake up at 06:00-06:59			22.85%
Wake up at 07:00-07:59			5.71%
Wake up at 08:00-08:59			14.28%
Wake up after 09:00			20%
Average Temperature (Gorontalo, Sep-Oct 2023)			
Morning (05:00 - 09:00)			23°-25°
Afternoon (11:00 – 14:00)			34°-38°
Evening (15:00 – 18:00)			30°-33°
International Physical Activity Questionnaire (IPAQ)			
Low-Level Physical Activity	195.2 (334.9)	135.0 (175.0)	
Walking (minutes/week)			
Moderate-Level Physical Activity	150.8 (335.0)	75.0 (155.0)	
e.g., playing soccer, tennis, etc.			
Active-Level Physical Activity	130.1 (311.6)	90.0 (300.0)	
Sitting at home (minutes/week)	320.3 (185.5)	260.0 (170.0)	
PAL*	2.4 (0.7)	3.0 (1.0)	
Pearson correlation coefficient (r) physical activity and sleep quality	0.52		
Coefficient of Determination (r^2)	0.27		
p-value	0.65		
Pearson Correlation (r) between Extreme Weather (Temperature) and Physical Activity	-0.77		
Coefficient of Determination (r^2)	0.59		
p-value	0.44		

Notes. SD =standard deviation; IQ =interquartile range; PAL =physical activity level.
*PAL ranks 1 as low physical activity level, 2 as moderate physical activity level, and 3 as high physical activity level.

In Table 1 the respondents were asked about their physical activity habits that they often do every day using the IPAQ instrument. Most respondents reported that they were active in moderate level physical activity (37.14%) by doing physical activities such as playing football, volleyball etc., while (25.71%) respondents reported applying active physical activity in daily activities such as jogging, cycling etc. with the aim of physical endurance and fitness, while low level physical activity (20%) with physical activity walking, but there were (17.4%) respondents who stated that they spent more time at home if they had free time than having to do physical activity. While the temperature picture that occurred in September to October 2023 provides information that the temperature range in the morning to the afternoon, the temperatures recorded in this table is the temperature released at a predetermined time but in some temperature applications on mobile phones shows the average temperature that is felt hotter than what has been released. this makes the community in carrying out its activities a little experiencing obstacles from the weather that happened at that time. Pittsburgh Sleep Quality Index (PSQI) is an instrument used to determine the quality of sleep experienced by respondents during the last 1 month both doing physical activity based on the level determined by IPAQ in table 1 in detail describes the quality of sleep experienced by respondents and the time to wake up everyday. Then there were (62.85%) respondents stated that they had good sleep quality within 1 month which was directly related to waking up in the morning, while there were (37.14%) respondents reported that they had difficulty falling asleep at night or other disturbances and had an impact on waking up in the morning.

Increased physical activity has a positive impact on an individual's sleep quality. Data shows that individuals with higher levels of physical activity tend to have lower Pittsburgh Sleep Quality Index (PSQI) scores, indicating better sleep quality. The average physical activity time per week was 130.1 minutes for high activity, 150.8 minutes for moderate activity, and 195.2 minutes for low activity, while sitting time was 320.3 minutes per week. The higher the physical activity level, the better the sleep quality, with the lowest PSQI score in the high activity group. Increased physical activity can reduce sleep disturbances and improve overall mental and physical health. Health promotion strategies that encourage increased physical activity, especially for more sedentary individuals, may improve sleep quality and general wellbeing.

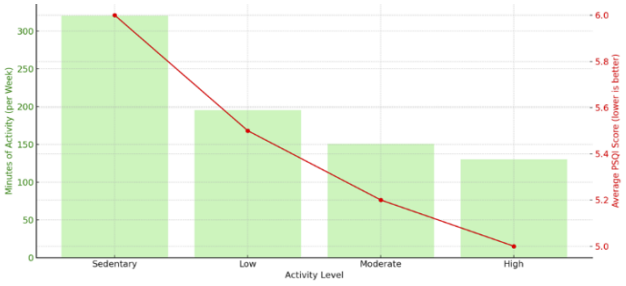

Figure 1. Physical activity on sleep quality

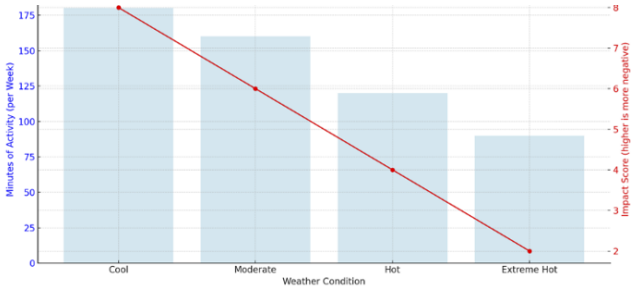

Figure 2. Relationship between extreme weather and physical activity.

Extreme weather can affect physical activity and, in turn, sleep quality. Increased physical activity in mild weather (180 minutes/week) supports health and fitness, while hotter temperatures significantly reduce activity, especially in extreme conditions (90 minutes/week). Negative impacts of hot weather include increased health risks such as dehydration and heat stroke, which can reduce motivation to exercise and lower physical well-being. As a result, sleep quality may be affected due to limited physical activity. It is important to adjust the time and place of physical activity to remain optimal even in extreme weather, such as exercising in the morning or cool indoors, and using technology to effectively plan activities.

Discussion

The discussion shows that there is a significant relationship between physical activity and sleep quality in the respondents of this study. Based on the data in Table 1, the Pearson correlation coefficient (r) between physical activity and sleep quality is 0.52, which indicates a moderate positive relationship. This means that the higher the level of physical activity, the better the quality of sleep experienced by the individual, which is reflected in lower Pittsburgh Sleep Quality Index (PSQI) scores. This is in line with the findings in Graph 1, where the high physical activity group had the lowest mean PSQI score of 5.0, compared to 6.0 in the low physical activity group. While this correlation is moderate, it is important to note that the p-value of 0.65 indicates that this relationship is not statistically significant, requiring further research with a larger sample to strengthen this finding.

In addition, the impact of extreme weather on physical activity is also evident in this study. Data from Table 1 shows that the Pearson correlation (r) between extreme temperatures and physical activity is -0.77, indicating a strong negative relationship. In other words, the higher the temperature (more extreme weather), the more physical activity tends to decrease significantly. Graph 2 supports this finding, where physical activity decreases from 175 minutes per week in mild weather conditions to less than 50 minutes per week in extremely high temperatures. This strong correlation, with an r^2 value of 0.59, confirms that almost 59% of the variability in physical activity levels can be explained by temperature, although the p value of 0.44 suggests that this result needs to be further scrutinised to ensure its consistency across a wider population.

Extreme weather, such as extreme temperatures or heavy rain, can disrupt individuals' sleep patterns, resulting in lower sleep quality. (Wagner et al., 2019) found that individuals facing rain as adverse weather are more likely to exercise indoors and delay their workouts compared to those facing heat as the main condition. This shows that extreme weather, like heavy rain, can disrupt individuals' exercise routines, potentially affecting their physical activity levels and overall health.

Research also shows that extreme weather can reduce opportunities or motivation for physical activity, especially outdoor activities. (Nguyen et al., 2021) highlighted that unfavorable weather conditions, including cold or hot temperatures and rain, lead children to shift their activities from outdoors to indoors. This shift involves reducing time spent on active pursuits and travel while increasing time allocated to sedentary activities like media consumption. These behavioral changes due to extreme weather can impact children's physical activity levels and overall well-being. Heat also contributes to decreased sleep quality, particularly in terms of timely sleep and early waking. (Zheng et al., 2019) highlighted the negative effects of high temperatures on human sleep quality and appetite. Insufficient sleep due to extreme weather can lead to more frequent accidents and economic losses, while reduced appetite can lead to weight loss or malnutrition, ultimately affecting overall health.

The decrease in sleep quality and physical activity due to extreme weather contributes to increased risks of health issues such as stress, fatigue, and lifestyle-related diseases. The relationship between weather conditions, physical activity, and sleep quality is crucial for understanding their combined impact on health outcomes. (Ferguson et al., 2023) found significant associations between weather variables such as maximum temperature and sleep duration, as well as physical activity levels among Australian adults. The study observed curvilinear relationships, indicating that deviations from optimal temperature ranges could affect sleep duration and physical activity patterns. These disruptions in sleep and physical activity due to extreme weather conditions may contribute to increased stress, fatigue, and susceptibility to lifestyle-related diseases. (Palmer et al., 2022) examined the association between sleep disturbances, delayed sleep timing, and post-traumatic stress symptoms in youth following natural disasters like hurricanes. The study found that later sleep timing and shorter sleep duration were linked to greater post-traumatic stress symptoms, highlighting the complex relationship between extreme weather events, sleep patterns, and mental health outcomes. This underscores the importance of addressing sleep disruptions caused by extreme weather to mitigate the risk of adverse health consequences.

The broader implications of extreme weather events on health and well-being have also been explored in the literature. (Sheehan, 2021) discussed various extreme weather records set in 2020, including wildfires, flooding, and hurricanes, emphasizing the significant impact of climate change on human well-being. Extreme weather events not only pose immediate risks to physical health but also contribute to psychological stress, disruptions in daily routines, and challenges in accessing healthcare services, all of which can exacerbate stress, fatigue, and lifestyle-related diseases. This research is expected to provide new insights into how climate change affects human health through less recognized pathways. For instance, the impact of extreme weather on

sleep patterns and physical activity can offer a more comprehensive view of how climate change affects overall public health. Targeted interventions promoting physical activity and improving sleep quality during extreme weather conditions can help reduce associated health risks.

Extremely high temperatures tend to make individuals less motivated to engage in physical activity and more prone to passive behavior. (Vasanthi & Ying, 2021) indicated that unfavorable weather conditions such as cold, heat, or heavy rain can reduce individuals' motivation, including that of older adults, to participate in physical activity. (Koh et al., 2022) found that common barriers to physical activity include lack of time, fatigue, insufficient exercise at work, and low motivation. These barriers can further exacerbate the impact of extreme weather conditions on individuals' exercise motivation, making it challenging to overcome multiple obstacles to engage in physical activity, especially outdoor activities. Recommendations for future research include further exploration of the specific mechanisms by which extreme weather affects sleep and physical activity. Research can focus on identifying effective interventions to mitigate the impact of extreme weather, such as promoting indoor exercise or stress management techniques that can help individuals maintain physical activity routines and good sleep quality despite adverse weather conditions. Addressing the interrelated factors between sleep, physical activity, and the impact of extreme weather on health can help individuals and communities better prepare for and reduce the adverse effects of extreme weather events on overall well-being.

In conclusion, extreme weather conditions have a complex and multifaceted impact on individual health, primarily through their influence on sleep quality and physical activity levels. A better understanding of the interactions between extreme weather, sleep, and physical activity is crucial for developing adaptive strategies and interventions that can help individuals and communities cope with the adverse effects of climate change on health. Therefore, this research provides valuable contributions to the literature on health and climate change and offers practical guidance to improve well-being in the face of extreme weather conditions.

Conclusion

This study examined the impact of extreme weather on sleep quality and physical activity using a cross-sectional research design in Gorontalo. The results showed that extreme weather such as high temperatures significantly reduced physical activity and affected sleep quality. The data shows that higher physical activity correlates with better sleep quality, while extreme temperatures negatively affect motivation to exercise and increase the risk of health problems such as dehydration and heat stroke. These results suggest the importance of public health interventions, that encourage physical activity in extreme weather conditions and improved sleep quality to reduce associated health risks. This study suggests further exploration of the specific mechanisms of how extreme weather affects sleep and physical activity and developing strategies to maintain healthy routines despite adverse weather conditions.

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