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How does planetary health redefine our steps? An integrative review on climate change and global physical activity.

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ABSTRACT

Introduction: Climate change is altering individual behaviors, particularly in terms of physical activity, with significant implications for body and mental health. **Objective:** This review aims to provide insights for researchers, public health professionals, and policymakers to promote physical activity effectively in the face of climate change challenges. **Methods:** We conducted an integrative review of studies involving adults published in English, Portuguese, or Spanish, using databases such as PubMed, Scielo, Lilacs, Web of Science, and Embase. **Results:** Eighty-three papers were included, revealing that heat waves reduce outdoor physical activity, while indoor activities are gaining popularity due to poor air quality. Sea level rise affects coastal areas and water-based sports, limiting access to these activities. Public policies are needed to promote physical activity for various groups, considering their specific needs and limitations. Despite these challenges, physical activity can increase resilience and be a catalyst for lifestyle changes, especially in areas most affected by climate change. **Conclusion:** A multidisciplinary approach is crucial for developing solutions to mitigate the negative impacts of climate change on physical activity. This review highlights the urgent need for adaptation strategies in promoting physical activity in the face of a changing environment and its implications for public health.

Keywords: Climate change; Physical activity; Environmental Policy; Exercise; Health Promotion.

1. INTRODUCTION

Climate change represents one of the greatest threats to human well-being and public health, with increasingly evident consequences worldwide [1] Among the extreme weather phenomena that have raised concern, heatwaves and changes in air and sea levels stand out as frequent and significantly impactful events [2]. In addition to their direct effects on human health, these alterations also have important implications for physical activity, an essential component for promoting health and the overall well-being of the population.[3]

Rising global temperatures are intricately connected to the proliferation of more frequent and severe heatwaves, presenting direct health hazards like heat exhaustion and increased hospital admissions.[4,5] Moreover, recent climate research indicates that global warming intensifies drought conditions by increasing evaporation and surface drying. Additionally, the atmosphere's elevated water vapor content leads to more intense precipitation events, including storms and flooding. These findings underscore the significant impacts of altered precipitation patterns on infrastructure, food security, and community health. [6] Given ongoing challenges posed by climate change, it is crucial for global communities to prioritize sustainable solutions that mitigate its impacts while fostering resilience among populations facing these profound environmental shifts.

These climate challenges are compounded by the complex interplay of environmental, social, and economic factors. For example, low-income communities and developing countries are often more vulnerable to the impacts of climate change due to limited resources for adaptation and mitigation.[7] Moreover, issues such as access to adequate healthcare, food security, and safe housing play a crucial role in communities' ability to cope with the challenges posed by climate change.[8]

In this context, understanding the importance of physical activity for overall health and its pivotal role in preventing chronic diseases, promoting mental well-being, and enhancing quality of life is essential in comprehending the intersections between climate change and physical activity. Engaging in regular physical activity not only fosters physical fitness but also significantly reduces the risk of chronic illnesses such as cardiovascular diseases, diabetes, and certain cancers.[9] Moreover, physical activity plays a crucial role in maintaining mental health by alleviating stress, anxiety, and depression, while also enhancing cognitive function and overall mood.[10,11] Recognizing the multifaceted benefits of physical activity underscores its significance as a protective factor against the adverse health effects of climate change and highlights the importance of incorporating it into adaptive strategies for resilient communities.

In line with all that, this research integrates evidence from various fields, exploring the impact of climate change on physical activity, including its effects on activity patterns, health outcomes, interventions, behavioral adaptations, disparities, technological innovations, and psychosocial dimensions. Through this integrative review, we aim to provide valuable insights for researchers, public health professionals, and policymakers, contributing to a more comprehensive and effective approach to promoting physical activity in challenging climate change contexts.

2. MATERIALS AND METHODS

For this integrative review, a methodical approach was adopted, utilizing the updated methodology proposed by Whittemore R, Knafl K. This encompassed formulating clear objectives, establishing inclusion and exclusion criteria for article selection, defining parameters for data extraction, conducting comprehensive result analysis, engaging in discussion and presentation of findings, and ultimately concluding with a review presentation.[12] It included observational studies, systematic reviews, integrative reviews, literature reviews, meta-analysis and clinical trials conducted with humans over 18 years old and that were published in English, Portuguese, and Spanish. Studies excluded were case reports and specialist' opinion. There was no stablished limited for year of publication. All the studies included were about climate change and its impact on our society.

Database used to research the literature were PubMed, Scielo, Lilacs, Web of Science and Embase. The research was completed with studies cited in primary identified studies and added manually in this review. Given the particularities in accessing the chosen databases, the search strategies for locating articles were adapted for each. These strategies were guided by the integrative review's predefined question and inclusion criteria, ensuring consistency in article retrieval, and mitigating potential biases. The keywords employed included: Heat waves; Physical activity; Climate change; Health outcomes; Sea level changes; Beach activities; Coastal communities; Technology; Wearable devices; Climate adaptation; Air quality; Public Policiy; Urban Health; Rural Health; Health Promotion; Psychosocial Intervention; Psychosocial Impact. This research was conducted in February-March of 2024.

After the conducted research, studies were selected according to the inclusion criteria and the previously defined topics discussed in this integrative review. All studies were analyzed first by its title and abstract. To conclude the analysis, some studies were

selected only after the complete reading of its topics. Two reviewers independently did the selections of each article.

The data extraction process followed a systematic approach. Each selected study was thoroughly examined to identify relevant information pertaining to the research question. Key data points were manually extracted and organized according to predetermined categories. These categories encompassed various aspects such as study characteristics including author(s), publication year, context, methodology, main findings, and conclusions. Throughout the extraction process, careful attention was paid to ensuring accuracy and completeness in capturing all pertinent details.

After completing the data extraction phase, a thorough analysis was conducted to synthesize the information and address the research question. This involved identifying recurring patterns, themes, concepts within the data, and gaps in the literature. Results from each study were carefully examined to synthesize empirical evidence across multiple domains, encompassing the effects of heatwaves on activity patterns, the influence of air quality on exercise behavior, the repercussions of sea level alterations on recreational pursuits, epidemiological associations between diminished physical activity and health outcomes, interventions and policy initiatives targeting physical activity in the face of climate shifts, behavioral adaptations amidst changing environmental conditions, urban and rural disparities in physical activity responses to climate dynamics, technological innovations fostering activity in adverse climates, and the psychosocial dimensions of climate adaptation and physical activity.

3. DEVELOPMENT

3.1 Impact of Heatwaves on Physical Activity

Heatwaves have been the subject of study concerning their effects on human physical activity.[13] In Texas, it was observed that pedestrians were more inclined to use trails when temperatures ranged between 7 and 27°C, with peak usage occurring at 17°C, while cyclists showed a preference for temperatures between 15 and 33°C, peaking at 27°C. This observation indicates that both pedestrians and cyclists were less likely to utilize the trail during temperature extremes.[14] Similarly, in New York City, bicycle usage significantly increased with rising temperatures but declined above 26–28°C. These underscores projections of rising bicycling rates in NYC by mid-century but increasing temperatures may alter this trend.[15]

In both Australia and Hong Kong, extreme weather conditions significantly influenced outdoor physical activity. In Hong Kong, during extreme temperatures, over a third of participants reported decreased activity, while 9.2% increased activity in extreme heat. Similarly, in Australia, adults showed reduced activity and increased sedentary behavior during extreme weather conditions. [16,17]

During heatwaves, older adults experienced reduced physical performance, including slower habitual walking speed and chair-rise performance. Likewise, residents of Montreal with chronic cardiac and pulmonary diseases significantly decreased their physical activity by over 75% during exposure to extreme temperatures.[18,19]

Strategies such as periodized training, heat acclimation/acclimatization, cooling, and nutritional strategies have been studied as possible adaptation methods for athletes competing in hot conditions. [20] These findings underscore the importance of understanding the effects of heatwaves on physical activity and the need to develop adaptation strategies to cope with these adverse environmental conditions.

3.2 Influence of Air Quality on Physical Activity

Nowadays, air pollution is a substantial subject that influences healthy of citizens all around the world and is considered our biggest environmental threat, with numbers of diseases correlated with these matters being comparable to other major global risks. [21] Furthermore, under this circumstances, bad air quality has influenced citizen's daily activities, especially the ones with previous diagnosed respiratory disease. [22] Data from 2005 Behavioral Risk Factor Surveillance has shown that 12% of those without a previous diagnosis of asthma and 25.6% of those with the diagnosis changed physical activity routine based on bad air quality perception (Association between media alerts of air quality index and change of outdoor activity among adult asthma in six states). In Ohio, 12% of the studied population changed their physical behavior due to bad air quality and 25% of those had some respiratory condition.

Cardiovascular diseases also may be affected by air pollution. People that exercised in days when the Air Quality Health index (AQHI) was higher than the acceptable had increased systolic and diastolic blood pressure and reduced oxygen saturation.[23] Another study has associated lower frequency of physical activity and increased exposure to air pollution with higher levels of blood pressure and prevalence of hypertension.[24]

3.3 Consequences of Sea Level Changes on Recreational Activities

Sea level changes caused by climate change have significant consequences for various aspects of our society, including recreational activities. Coastal communities heavily rely on activities like swimming, surfing, and boating that take place in marine environments. As sea levels continue to rise over the next decades, the threats to shorelines, wetlands, and coastal development will also increase, amplifying the challenges faced by these communities.[25]

Recent research at five Japanese beaches highlights the complex relationship between projected climate change and recreational beach tourism. While projections suggest improved climatic suitability for beach activities, they also indicate significant beach loss which emphasizes the need for comprehensive assessments. Prioritizing adaptation strategies can help coastal communities mitigate adverse effects and ensure resilience of recreational resources.[26]

Furthermore, sea level changes also impact recreational activities in coastal areas such as the Caribbean. Monitoring data from eight Caribbean islands between 1985-2000 show significant beach erosion trends worsened by factors like hurricanes and human influences. To address these challenges effectively, recommended adaptation measures include structural improvements as well as planning or ecological approaches that involve community participation and careful consideration in their implementation. [27]

3.4 Epidemiology of Reduced Physical Activity and Public Health

The correlation between alterations in climate patterns and a decline in physical activity has raised significant concerns regarding public health outcomes. This relationship becomes increasingly relevant as we consider the specific health implications associated with reduced physical activity levels. Studies have consistently highlighted the critical role of regular physical activity in maintaining overall health and preventing chronic diseases.[28] However, emerging evidence suggests that factors such as air pollution and changes in ambient temperature may impede individuals' ability or willingness to engage in physical activity, particularly in highly polluted or extreme weather conditions.[29]

Moreover, the interplay between global warming and public health, particularly in the context of the obesity epidemic, underscores the complex dynamics at play. A

conceptual model proposes a multifaceted relationship, wherein factors like the fossil fuel economy, urbanization, and agricultural practices contribute to both global warming and increased rates of obesity through mechanisms such as nutrition transition and physical inactivity.[30]

Importantly, epidemiological data also highlight the differential vulnerability of certain population groups to these impacts. For instance, studies examining the association between weather conditions and health outcomes, such as intracranial hemorrhages and cardiovascular diseases, underscore the heightened risk faced by specific demographic segments. [13,31]

In the United States, modeling projections suggest alarming increases in mortality from cardiovascular diseases and stroke due to rising average ambient temperatures. By 2099, these projections estimate a substantial rise in annual deaths attributable to cardiovascular diseases and stroke, surpassing the expected impacts of extreme hot weather events.[31]

Understanding the link between climate change and public health is crucial, particularly regarding the impact of altered climate patterns on physical activity. Research highlights how environmental factors affect health behaviors and outcomes, with certain groups being more vulnerable. Targeted interventions are necessary to address these disparities. [13,28,29,31,32]

3.5 Interventions and Public Policies to Stimulate Physical Activity

There must be a bond between public policy and individual interventions to reduce climate change damage and its impact in daily physical practice. A study conducted in 2011 explained some methods to avoid the consequences of air pollution, such as health professionals teaching the population how to apply the AQHI scale and the media spreading the consequences of air pollution and how to avoid it. [33]

Another way to battle against air pollution is to adapt to a lifestyle that reduces the emission of these pollutants. [33]. The use of active transportation is one of the mainly objectives to reduce emissions of pollution. In the United States, the transportation sector holds 29% of all emission in the country.[34] In New Zealand, the use of active transportation reduced 1% after an infrastructure development and lifestyle change of the population.[35]

Furthermore, public policy must improve monitoring of the air conditions around the globe to guide future policies and promote a healthier environment for the

population.[36] Another way public politics must reduce pollutants spread is promoting projects supporting decarbonation of the industrial system.[35] Authorities can also reduce the morbidity and mortality of climate change by increasing the access to basic health care needs and vaccination to all communities. Also, there must be strategies to think health institutions with evidence -based strategies that reduce its carbon footprint. [37]

3.6 Behavioral Adaptations in Response to Climate Changes

Behavior adaptation with climate change varies according to where and when the individual is located. Global warming must affect positively outdoor winter PA even in winter or colder location. However, it is also predicted that it will lead to more frequent natural disasters.[38] Under this second scenario, PA has been recognized as important promoters of resilience after disasters. Active transportations may be the only way to reach groups isolated after such tragedies and bicyclist communities have played an important role creating a trail to reach theses individual and increase their chance of survival. Sports can also be a way to promote to kids, who have survived these scenarios, a health development.[39]

The use of indoor activities is also an answer to climate change. Studies about the behavior of climate change in future all indicates an increase in air pollution, heat waves, duration of extreme temperatures and intensity of natural.[40] Therefore, the presence of indoor PA with air filters has been proved to have a positive impact in cardiovascular function, especially in those with respiratory diseases. [41]

3.7 Urban and Rural Challenges

Physical activities are also important in rural population, as they as affected as urban communities by climate change. A study conducted in Chinese with 3408 rural older adults described that physical activity reduced the negative consequences of long-term NO2 exposure on sleep efficiency.[42] Also, rural individuals exposed to pollution that exercise have a more stable telomere length, a biomarker responsible for promoting age processing and genome stability and integrity. [43]

The consequences of climate change have a different impact on rural and urban communities, taking place as an obstacle to physical activities in those regions. In terms of natural disasters, equality of recovery efforts and response of public policies to both groups are needed. Therefore, the union among researchers, community members, service provides, and policy makers is necessary to understand problems in diverse points of views

and reach the most positive solution.[44] Social isolation have been reported, in China, as a risk factor to physical inactivity in rural older adults, highlighting the need to promote interactive activities that explore exercises and social interactions.[44] Other independent risk factors explored in rural primary health care units in Egypt were Obesity, urban residence, unemployment and illiteracy. [45]

3.8 Technology and Innovation in the Context of Physical Activity and Climate Changes

Technology and innovation have revolutionized the landscape of physical activity, particularly in challenging weather conditions. Numerous applications and technological devices have been devised to facilitate and augment physical activity despite adverse weather conditions. [46] These include weather prediction apps that furnish accurate and real-time forecasts, empowering individuals to plan their physical activities accordingly. Additionally, advancements in sustainable sports equipment have significantly contributed to promoting physical activity.[47]

The potential of integrating these technologies into clinical practice as part of health behavior modification strategies is profound.[48] Moreover, within the context of climate change, technology has played a pivotal role in fostering sustainable practices in the sports and physical activity industry. Innovations in eco-friendly materials for sports equipment and attire, coupled with the utilization of renewable energy sources in indoor fitness facilities, have substantially mitigated the environmental footprint of physical activity.[49]

Furthermore, virtual reality and augmented reality technologies have transformed the approach to physical activity by providing immersive and captivating experiences that transcend the constraints of adverse weather conditions. Augmented reality-based training has demonstrated efficacy in enhancing balance, muscular strength, endurance, and motivational levels among adult men.[50] These innovations underscore the pivotal role of technology in promoting physical activity and sustainability in the face of evolving climatic challenges.

3.9 Psychosocial Aspects of Adaptation to Climate Change and Physical Activity

Climate change is a global situation that is characterized by uncertainty and treat to our current lifestyle what can result in high levels of anxiety and increase of mental health diseases. However, people with higher levels of anxiety after understanding about

the consequences of climate change are related to a higher engagement in taking action to change this reality.[51] Furthermore, these changes are linked to aggressive actions, anxiety, behavior changes in children, psychiatric hospitalization, suicidality, abuse of substances and changes in metabolic processing.[52]

Under these disturbing circumstances, physical activity has already been proven to reduce the severity of psychiatric disfunctions. In a study conducted with 1405 patients, the ones that have more time of exercise were in the group with more resilient mindset.[53]

Another study specifically with women with post-traumatic stress disorder has demonstrated that aerobic exercises reduce levels of anxiety and fear of the unpredictable threats with higher rates of stable mood states.[54] These facts just improve the importance of actions that promote physical activities even in chaotic or unpredictable scenarios, such as climate change.

4. CONCLUSIONS

In conclusion, this study highlights the need to expand research on the interaction between climate change and physical activity, particularly regarding different demographic groups and geographical contexts. We have identified significant gaps in current understanding, particularly regarding the influence of specific environmental factors on physical activity patterns and the long-term consequences of climate change in this area.

To advance in this field, it is crucial to explore the role of environmental policies and urban planning in promoting active lifestyles, as well as to consider the potential of emerging technologies to facilitate engagement in physical activities. Furthermore, we emphasize the importance of interdisciplinary collaboration among researchers, policymakers, urban planners, health professionals, and communities to develop integrated approaches that address the complex interaction between climate change, physical activity, and public health. This collaborative approach is essential for the development of evidence-based strategies that promote active lifestyles in a context of ongoing climate change.

CONFLICT OF INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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AUTHORS' CONTRIBUTIONS

The authors of this study have contributed significantly to the work presented here, each fulfilling specific roles as outlined by the CRediT (Contributor Roles Taxonomy) guidelines:

Ana Rafaela Soares do Vale: Conceptualization, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing; **Milca Rodrigues Vieira de Andrade:** Conceptualization, Resources, Original Draft, Writing - Review & Editing, Visualization; **Nelzair Araújo Vianna:** Conceptualization, Writing - Original Draft,

Visualization; **Clarcson Plácido Conceição dos Santos:** Conceptualization, Supervision, Project administration, Writing - Review & Editing.

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