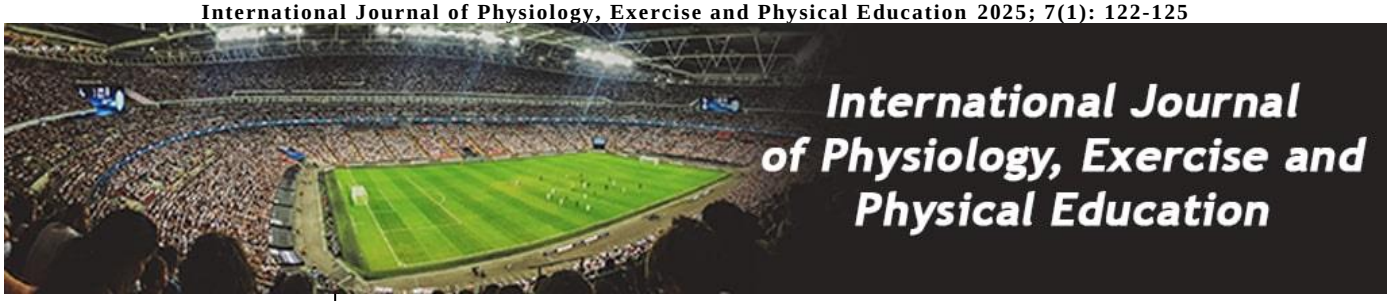

ISSN Print: 2664-7249
ISSN Online: 2664-7257
IJPEPE 20254; 7(1): 122-125
www.physicaleducationjournals.com
Received: 20-02-2025
Accepted: 22-03-2025

S Bushra Ali
London Sports Institute, Middlesex University, London, United Kingdom

Corresponding Author:
S Bushra Ali
London Sports Institute, Middlesex University, London, United Kingdom

Heat and steps: An unexpected VO2 max decline

S Bushra Ali

DOI: https://www.doi.org/10.33545/26647249.2025.v7.i1b.161

Abstract
This case report examines the impact of a change in exercise routine and environmental conditions on a client's VO2 max. The client transitioned from resistance training to a high-volume walking regimen in a hot, humid Middle Eastern climate. Contrary to expectations, this shift resulted in a decrease in VO2 max, measured using a Garmin Fenix wearable device, from 43 to 38 mL/kg/min. This decline highlights the complex interplay of exercise modality, intensity, and environmental factors in influencing aerobic fitness. The report explores potential physiological mechanisms underlying this observation, including the impact of heat stress on cardiovascular function and the limitations of low-intensity exercise in maintaining VO2 max. The role of wearable technology in fitness monitoring is also discussed, emphasizing the need for caution when interpreting data from these devices. Further considerations for personalized training approaches and the importance of continuous monitoring are emphasized.

Keywords: VO2 Max, walking, heat acclimatization, wearable technology, strength training

Introduction
VO2 max, or maximal oxygen consumption, represents the pinnacle of aerobic power, reflecting the body's ability to utilize oxygen during intense exercise. It is widely recognized as a key indicator of an athlete's physical capacity and overall aerobic fitness (Rankovic *et al*., 2010) [12]. As a health indicator, VO2 max demonstrates the body's efficiency in transporting and utilizing oxygen, which impacts both athletic performance and overall well-being (Laury and Tehrany, 2019) [5]. VO2 max is typically expressed in milliliters of oxygen per kilogram of body weight per minute (mL/kg/min), providing a standardized measure for comparison across individuals of varying sizes (Iswahyudi *et al*., 2020) [3]. Additionally, as a longevity marker, a decline in VO2 max is associated with a worsened prognosis for degenerative diseases (Lestari *et al*., 2020) [7]. It reflects the integrated function of the respiratory, cardiovascular, and muscular systems, all working in harmony to deliver and extract oxygen from the air we breathe (Morehouse *et al*., 1972; Phillips *et al*., 2017) [10].
Peter Attia, a prominent figure in the field of longevity research, has identified three key markers associated with increased lifespan: strength, VO2 max, and muscle mass. Strength is important for maintaining functional independence and performing daily activities. VO2 max signifies cardiovascular health and efficient energy utilization, while muscle mass contributes to metabolic health and overall resilience. Scientific investigations have consistently demonstrated that individuals with higher VO2 max values exhibit a reduced risk of chronic diseases such as cardiovascular disease, type 2 diabetes, and certain types of cancer (Elsawy and Higgins, 2010; Novak *et al*., 2014) [2, 11]. VO2 max is not solely determined by genetics; it is also highly responsive to training and lifestyle modifications. Regular aerobic exercise, such as running, swimming, or cycling, can significantly improve VO2 max, regardless of age or fitness level. This adaptability underscores the importance of physical activity in promoting overall health and preventing age-related decline. Moreover, understanding individual variability in response to exercise is paramount for optimizing training outcomes (Izquierdo *et al*., 2020) [4].
This report provides an in-depth examination of a case study focused on a client's VO2 max and related health considerations. It is worth noting that exercise leads to intricate integrative responses that produce multisystem effects (Ruegsegger and Booth, 2017) [13]. Furthermore, there is accumulating evidence that exercise-induced metabolic signals can have a beneficial impact on brain function (Leak *et al*., 2018) [6].

The interaction between physical activity, environmental factors, and physiological responses is a complex area that warrants further investigation.

During muscle contractions, the demand for oxygen increases significantly, sometimes by 10- to 20-fold, highlighting the importance of efficient oxygen transport (Antonio *et al*., 2009) [1]. As we age, changes in mitochondrial function may not occur at a constant rate, suggesting that mitochondrial health should be monitored across the adult lifespan (Short *et al*., 2005) [14]. This highlights the need to characterize mitochondrial functional parameters during early developmental stages and correlate them with lifespan, as the benefits of interventions are often programmed during these critical periods (Maglioni *et al*., 2019) [8]. Understanding the factors that influence mitochondrial function and their relationship to overall health is essential for promoting longevity and preventing age-related decline.

VO2 max is a quantifiable measure that reflects the maximum rate at which an individual can utilize oxygen during intense exercise. This physiological parameter is a cornerstone in assessing cardiovascular fitness and endurance capacity (Smirmaul *et al*., 2013) [15]. The purpose of this case study is to explore the impact of exercise modality and environmental factors on a client's VO2 max. By examining the specific circumstances of this case, valuable insights can be gained into the complexities of exercise prescription and the importance of considering individual needs and environmental conditions.

Case Report

The client is a 45-year-old female with a history of regular resistance training. Prior to the change in exercise routine, she engaged in resistance training three times per week, focusing on compound exercises such as squats, deadlifts, and bench presses. Her VO2 max, as measured by a Garmin Fenix wearable device, was 43 mL/kg/min. The client's diet, sleep patterns, and stress levels were stable during this period. She maintained a balanced diet consisting of whole foods and adequate hydration. Her sleep patterns were consistent, averaging 7-8 hours of sleep per night. Stress levels were managed through mindfulness practices and social support.

Due to a relocation to the Middle East, the client decided to discontinue resistance training and instead incorporated prolonged walking into her exercise routine. She aimed to reach 10,000 steps per day, with brief periods of running, in the hot, humid climate. The client anticipated that the increased daily steps and exposure to heat would lead to similar or improved exercise outcomes, particularly in terms of weight management and cardiovascular health. She believed that the increased physical activity would contribute to overall well-being and enhance her ability to adapt to the new environment.

After three months of this new exercise routine, the client's VO2 max was measured again using the same Garmin Fenix device. Surprisingly, her VO2 max had decreased to 38 mL/kg/min. This decline occurred despite the increased volume of exercise and the client's perception of increased effort due to the hot environment. The client reported no significant changes in diet, sleep, or stress levels during this period. She maintained a consistent dietary intake, sleep schedule, and stress management practices.

The client's expectations regarding the health benefits of exercising in a hot climate were based on a combination of factors, including cultural beliefs, marketing claims, and generalized health advice. She believed that the increased heat stress would stimulate physiological adaptations that would ultimately lead to improved fitness and well-being. However, these expectations were not met, and her VO2 max declined. The discrepancy between the client's expectations and the actual results highlights the importance of evidence-based exercise prescription and the need to consider individual responses to exercise and environmental stress.

Discussion

The observed decrease in VO2 max in this case highlights the complex interplay of exercise modality, intensity, and environmental factors in influencing aerobic fitness. The transition from resistance training to prolonged walking, coupled with exposure to a hot, humid climate, likely contributed to the decline (O'Brien *et al*., 2014). Understanding the specific contributions of each of these factors is essential for developing effective exercise strategies.

Resistance training is known to be an effective stimulus for improving VO2 max. High-intensity resistance exercise can elicit significant cardiovascular responses, leading to improvements in oxygen delivery and utilization. In contrast, prolonged walking, while beneficial for overall health, may not provide a sufficient stimulus to maintain a high VO2 max (Milanovic *et al*., 2015) [9]. The intensity of exercise plays a crucial role in stimulating physiological adaptations that enhance VO2 max. Walking typically elicits a lower cardiovascular demand compared to resistance training or high-intensity interval training. The lack of high-intensity intervals in the client's new exercise routine may have contributed to the decline in VO2 max.

Exercising in a hot, humid environment can further compromise performance and physiological function. Heat stress can lead to cardiovascular drift, where heart rate increases, and stroke volume decreases over time. This can impair oxygen delivery to the muscles, limiting aerobic capacity and reducing VO2 max. The client's experience in the Middle Eastern climate likely contributed to the decline in VO2 max due to these factors. The combination of high temperature and humidity can increase the physiological strain of exercise, making it more difficult to maintain a high level of performance.

The client's VO2 max was quantified using a Garmin Fenix wearable device. While wearable devices have become increasingly popular for estimating VO2 max due to their convenience and accessibility, it is essential to acknowledge their limitations. The Garmin algorithm estimates VO2 max based on heart rate data, pace, and personal information such as age, gender, and weight. While these devices provide valuable insights into fitness trends, they are subject to measurement errors and should not be considered a replacement for clinical exercise testing. The accuracy of wearable devices can be affected by factors such as skin temperature, sweat rate, and individual variations in physiology. Therefore, it is important to interpret the data from wearable devices with caution and to consider other factors that may influence VO2 max.

While the change in exercise routine and environmental conditions are the most likely explanations for the observed

decline in VO2 max, other factors should also be considered. These include:

- **Measurement Error:** As mentioned above, wearable devices are subject to measurement errors, and the observed decline in VO2 max may be due to inaccuracies in the device.
- **Dehydration:** Although the client maintained a stable hydration level, subtle changes in hydration status can affect cardiovascular function and VO2 max.
- **Acclimatization:** The client may not have fully acclimatized to the hot, humid environment, which could have impaired her ability to exercise at a high intensity.
- **Individual Variability:** Individuals respond differently to exercise and environmental stress, and the client's response may be unique.
- **Training Volume:** Although step count increased, it might not equate to the same level of exertion, especially considering the change in muscle groups being trained.
- **Psychological Factors:** The mental fatigue of performing cardio versus the fulfillment derived from resistance training could have had an impact.

To mitigate the negative impact of heat stress and maintain or improve VO2 max in a hot environment, several strategies can be employed:

- **Heat Acclimatization:** Gradual exposure to heat stress through repeated exercise sessions promotes physiological adaptations such as increased plasma volume, improved sweating rate, and reduced core temperature.
- **Pre-Exercise Cooling:** Cooling the body before exercise can reduce the physiological strain of exercising in the heat.
- **Fluid and Electrolyte Replacement:** Maintaining adequate hydration and electrolyte balance is crucial for preventing dehydration and supporting cardiovascular function.
- **Exercise Timing:** Exercising during cooler times of the day can reduce heat stress.
- **Exercise Modality:** Incorporating higher intensity exercise, such as interval training or resistance training, can help maintain or improve VO2 max.
- **Monitoring and Adjustment:** Regularly monitoring VO2 max and adjusting the exercise routine as needed can help optimize fitness outcomes.
- **Personalized Training Programs:** Considering individual fitness levels, goals, and environmental conditions when designing exercise programs is essential.
- **Continuous Monitoring:** Regularly monitoring physiological parameters such as heart rate, body temperature, and hydration status can help prevent overexertion and optimize exercise performance.

In conclusion, this case study underscores the importance of individualized exercise prescriptions that take into account a variety of parameters and conditions.

Conclusion

This case report highlights the importance of considering exercise modality, intensity, and environmental factors when prescribing exercise for improving or maintaining aerobic fitness. The transition from resistance training to prolonged walking in a hot, humid climate resulted in an unexpected decline in VO2 max in this client. This observation underscores the need for a tailored approach to exercise prescription, considering individual fitness levels, goals, and environmental conditions. While wearable devices can provide valuable insights into fitness trends, their limitations should be acknowledged, and data should be interpreted with caution. Moving forward, healthcare professionals and fitness trainers should prioritize comprehensive assessments and individualized exercise programs to optimize health outcomes and prevent unintended consequences. Educating clients about the importance of evidence-based practices and realistic expectations is also crucial for fostering long-term adherence and promoting overall well-being. Continuous monitoring and adjustments to exercise routines, along with consideration of environmental factors and individual responses, are essential components of a successful fitness journey.

Table 1: Progressive Decline in VO_2 Max Over Seven Months

Months	VO2 Max (ml/kg/min)
April 2023	43
May 2023	43
June 2023	42
July 2023	41
August 2023	40
September 2023	39
October	38

Acknowledgments

This case study was conducted without external funding or support. The author is solely responsible for the design, data collection, analysis, and interpretation of the findings. Sincere appreciation is extended to the client for their invaluable contribution to this research.

References

1. António J, Kalman D, Stout JR, Greenwood M, Willoughby DS, Haff GG. Cardiovascular and pulmonary responses to exercise. In: Humana Press eBooks. Totowa, NJ: Humana Press; 2009. p. 56. DOI:10.1007/978-1-59745-302-8_4
2. Elsawy B, Higgins KE. Physical activity guidelines for older adults. American Family Physician. 2010;81(1):55.
3. Iswahyudi N, Fajar MK, Sugeng I, Derana GT. Latihan circuit training terhadap peningkatan daya tahan aerobik (VO_2 max). Altius Jurnal Ilmu Olahraga dan Kesehatan. 2020;9(2):61. DOI:10.36706/altius.v9i2.12862
4. Izquierdo M, Morley JE, Lucía A. Exercise in people over 85. BMJ. 2020; DOI:10.1136/bmj.m402
5. Laury D, Tehrany AM. VO_2 max improvement of 96% in a non-elite recreational athlete over 24 months. Surgery Journal. 2019;5(1). DOI:10.1055/s-0039-1688438
6. Leak RK, Calabrese EJ, Kozumbo WJ, Gidday JM, Johnson TE, Mitchell JR, *et al*. Enhancing and extending biological performance and resilience. Dose-Response. 2018;16(3). DOI:10.1177/1559325818784501

7. Lestari KDP, Wahyuni N, Nugraha MHS, Tianing NW. Hubungan indeks massa tubuh, persentase lemak total tubuh dan aktivitas fisik terhadap tingkat volume oksigen maksimal pada remaja putri di Denpasar Selatan. Majalah Ilmiah Fisioterapi Indonesia. 2020;8(1):49. DOI:10.24843/mifi.2020.v08.i01.p11
8. Maglioni S, Mello DF, Schiavi A, Meyer JN, Ventura N. Mitochondrial bioenergetic changes during development as an indicator of *C. elegans* health-span. Aging. 2019;11(16):6535. DOI:10.18632/aging.102208
9. Milanović Z, Sporiš G, Weston M. Effectiveness of high-intensity interval training (HIT) and continuous endurance training for VO_2max improvements: A systematic review and meta-analysis of controlled trials. Sports Medicine. 2015;45(10):1469. DOI:10.1007/s40279-015-0365-0
10. Morehouse L, Miller AT, Horvath SM. Physiology of exercise. Medicine & Science in Sports & Exercise. 1972;4(3):127. DOI:10.1249/00005768-197200430-00004
11. Novák J, Zeman V, Matoulek M, Topolčan O, Svobodová Š, Ráček J, *et al*. Optimalization of recovery, regeneration and rehabilitation. EPMA Journal. 2014;5. DOI:10.1186/1878-5085-5-s1-a152
12. Ranković G, Mutavdžić V, Toskić D, Preljević A, Kocić M, Nedin-Ranković G, *et al*. Aerobic capacity as an indicator in different kinds of sports. Bosnian Journal of Basic Medical Sciences. 2010;10(1):44. DOI:10.17305/bjbms.2010.2734
13. Ruegsegger GN, Booth FW. Health benefits of exercise. Cold Spring Harbor Perspectives in Medicine. 2017;8(7). DOI:10.1101/cshperspect.a029694
14. Short KR, Bigelow ML, Kahl J, Singh R, Coenen-Schimke JM, Raghavakaimal S, *et al*. Decline in skeletal muscle mitochondrial function with aging in humans. Proceedings of the National Academy of Sciences. 2005;102(15):5618. DOI:10.1073/pnas.0501559102
15. Smirmaul BPC, Bertucci DR, Teixeira IP. Is the VO_2max that we measure really maximal? Frontiers in Physiology. 2013;4. DOI:10.3389/fphys.2013.00203