

A monodisciplinary approach to study running performance: a bibliometric analysis

Mabligny Thuany¹ , Thayse Natacha Gomes² , Beat Knechtle^{3,4} , Katja Weiss⁴ , Kevin Kipchumba⁵, Ramiro Rolim¹ , Marcos André Moura dos Santos^{6,7} 

¹Universidade do Porto, Faculdade de Desporto, Porto, Portugal; ²Universidade Federal de Sergipe, Departamento de Educação Física, São Cristóvão, SE, Brasil; ³Medbase St. Gallen Am Vadianplatz, St. Gallen, Switzerland; ⁴University of Zurich, Institute of Primary Care, Zurich, Switzerland; ⁵Kenyatta University, Department of Physical Education, Exercise and Sports Science, Nairobi, Kenya; ⁶Universidade de Pernambuco, Recife, PE, Brasil; ⁷Universidade Federal da Paraíba, João Pessoa, PB, Brasil.

Associate Editor: Paulo Henrique Guerra , Universidade Estadual Paulista “Júlio de Mesquita Filho”, Instituto de Biociências, Departamento de Educação Física, Rio Claro, SP, Brazil. E-mail: paulo.guerra@unesp.br.

Abstract - Background: The toolkits of bibliometrics analysis enable the mapping and identification of trends within a given research area. This study aims to conduct a bibliometric analysis to identify the evolution of the “running performance” research field, focusing on publication characteristics and trends. **Methods:** We conducted a search for original articles, using the “advanced search” feature of Web of Science Core Collection (WoSCC). A predefined search strategy was developed using the PICO strategy. Studies were screened by titles and abstracts. The information was used to map authors, organisations, countries, journals, and authors’ keywords. VOSviewer software (version 1.6.18) was used to construct and visualise bibliometric networks. **Results:** A total of 324 articles were included, with the publication data ranging from 1983 to 2023, with some variation over time. The United States and Canada presented the strongest influence in this research field, followed by European countries such as England, France, Switzerland, and Spain. The leading journals were the International Journal of Sports Medicine, followed by the Journal of Strength and Conditioning Research, and Medicine and Science in Sports and Exercise. Temporal trends indicated that the earlier studies primarily focused on physiological tests/variables, while more recent studies have shown a growing interest in biomechanics, pacing, and technology (footwear). **Conclusion:** North America and European countries present a strong influence in this field of study. Earlier investigations primarily focused on physiological tests/variables, while recent research has focused on diverse topics such as technology (footwear). Researchers interested in this research area should consider adopting a multidisciplinary approach in future studies.

Keywords: endurance, exercise, bibliometric analysis.

Introduction

Endurance running has played a significant role in human evolution¹. Nowadays, running is no longer a survival strategy, but the number of runners has risen over the last 20 years^{2,3}. This increase has been observed among both non-professional runners⁴ and elite athletes who break records and reach the highest human performance level^{5,6}. The popularity of running events has been related to the monetary prizes and awards distributed for professional athletes competing over continents, changes in women's participation rules, and challenges associated with endurance

events participation⁷. In parallel, new events, products⁸, and technologies have been developed to meet the demands of this phenomenon^{9,10}.

Simultaneously, the search for improving training methods, technologies, and evidence-based training has increased among researchers^{11,12}. For example, a search using the words ‘marathon’ and ‘running performance’ in the PubMed database showed a visual linear increase in the number of studies over time. These studies cover a wide range of topics, frequently related to the understanding of performance predictors^{11,13,14}, been covered from different perspectives. A recent narrative review highlighted that

performance in both short- (i.e., 5 km and 10 km) and long-distance events (i.e., half-marathon and marathon) is determined by morphological variables, training characteristics, and physiological factors¹³, with the relative importance of these variables varying according to the race distance. Also, genes associated with marathoners' performance were studied among African runners¹⁵, as well as summarised in a systematic review^{16,17}. The importance of maximal oxygen uptake (VO₂max), lactate threshold, running economy, and oxygen uptake kinetics^{18,19} for runners' performance is also well established in previous literature.

Beyond understanding the factors associated with performance in runners, pacing strategies adopted during events ranging from 5 km to the marathon have been explored²⁰⁻²³. Also, researchers have investigated the influence of weather on athletes' performance competing in the major marathon events²⁴⁻²⁸, monetary and extrinsic factors related to the motivation to compete, and the psychological characteristics related to runners' motivation²⁹⁻³¹. The compiled findings highlight performance in runners as a complex phenomenon, influenced by different factors that include both individual characteristics and its interaction with the environment.

Despite the range of topics covered in the scientific literature, no information is available regarding the emerging hot topics, leading authors/countries, and research trends within this field of study. Understanding the background and being able to identify future trends is crucial for advancing the field of study, especially for early-career researchers. Among the different research strategies to map a scientific field, bibliometric analysis has increased over the last few years^{32,33}, and allows identifying research topics, main journals, authors, and countries in which research has been developed³⁴⁻³⁶. Therefore, this study aims to conduct a bibliometric analysis to identify the evolution of the "running performance" research field, focusing on publication characteristics and global research trends.

Methods

Bibliometric data source and acquisition process

Bibliometric analysis is an approach used to map scientific fields and production, and evaluate their quality, impact, and time trends³². During August/2022, we performed a search of original articles, using the "advanced search" of Web of Science 65 Core Collection (WoSCC). Among the scientific databases available for the study of global trends and research hotspots, we selected the WoSCC database due to its extensive collection, especially in the field of sports science³³.

Search strategy and eligibility criteria

A predefined search strategy was developed for trials. We used the PICO strategy to refine the search strategy (Table 1), combining terms using the Boolean operators "OR", "AND", and "NOT". The first equation used was "((Runners) NOT (Ultramarat* OR swim* OR cyclists OR animal))", considering the topic (the title, abstract, or key words) as a filter. Following, we added the second equation "((Running OR "Long-distance running" OR marathon OR half-marathon OR 5km OR 10km) NOT (Soccer OR football OR cycling OR swimming OR triathlon OR Rowing))", combined by the Boolean operator "AND". Thirdly, we searched for "Performance OR prediction" NOT "team analysis" OR "match analysis" in titles. All records retrieved by the search query were imported into EndNote X7 (Thompson Reuters, Carlsbad, CA, USA), exporting complete information.

Eligibility criteria

Inclusion criteria comprised original articles published in English, in peer-reviewed journals, using both qualitative and quantitative approaches. Studies developed with untrained subjects, ultramarathons, cross-country events, and skiers were excluded. Studies assessing the effect of running in specific out-

Table 1 - PICO strategy to search and eligibility criteria.

Terms	Inclusion	Exclusion
P Runners; Ultramarat*; swim*; cyclists; animal	Runners competing in half-marathon or marathon distances	Ultramarathoners (> 42.195 km or > 6 hours durations); swimmers; cyclists; animal studies
I Running; Long-distance running; marathon; half-marathon; 5 km; 10 km; soccer; football; cycling; swimming; triathlon; rowing	Studies report running as the main activity, including marathons; half-marathons; 5 km; 10 km	Not assessing endurance running outcomes (e.g., soccer; football; cycling; swimming; triathlon; Rowing)
C No applied	No applied	Not applied
O Performance; prediction; team analysis; match analysis	Studies reporting performance/performance prediction or associated factors; prediction	Studies performed in the context of sports clubs

comes, investigating time-limited events, trail runs, and simulated races were not considered.

Study selection and data extraction strategy

Titles and abstracts of potentially relevant papers were screened, and those selected were screened independently in full text by two reviewers (MT, TNG). When discrepancies arose, they were solved by discussion.

Data analysis

Descriptive information was presented in absolute and relative frequencies (%). To assess trends of the number of studies over time, we estimated a one-equation model. Based on the r^2 values of the different equations created (i.e., linear model, polynomial), the trend was best explained by a polynomial line, since some fluctuations in the number of studies were shown over the years. For the bibliometric analysis, we considered the authors' names, organizations (top 10), and countries, the authors' keywords, and the leading journals used to report the results. For all analyses, the threshold considered to be included in the final report was at least five. When possible, information was clustered by association (links between documents), and colours were indicated. Information regarding countries was presented considering the entire period and stratified into the following intervals: 1953-1989; 1990-2010, and 2011-2023. VOSviewer software

(version 1.6.18) was used to construct and visualize bibliometric networks.

Results

A total of 564 original studies were identified from the WoSCC. A total of 240 studies were excluded based on title and abstract screening. The studies sampled different target populations (e.g., untrained subjects, ultramarathoners), assessed the effects of running on health outcomes, used different running events, simulated races, sky, or cross-country running, or were not original studies. A total of 324 studies were included in this bibliometric review. The publication data ranged from 1983 ($n = 1$) to 2023 ($n = 9$). Since 1990, the number of studies published has grown across the years, indicating a trend of increasing (Figure 1). The highest number of published studies was shown in 2021 ($n = 36$). A polynomial trend line was the best adjustment for the data ($r^2 = 60\%$).

Table 2 shows the top 10 organizations in which the running performance predictors have been studied, based on the total of documents and a minimum occurrence of five. A total of 509 organizations were listed. The University of Zurich ($n = 10$), the University of Cape Town ($n = 9$), the James Cook University ($n = 7$), and the University of Zaragoza ($n = 7$) were the top three organizations, representing 42.30% of the publications among the top 10 organizations. Figure 2 presents the leading authors in the field. Authors posi-

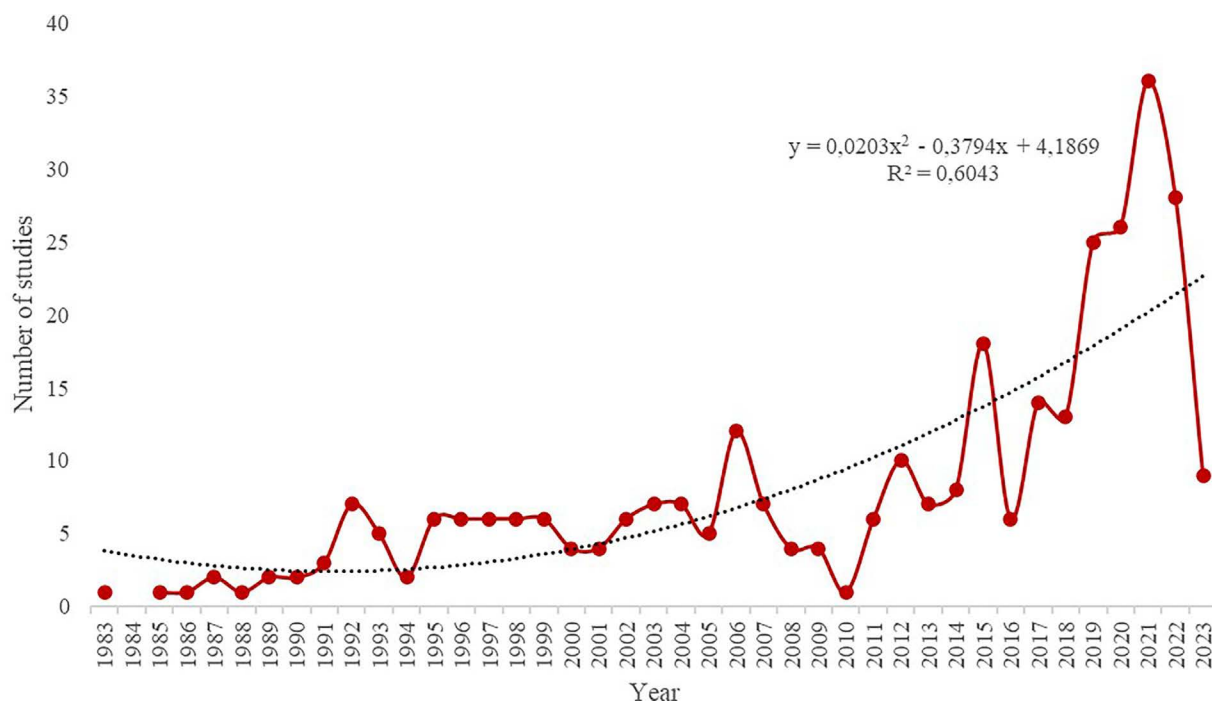
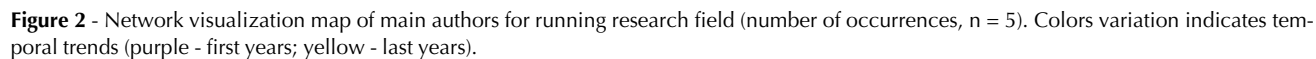


Figure 1 - Number of publications by year.

Ranking	Organization	Total of documents	Total of citations	Country
1st	University Zurich	10	116	Switzerland
2nd	University Cape Town	9	670	South Africa
3rd	James Cook University	7	142	Australia
4th	University of Zaragoza	7	219	Spain
5th	Australian Institute of Sport	6	79	Australia
6th	University of the Basque Country	6	104	Spain
7th	State University of Maringá	6	27	Brazil
8th	University of Jyväskylä	6	196	Finland
9th	University of Porto	6	57	Portugal
10th	Ritsumeikan University	5	33	Japan



tioned in the centre of the network present a significant influence, acting as connectors between different researchers.

Of the total of 51 countries, a total of 22 countries, with at least five documents, were presented in Figure 3. The North American countries (i.e., the United States and Canada) presented the highest influence in this field of study, followed by European countries, such as England, France, Switzerland, and Spain. Countries tend to be clustered based on geographical distribution. Data were stratified into three periods (1953-1989; 1990-2010, 2011-2023). Across all periods, the United States led in the number of published documents. The United States and England are the leading countries among the top five, throughout the stratification. Over time, the number of countries with published documents has increased. Brazil appears in the top five only in the 201-2023 period, while no African countries were shown during this frame.

Table 3 presents the leading scientific journals. With a total of 27 published papers, the International Journal of Sports Medicine was the first, followed by the Journal of Strength and Conditioning Research ($n = 22$), and Medicine and Science in Sports and Exercise ($n = 18$).

The most cited journals were the *Journal of Applied Physiology* ($n = 1743$), *Medicine and Science in Sports and Exercise* ($n = 1048$), *International Journal of Sports Medicine* ($n = 745$), *Journal of Sports Sciences* ($n = 700$), and *European Journal of Applied Physiology and Occupational Physiology* ($n = 623$), respectively. The authors' keywords are presented in Figure 4. A total of 752 authors' keywords were identified, with 41 meeting the threshold of appearing at least five times. The most frequently used words were "exercise", "running", "performance", "endurance", and "fatigue". The temporal trends (2006 - blue colours to 2014 - yellow colours) indicate a shift in

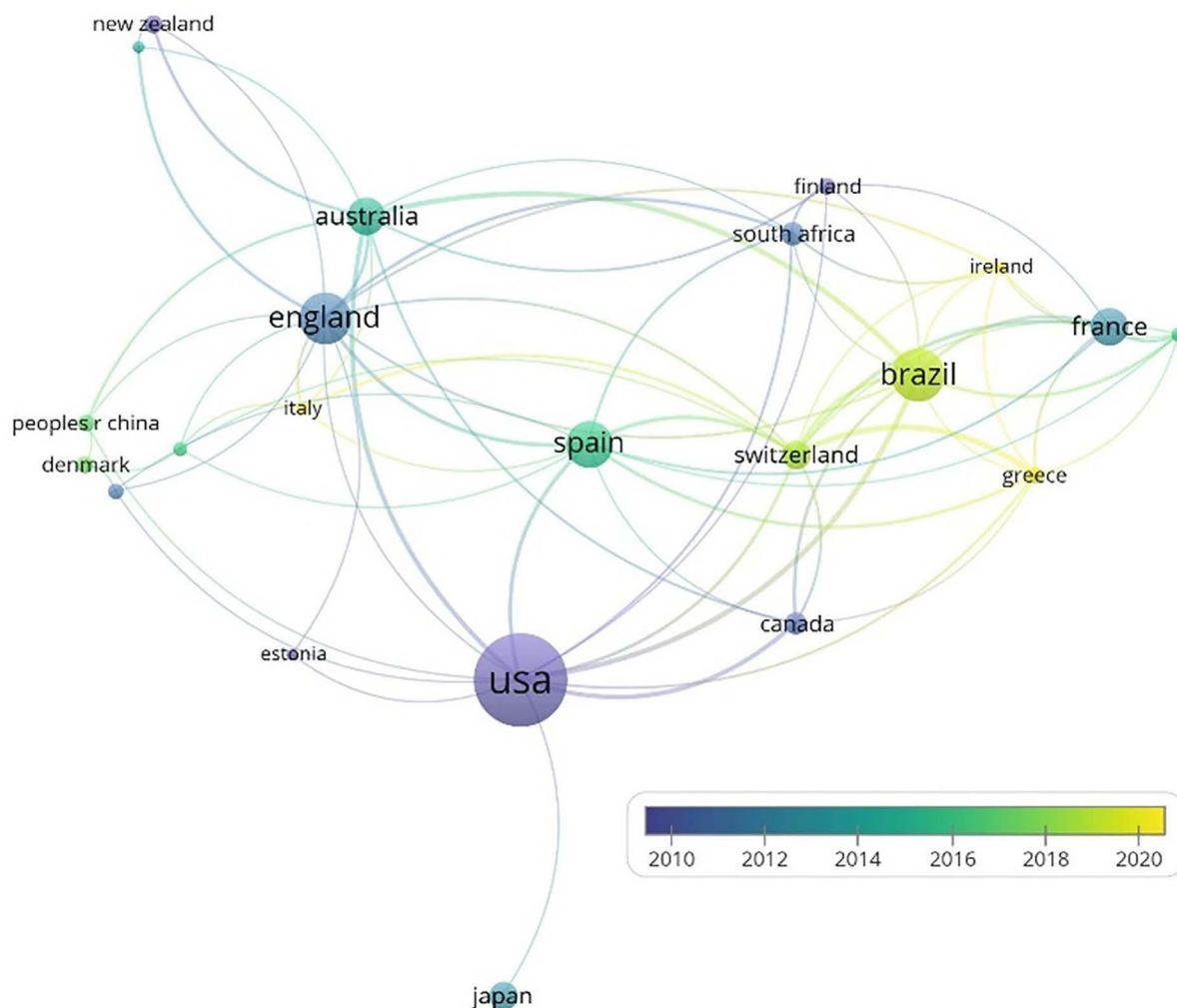


Figure 3 - Countries' distribution over time (number of occurrences, $n = 5$).

Table 3 - Top 20 scientific journals publishing about running performance predictors (number of occurrences, $n \geq 5$).

Ranking	Journal name	Total of documents
1 st	International Journal of Sports Medicine	27
2 nd	Journal of Strength and Conditioning Research	22
3 rd	Medicine and Science in Sports and Exercise	18
4 th	Journal of Sports Sciences	16
5 th	International Journal of Sports Physiology and Performance	14
6 th	Journal of Applied Physiology	14
7 th	International Journal of Environmental Research and Public Health	13
8 th	Journal of Sports Medicine and Physical Fitness	11
9 th	European Journal of Applied Physiology and Occupational Physiology	10
10 th	Frontiers in Physiology	10
11 th	Plos One	7
12 th	International Journal of Sport Nutrition and Exercise Metabolism	6
13 th	Journal of Science and Medicine in Sport	6
14 th	Research Quarterly for Exercise and Sport	6
15 th	Sport Sciences for Health	6
16 th	Applied Physiology Nutrition and Metabolism	5
17 th	European Journal of Applied Physiology	5
18 th	Journal of Human Kinetics	5
19 th	Nutrients	5
20 th	Scandinavian Journal of Medicine & Science in Sports	5

research focus. Earlier studies were centred on physiological tests/variables (e.g., lactate threshold, $\text{VO}_{2\text{max}}$, ventilatory threshold), while more recent studies have shown a trend to include investigation of biomechanics, pacing, and technology (footwear). Most of the keywords highlight the individual-centred approach in endurance running studies.

Discussion

Analyzing the trend in a field of study is challenging, and understanding the development of a field of study implicates a broad and contextual approach, considering historical background, economic development, research paradigms, and technological advances. This study used a bibliometric analysis to identify the evolution of the “running performance”

research field, focusing on publication characteristics and temporal trends. The main findings showed fluctuations in the number of studies over time; the field was firstly influenced by North American and European countries; and most of the keywords used by researchers highlighted the individual-centered approach in endurance running studies.

Laboratory testing of endurance athletes dates back at least 100 years of history, and North American and European countries made important contributions to this development. In 1955, one of the most important research studies in the field of exercise physiology was published in the *Journal of Applied Physiology* by USA researchers, and this study has provided an important base for subsequent researches³⁷. The mentioned journal ranked in the 4th position among the leading scientific journals, with a total of 422 documents, and held the 2nd position in the total of citations.

Similarly, the interest in “fatigue” research is also related to a pioneering study developed by Hill in 1925, which pointed out fatigue as an important factor for race speed³⁸. In this sense, the presence of North American (i.e., USA, Canada) and European countries (England) in the field is closely linked to the development of running and physiology laboratories over time. This influence created deep roots in the field, which can be observed through the keywords used in the studies, since most of them are related to the physiological/medical approach and highlight the focus on understanding running performance through an athlete-centred approach. This focus is related to the relationship between physiological indicators and athletes’ performance³⁹.

Based on the terms used by the authors (“fatigue”, “heart rate”, “oxygen consumption”, “running economy”, “training”) it suggests the maintenance of interest in understanding the physiological aspects of running performance, with recent years showing an increase in the number of words related to the biomechanics, technology, and shoes. The interest in covering these topics can be related to the advanced footwear technology introduced by Nike in 2016/2017. Since then, the number of studies related to the influence of shoes in athletic performance, movement patterns, and running records has increased.

Furthermore, the USA and England host four of the world's six major marathon events (Boston Marathon; Chicago Marathon; New York City Marathon; London Marathon), with the USA holding one of the oldest marathon events worldwide - the Boston Marathon. These factors can be related to the interest and the culture of running in these places, their influence on scientific research, and technological development, which also allows laboratories to investigate emerging



This study is not free of limitations. Our approach presents insights into the field of running performance predictors; however, it was not purposed to present an exhaustive and historical perspective of the field. First, we only used the WSCC database to search. Second, we presented a general analysis of the field and did not provide information about the development of the field in specific countries, which could have indicated study trends considering geographical distribution. Also, we did not stratify the results based on the sam-

In another way, to the best of the author's knowledge, this is the first study to present a bibliometric analysis in this field of study. Results have the potential to guide the next years of research. Moreover, early career researchers interested in studying running performance are encouraged to advance the field by exploring topics beyond those usually covered in the scientific literature. This can be achieved through the integration of disciplines (such as psychology, biomechanics, and technology), which could provide additional research questions. Finally, international collaboration could further drive progress and allow the sharing of expertise among researchers of different fields and varying levels of experience. It can foster innovative approaches, provide mentorship opportunities for early-career researchers, and facilitate the development of com-

prehensive solutions to complex questions in the field of running performance.

Conclusion

The hot topics derived from the authors' keywords suggest an interest in physiological (running economy, maximum oxygen uptake, anaerobic threshold, fatigue) and biomechanical factors (kinetics, gait analysis). Most recently, words that highlight the interest in technological aspects (footwear, technique, minimalist) can be explained by the shoes' technological development in recent years. North American and European countries present a high influence in this field of study. These findings highlight the predominance of a monodisciplinary approach used in studies investigating endurance sports and underline the need to move the field through a multidisciplinary approach.

AI use statement

No AI was used in this research.

Author contributions (CRediT)

Mabliny Thuany: conceptualisation, investigation: methodology, writing - original draft, writing - review and editing, visualisation. **Thayse Natacha Gomes:** methodology, writing - review and editing. **Beat Knechtle:** writing - review and editing. **Katja Weiss:** writing - review and editing. **Kevin Kipchumba:** writing - review and editing. **Ramiro Rolim:** writing - review and editing. **Marcos André Moura dos Santos:** methodology, writing - review and editing.

Funding

Mabliny Thuany was founded by the Fundação para a Ciência e Tecnologia, 2023.04886.BD.

Data availability statement

The research data is available by request the first author.

Conflict of interest statement

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

References

1. Bramble D, Lieberman D. Endurance running and the evolution of Homo. *Nature*. 2004;432(7015):345-52. [doi](#)
2. Vitti A, Nikolaidis P, Villiger E, Onywera V, Knechtle B. The "New York City Marathon": participation and performance trends of 1.2M runners during half-century. *Res Sports Med*. 2019;28(1):121-37. [doi](#)
3. Nikolaidis P, Zingg M, Knechtle B. Performance trends in age-group runners from 100 m to marathon. *The World Championships from 1975 to 2015*. *Scand J Med Sci Sports*. 2017;27(12):1588-96. [doi](#)
4. Hulteen R, Smith J, Morgan P, Barnett L, Hallal P, Colyvas K et al. Global participation in sport and leisure-time physical activities: a systematic review and meta-analysis. *Prev Med*. 2017;95:14-25. [doi](#)
5. Snyder K, Hoogkamer W, Triska C, Taboga P, Arellano CJ, Kram R. Effects of course design (curves and elevation undulations) on marathon running performance: a comparison of Breaking 2 in Monza and the INEOS 1:59 Challenge in Vienna. *J Sports Sci*. 2021;39(7):754-9. [doi](#)
6. Billat V, Vitiello D, Palacin F, Correa M, Pycke JR. Race analysis of the world's best female and male marathon runners. *Int J Environ Res Public Health*. 2020;17(4). [doi](#)
7. Lieberman D, Bramble D. The evolution of marathon running: capabilities in humans. *Sports Med*. 2007;37(4-5):288-90. [doi](#)
8. Quealy K, Katz J. Nike says its \$250 running shoes will make you run much faster. What if that's actually true? *The New York Times*. 2018 Jul 18. Available from: <https://www.nytimes.com/interactive/2018/07/18/upshot/nike-vaporfly-shoe-strava.html>
9. Senefeld J, Haischer M, Jones A, Wiggins C, Beilfuss R, Joyner M et al. Technological advances in elite marathon performance. *J Appl Physiol*. 2021;130(6):2002-8. [doi](#)
10. Santos-Concejero J, González-Mohino Fernando, González-Ravé JM. Commentaries on viewpoint: physiology and fast marathons. *J Appl Physiol*. 2020;128(4):1069-85. [doi](#)
11. Doherty C, Keogh A, Davenport J, Lawlor A, Smyth B, Caulfield B. An evaluation of the training determinants of marathon performance: a meta-analysis with meta-regression. *J Sci Med Sport*. 2020;23(2):182-8. [doi](#)
12. Casado A, González-Mohino F, González-Ravé J, Foster C. Training periodization, methods, intensity distribution, and volume in highly trained and elite distance runners: a systematic review. *Int J Sports Physiol Perform*. 2022;17(6):820-33. [doi](#)
13. Alvero-Cruz J, Carnero E, García M, Alacid F, Correias-Gómez L, Rosemann T et al. Predictive performance models in long-distance runners: a narrative review. *Int J Environ Res Public Health*. 2020;17(21):8289 [doi](#)
14. Christou G, Pagourelas E, Deligiannis A, Kouidi E. Exploring the anthropometric, cardiorespiratory, and haematological determinants of marathon performance. *Front Physiol*. 2021;12:693733. [doi](#)
15. Zani A, Gouveia M, Aquino M, Quevedo R, Menezes R, Rotimi C et al. Genetic differentiation in East African ethnicities and its relationship with endurance running success. *PLoS One*. 2022;17(5):e0265625. [doi](#)
16. Coso J, Moreno V, Gutiérrez-Hellín J, Baltazar-Martins G, Ruíz-Moreno C, Aguilar-Navarro M et al. ACTN3

- R577X genotype and exercise phenotypes in recreational marathon runners. *Genes*. 2019;10(6):413. [doi](#)
17. Moir H, Kemp R, Folkerts D, Spendiff O, Pavlidis C, Opara E. Genes and elite marathon running performance: a systematic review. *J Sports Sci Med*. 2019;18(3):559-68.
 18. Joyner M. Physiological limits to endurance exercise performance: influence of sex. *J Physiol*. 2017;595(9):2949-54. [doi](#)
 19. Joyner M, Coyle E. Endurance exercise performance: the physiology of champions. *J Physiol*. 2008;586(1):35-44. [doi](#)
 20. Casado A, Hanley B, Jimenez-Reyes P, Renfree A. Pacing profiles and tactical behaviors of elite runners. *J Sport Health Sci*. 2020;10(5):537-49. [doi](#)
 21. Nikolaidis P, Knechtle B. Effect of age and performance on pacing of marathon runners. *Open Access J Sports Med*. 2017;8:171-80. [doi](#)
 22. Deaner R, Addona V, Carter R, Joyner M, Hunter S. Fast men slow more than fast women in a 10 kilometer road race. *PeerJ*. 2016;4:e2235. [doi](#)
 23. Renfree A, Gibson A. Influence of different performance levels on pacing strategy during the women's World Championship marathon race. *Int J Sports Physiol Perform*. 2013;8(3):279-85. [doi](#)
 24. Weiss K, Valero D, Villiger E, Thuany M, Scheer V, Cuk I et al. Temperature and barometric pressure are related to running speed and pacing of the fastest runners in the Berlin Marathon. *Eur Rev Med Pharmacol Sci*. 2022;26(12):4177-87. [doi](#)
 25. Knechtle B, Valero D, Villiger E, Alvero-Cruz J, Nikolaidis P, Cuk I et al. Trends in weather conditions and performance by age groups over the history of the Berlin Marathon. *Front Physiol*. 2021;12:654544. [doi](#)
 26. Knechtle B, Valero D, Villiger E, Alvero-Cruz J, Nikolaidis P, Cuk I et al. Elite marathoners run faster with increasing temperatures in Berlin Marathon. *Front Physiol*. 2021;12:649898. [doi](#)
 27. Nikolaidis P, Di Gangi S, Chtourou H, Rüst C, Rosemann T, Knechtle B. The role of environmental conditions on marathon running performance in men competing in Boston Marathon from 1897 to 2018. *Int J Environ Res Public Health*. 2019;16(4):614. [doi](#)
 28. Helou N, Tafflet M, Berthelot G, Tolaini J, Marc A, Guillaume M et al. Impact of environmental parameters on marathon running performance. *PLoS One*. 2012;7(5):e37407. [doi](#)
 29. Thuany M, Vieira D, Scheer V, Ouerghi N, Chalabaev A, Nikolaidis P et al. Fear of failure in Brazilian runners. *Res Sports Med*. 2022;32(2):290-01. [doi](#)
 30. Pereira H, Palmeira AL, Encantado J, Marques M, Santos I, Carraa E et al. Systematic review of psychological and behavioral correlates of recreational running. *Front Psychol*. 2021;12:624783. [doi](#)
 31. Leon-Guereno P, Tapia-Serrano M, Castaneda-Babarro A, Malchrowicz-Mosko E. Do sex, age, and marital status influence the motivations of amateur marathon runners? The Poznan Marathon case study. *Front Psychol*. 2020;(31)11:2151. [doi](#)
 32. Donthu N, Kumar S, Mukherjee D, Pandey N, Lim WM. How to conduct a bibliometric analysis: an overview and guidelines. *J Bus Res*. 2021;133:285-96. [doi](#)
 33. Mongeon P, Paul-Hus A. The journal coverage of Web of Science and Scopus: a comparative analysis. *Scientometrics*. 2016;106(1):213-28. [doi](#)
 34. Jenkins A, Pollock J, Moore M, Makovicka J, Brinkman J, Chhabra A. The 100 most-cited and influential articles in collegiate athletics. *Orthop J Sports Med*. 2022;10(7):23259671221108401. [doi](#)
 35. Qin Y, Li M, Han J, Cui G, Du W, Yang K. Research hotspots and trends of kinesio taping from 2011 to 2020: a bibliometric analysis. *Environ Sci Pollut Res Int*. 2022;30(2):2029-41. [doi](#)
 36. Singh N. The top 100 most-cited publications in musculoskeletal rehabilitation: a bibliometric analysis. *Indian J Orthop*. 2022;56(8):1327-38. [doi](#)
 37. Taylor H, Buskirk E, Henschel A. Maximal oxygen intake as an objective measure of cardio-respiratory performance. *J Appl Physiol*. 1955;8(1):73-80. [doi](#)
 38. Hill A. The physiological basis of athletic records. *Lancet*. 1925;206(5323):481-6. [doi](#)
 39. Robinson S, Edwards H, Dill D. New records in human power. *Science*. 1937;85(2208):409-10. [doi](#)
 40. RunRepeat. Marathon statistics 2019 worldwide. Available from: <https://runrepeat.com/research-marathon-performance-across-nations>. Accessed 2020 Mar 7.
 41. Thuany M, Gomes T, Estevam L, Almeida M. Crescimento do número de corridas de rua e perfil dos participantes no Brasil. In: *Atividade física, esporte e saúde: temas emergentes*. Belém: RBF Editora; 2021.

Corresponding author

Mablíny Thuany. Universidade do Porto, Faculdade de Desporto, Porto, Portugal.
E-mail: mablínysantos@gmail.com.

Manuscript received on March 21, 2023

Manuscript accepted on December 27, 2024



Motriz. The Journal of Physical Education. UNESP. Rio Claro, SP, Brazil - eISSN: 1980-6574 - under a license Creative Commons - Version 4.0