

# Trends research of para-cycling: A bibliometric analysis

*Fadilah Umar*<sup>1\*</sup>, *Misbah Misbah*<sup>2</sup>, *Ulfa Fatahara Laras Fadian*<sup>1</sup>, and *Abdul Aziz Purnomo Shidiq*<sup>1</sup>

<sup>1</sup>Faculty of Sport, Universitas Sebelas Maret, 57126 Surakarta, Indonesia

<sup>2</sup>Faculty of Teacher Training and Education, Universitas Lambung Mangkurat, 70123 Banjarmasin, Indonesia

**Abstract.** This bibliometric analysis research aims to map research on para-cycling. Based on search results in the Scopus database with the keywords "para cycling" OR 'para-cycling', 47 documents were obtained. The visualization of the data using the VOSviewer. The number of publications increased in 2016-2018 and 2019-2021. The largest number of documents was published in 2021. Much research on this topic is published in Q1 journals, while Elsevier publishes many. The Netherlands, as the most productive country, has done a lot of research on this topic. Authors who publish many articles in this field are dominated by writers from Ireland, such as Clifford, E.; Mannion, P.; and Hajdukiewicz, M. Affiliates with the largest number of publications come from Belgium, such as Université de Liège and KU Leuven. Four clusters were obtained on this topic based on the VOS viewer visualization results. Research on this topic in the last two years included cyclist, race, muscle strength, physiology, and athletic performance. This study shows that research on this topic is still scarce and is expected to continue to grow in the coming years. This study can be used as a basis for further research on this topic.

## 1 Introduction

Para-cycling is a discipline in high-level competitive sports [1]. The Union Cycliste Internationale (UCI) oversees para-cycling and establishes classes depending on the cyclist's capability [2]. The third-largest Paralympic sport is para-cycling, which is managed by the International Cycling Federation. [3]. Para-cycling is the sport of utilizing bicycles, tandems, tricycles, and handbikes to compete the track and on the road by people with disabilities [4]. Competitors in para-cycling are categorized according to functional disability, so riders with neurological and locomotor disabilities compete against one another [5]. Objective Para-cycling classification aims to generate fair competition [6].

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\* Corresponding author: [fadilahumar@staff.uns.ac.id](mailto:fadilahumar@staff.uns.ac.id)

However, discussion about para-cycling is still limited. Some only research on aspects of epidemiological data regarding the injuries it causes [1], a para-cycling classification system [7], and sports nutrition [8]. No one has yet conducted a comprehensive analytical review of para-cycling.

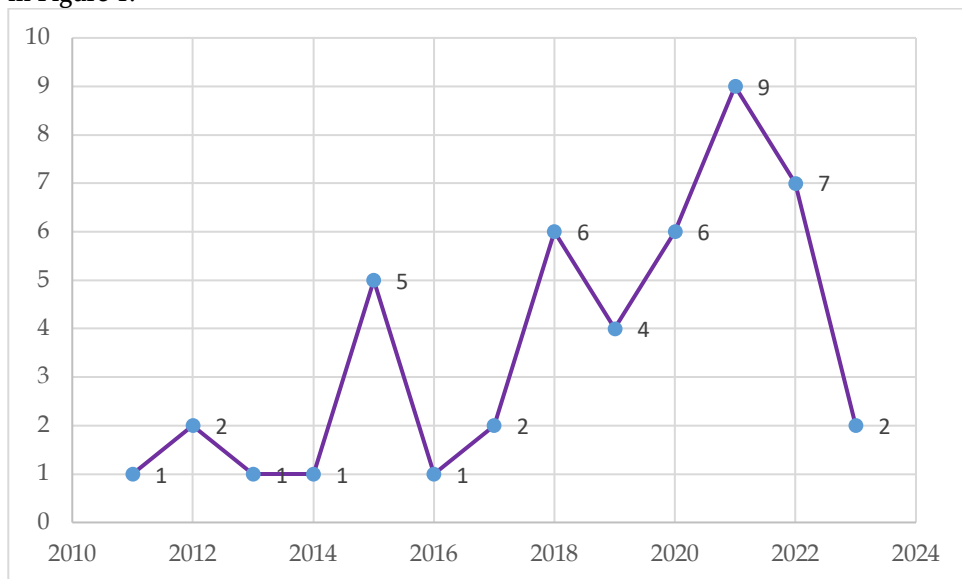
Therefore, to get a comprehensive picture of para-cycling, a bibliometric analysis was carried out based on research that has been published in the Scopus database. This bibliometric analysis research aims to map research on para-cycling from 2011-2023\*. The research questions are as follows: (1) What is the trend in the number of para-cycling publications from 2011-2023\*? (2) Which top ten journals publish the most articles about para-cycling?, (3) Which top ten countries do the most? Who published articles on para-cycling? (4) Who are the top ten authors on this topic in terms of the number of citations and the number of documents?, (5) Which top ten affiliates published articles on para-cycling?, and (6) How are the visual network and overlay of this para-cycling topic based on co-occurrence?

## 2 Methods

This study is a bibliometric analysis [9]. The reference search was conducted on August 21, 2023, and obtained 47 documents in the Scopus database using the keywords "para-cycling" OR "para-cycling". Based on the 47 documents obtained, consisting of 89% or 42 articles and 11% or five reviews. Then, the data is saved in CSV form, and analysis and visualization are carried out using VOSviewer.

## 3 Results and discussion

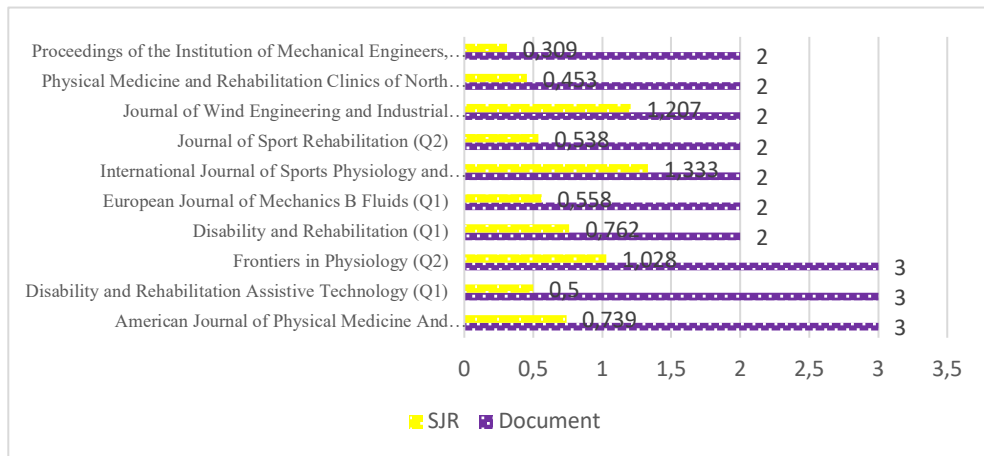
The following number of publications each year on the topic of para-cycling is presented in Figure 1.



**Fig. 1.** Number of publications on para-cycling per year.

Figure 1 shows increased publications in 2016-2018 and 2019-2021. The highest number of documents was published in 2021. This is in line with studies in the discipline of Adaptive Physical Education, which also experiences an increase in publications yearly [10]. The number of publications on this topic will likely increase because there is little research discussing para-cycling. This has the opportunity to be researched further and in-depth.

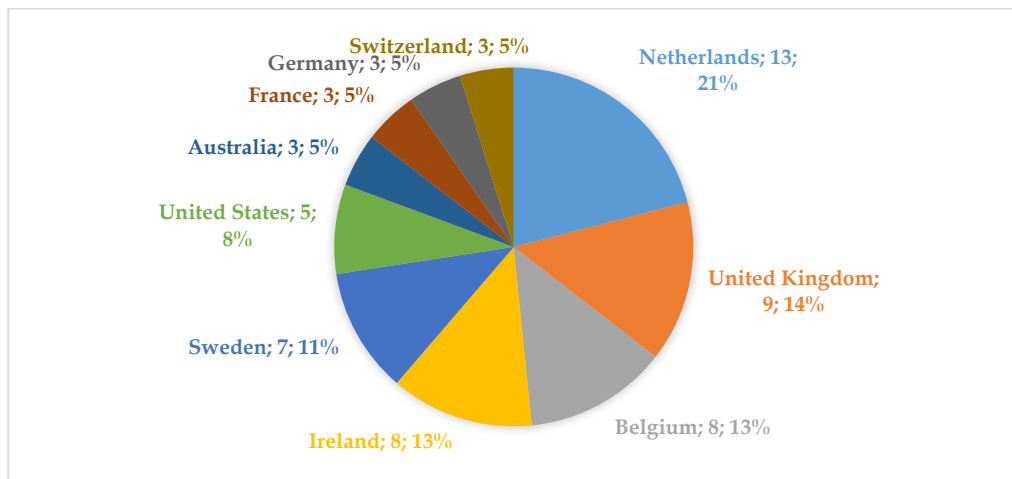
The top ten journals on para-cycling are listed in Figure 2.



**Fig. 2.** Top 10 journals that publish research on para-cycling.

Figure 2 shows that research on this topic is mostly published in Q1 journals, while most publishers are Elsevier. In three articles in the American Journal of Physical Medicine and Rehabilitation, para-cycling is discussed. One of the articles maps the effects of lower extremity diseases on para-cycling performance by examining the substantial correlation between isometric and dynamic strength with sprint power and race pace. Potential for para-cycling classification using MMT and its isometric and dynamic metrics [6]. As for the articles published by publisher Elsevier, one of them discusses aerodynamics in cycling science. This is important because aerodynamic clothing and equipment, athlete posture, and racing strategy utilize scientific aerodynamics knowledge [11].

Top ten countries publish considerably on para-cycling, as presented in Figure 3.



**Fig. 3.** Top ten countries publish considerable about para-cycling.

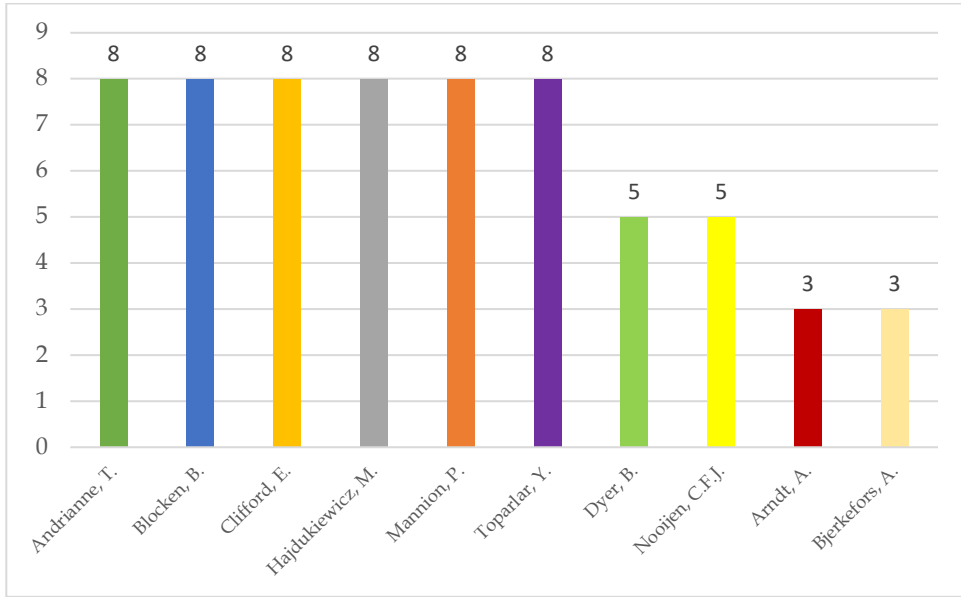
Figure 3 demonstrates that, according to numerous studies on this subject, the Netherlands is the most productive nation. Like crosswinds' effects in tandem aerodynamics studied by Mannion et al. [11]. When cyclists ride at a non-zero angle to the wind, crosswinds happen. Aerodynamic features associated with cyclists' leg rotation new light on flow structure and drag trends [11]. Effects of the torso angles of the pilot and stoker on the aerodynamics of tandem para-cycling [12]. Top ten authors in the field of para-cycling based on the numbers of citations are presented in Table 1.

**Table 1.** Top ten authors in the field of para-cycling based on the numbers of citations.

Authors	Q	Cited by	Publisher
West et al. [13]	Q1	31	Wiley-Blackwell
Mannion et al. [14]	Q2	26	Springer London
Krassioukov et al. [15]	Q1	24	Nature Publishing Group
Mannion et al. [16]	Q1	22	Elsevier B.V.
Mannion et al. [17]	Q1	20	Elsevier B.V.
Flueck [18]	Q2	18	Frontiers Media S.A.
Dyer [19]	Q2	17	SAGE Publications Inc.
Zeller et al. [20]	Q1	15	Rehabilitation Research and Development Service
Mannion et al. [11]	Q1	12	Elsevier Ltd
Stephenson [21]	Q1	12	Blackwell Munksgaard

Based on Table 1, it is found that the authors whose articles are widely cited come from international journals indexed by Scopus with the Q1 quartile [13], [15] and are dominated by the publisher Elsevier [11], [14], [22].

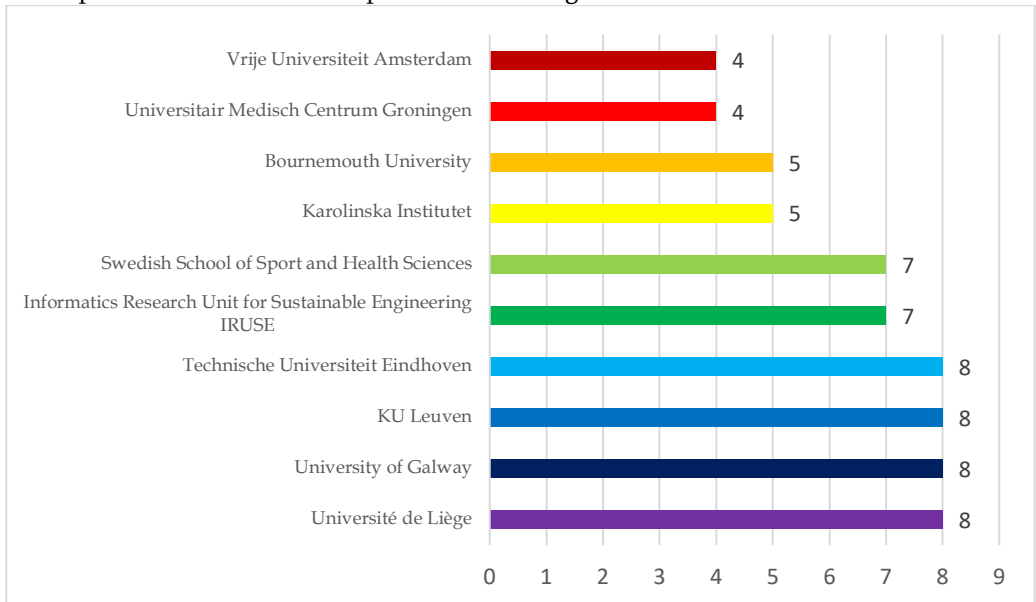
Top ten authors in the field of para-cycling based on the numbers of documents are presented in Figure 4.



**Fig. 4.** Top ten authors in the field of para-cycling based on the numbers of documents.

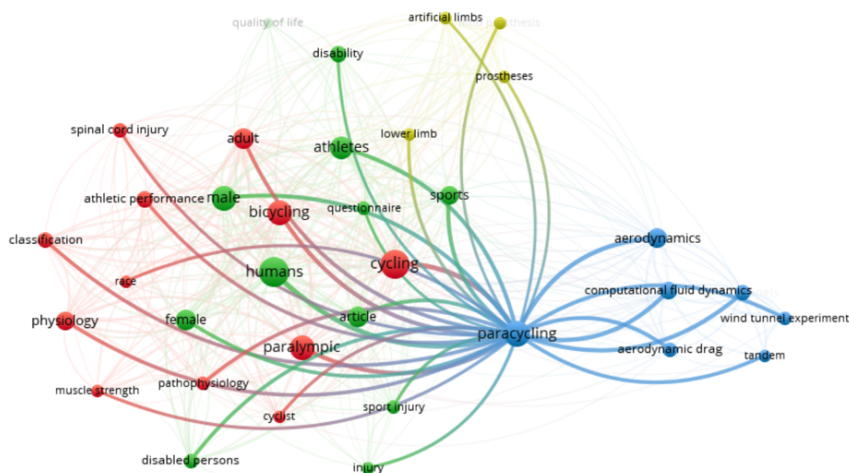
Figure 4 shows the top 6 authors with each 8 (eight documents) majority from Ireland, such as Clifford, E.; Mannion, P.; and Hajdukiewicz, M [14], [16], [17].

The top ten affiliations in this topic are listed in Figure 5.



**Fig. 5.** Top ten affiliation in this topic.

Figure 4 shows Affiliates with the largest number of publications coming from Belgium, such as Université de Liège and KU Leuven. One of the authors from KU Leuven is Mannion et al, who have done a lot of research in para-cycling [14], [16], [17]. The results of the network and overlay on para-cycling are presented in Figures 6 and 7.



**Fig. 6.** Network visualization for para-cycling.

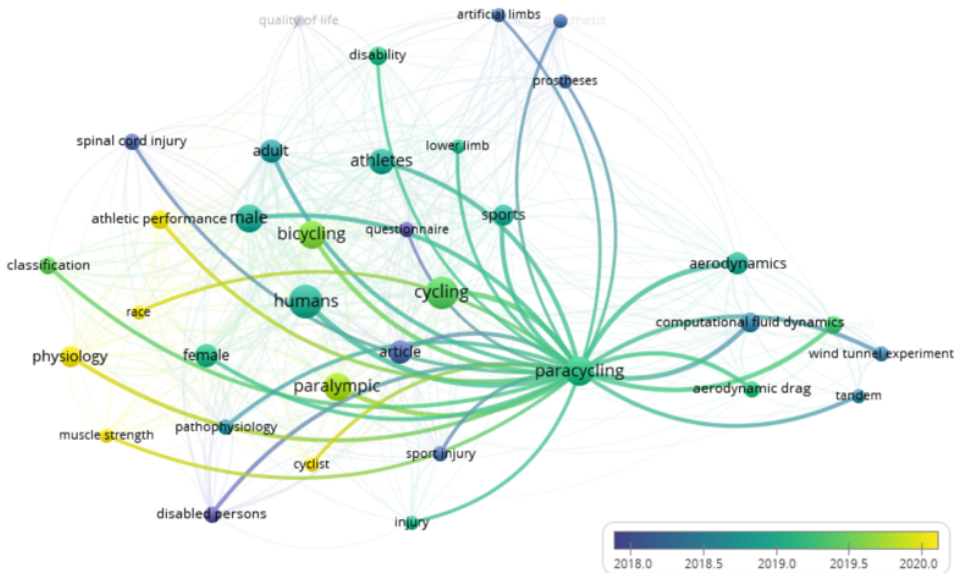
Figure 6 shows four clusters characterized by blue, red, green, and yellow. Each cluster shows the para-cycling article numbers shown in Table 2.

**Table 2.** Research development for each cluster.

No	Cluster	Number of Items	Keywords
1	Red	13	Adult, Athletic performance, bicycling, classification, cycling, cyclist, muscle strength, paralympic, pathophysiology, physiology, race, spinal cord injury
2	Green	12	Article, athletes, disability, disabled persons, female, humans, injury, male, quality of life, questionnaire, sport injury, sports
3	Blue	8	aerodynamic drag, aerodynamics, computational fluid dynamics, para-cycling, tandem, wind tunnel experiment, wind tunnels
4	Yellow	7	artificial limbs, limb prosthesis, lower limb, prostheses

There is cluster 1 discusses a lot about the Paralympic and classification in cycling, such as the identification of performance characteristics associated with the classification of visual impairment in para-cycling [23]. Cluster 2 discusses a lot about athletes, disabled persons, and injury. In recent years, the importance of standardized monitoring systems for injuries and illnesses in elite athletes has been emphasized. Although the training and competition load for athletes with disabilities is increasing, documentation regarding their injuries and illnesses remains scant [24]. Cluster three discusses a lot about the-

cycling, tandem, dan aerodynamics. Trajectory measurements, wind tunnel tests, and numerical models using computational fluid dynamics can be used to examine tandem aerodynamics [14]. Cluster 4 discusses a lot about prostheses. Aerodynamic enhancement of cycling prostheses is now possible with the goal of enhancing para-cycling performance [25].



**Fig. 7.** Overlay visualization for para-cycling.

Figure 7 shows that the topic of para-cycling in the last 3 years is related to cyclists, race, muscle strength, physiology, and athletic performance. There were no differences between sprint power and road time trial performance across cyclists, based on impairment type or bike type. For those competing on a bicycle, tricycle, or hand cycle while lying down or kneeling, the sprint test may be useful for predicting or monitoring time trial performance [26]. Several studies looked at the performance of tricycles (class T) and bicycles (class C) at road race competitions held by the International Cycling Federation between 2011 and 2019 [27], as well as the performance of 427 cyclists who took part in the Championship in the 1 km tandem race. The Paralympics and World Para-cycling [23]. Based on the results of the analysis of the articles reviewed, there is still little research on para-cycling in Indonesia. This could be an opportunity to research para-cycling in Indonesia related to coaching para-cycling athletes, improving athletes' performance, etc.

## 4 Conclusions

Based on results and discussion, it can be concluded that there are four clusters were obtained on this topic based on the VOS viewer visualization results namely: (1) cluster 1 discussing a lot about Paralympic and classification in cycling; (2) cluster 2 discusses a lot about athletes, disabled persons, and injury; (3) cluster 3 discussing a lot about the-

cycling, tandem, dan aerodynamics; and (4) cluster 4 discussing a lot about prostheses. Research on this topic in the last two years included cyclist, race, muscle strength, physiology, and athletic performance. This study shows that research on this topic is still scarce and is expected to continue to grow in the coming years.

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