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Article

Digitalization in Trail Running: Digital Tools as Sustainable Outdoor Infrastructure

Orsolya Czeglédi ^{1,*} , Simon Beaucoustin ², Daniel Caballero-Julià ³  and Philippe Campillo ⁴

¹ Faculté des Sciences du Sport et de l'Éducation Physique (FSSEP), University of Lille, 59790 Ronchin, France

² Prosport Group, 80480 Pont-de-Metz, France; simon.beaucousin@gmail.com

³ Grupo MOVERE, Departamento de Didáctica de la Expresión Musical, Plástica y Corporal, Escuela de Magisterio de Zamora, University of Salamanca, 37008 Salamanca, Spain; dcaballero@usal.es

⁴ URePSSS Research Laboratory (Multidisciplinary Research Unit for Sport, Health, Society), University of Lille ULR 7369, 59000 Lille, France; philippe.campillo@univ-lille.fr

* Correspondence: orsolya.czegledi@univ-lille.fr

Abstract: Studies focusing on the territorial impact of outdoor activities rarely take into account the use of digital tools, such as digital mobile devices and applications. However, these digital tools can serve as sustainable outdoor infrastructure. While digital technology is not universally embraced by trail runners today, consumer studies confirm a growing usage of digital equipment. To provide a concrete example of how digital tools are used and their potential, our study aimed to understand the patterns of digital use among trail runners in France. Through an online questionnaire study (n = 699), we found four main logics of digital use: (1) playful visit, (2) tourist discovery, (3) performance analysis, and (4) social use. Among all forms of use, the most commonly mentioned applications used by respondents during their trail runs were Strava, Garmin, and Suunto. Overall, trail runners demonstrated a high proficiency in digital use, with 95% reporting the use of these applications.

Keywords: digitalization; digital tools and applications; trail running; sustainable infrastructure; outdoor infrastructure; France



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1. Introduction

The role of physical activities in territorial development is widely studied [1–4] through the analysis of stakeholder activities and site-related factors, often adopting a geographical and economic approach. However, the use of digital tools such as digital mobile devices and mobile applications is rarely taken into consideration, despite their potential as sustainable infrastructure for outdoor activities. Sustainability involves meeting present needs without compromising the ability of future generations to meet their own needs. Recent studies emphasize the need to integrate social, environmental, and economic dimensions [5]. The United Nations' Sustainable Development Goals (SDGs) provide a framework for addressing these challenges (Source: <https://www.un.org/en/academic-impact/sustainability> (accessed on 29 June 2023)). Digitalization can play a crucial role in achieving sustainability objectives by enabling data-driven decision-making, resource optimization, and the development of innovative solutions.

The diversity of available nature sites for physical activities, along with technological innovations and the growing popularity of these sites for outdoor activities such as training, recreation, and tourism, has led site managers to innovate and create new products, services, and infrastructure. However, sustainability considerations have also led to an opposing tendency in nature site management, where stakeholders are increasingly committed to limiting the implementation of infrastructural development. They aim to return to traditional activities, reducing meaningless and unnecessary consumption [6]. These two opposing tendencies, while potentially complementary, require a choice from nature site administrations: either attract visitors through infrastructural innovation or preserve

the nature site, reduce consumption, and promote local traditional activities. An intermediate solution is to provide digital infrastructure, often in the form of mobile applications and websites, for local outdoor activities. This approach allows for innovation without jeopardizing nature protection.

The daily presence of digital technology among the French population is evident. A national survey conducted by CRÉDOC in 2019 on Internet and digital device usage confirms the extensive use of mobile equipment, particularly smartphones. Currently, 77% of the population is equipped with smartphones [7]. This digital advancement is accompanied by a significant increase in the number and variety of applications and digital devices. For instance, in France in 2019, excluding sports stores and jewelry stores, 1.6 million connected watches were sold, amounting to a total of 446 million euros. This shift in the use of digital tools, including digital devices and applications, is also reflected in research on leisure and sports activities [8].

With the increasing number of applications, there is a growing trend of applications being related to health, physical activities, and sports. The development of these applications encompasses both a qualitative evolution, with functionalities becoming more sophisticated, and a quantitative evolution, marked by an expanding number of features and usage options. Features that were initially used for monitoring purposes in patients with cardiac dysfunction are now widely adopted in the realm of physical activities [9]. Furthermore, these features are increasingly integrated into various digital tools designed to quantify physical activities. Connected watches, bracelets, and heart rate sensors have been available on the French market since the 1980s [10].

As technologies continue to advance, devices have become “smarter” and more distinguished in acquiring signals, occupying an increasingly significant role in our daily lives [11]. However, there is also an observable reverse phenomenon of minimizing this dependence, as efforts are made to avoid excessive use or overuse [12]. On one end of the continuum, social constructivism suggests that society determines how new technologies are designed and used. On the other hand, technological determinism argues that technology development precedes social development while influencing its direction [13]. In the context of outdoor activities, digital tools are being increasingly utilized, and this trend appears to have been reinforced since the outbreak of the SARS-CoV-2 pandemic [14]. The confinement and isolation measures have led to innovations in physical activities, such as home sports sessions, virtual events, and the creation of virtual communities centered around sports and recreational themes.

Based on a recent study [15], it was found that the French population tends to download applications related to physical activities, such as Strava (Strava is a popular social fitness platform and mobile application used by athletes, primarily focused on tracking and analyzing various types of physical activities such as running, cycling, and swimming). It allows users to record their workouts using GPS technology, providing data on distance, time, pace, elevation, and more. Users can connect with a community of like-minded individuals, share their activity updates, and engage in social interactions through comments, kudos, and virtual competitions). However, the study reveals that the actual usage of these applications is low, with only 9% of runners and joggers utilizing community applications.

In the realm of sports, the growth of Strava represents the widespread adoption of digital technology. Strava was already experiencing significant development before the health crisis, but its expansion accelerated during the pandemic [14]. According to a study conducted by Strava in 2021, the application witnessed a 38% annual increase in activity, with a total of 1.8 billion downloads within the past 12 months. The number of running activities downloaded on the application also saw a 30% increase.

Indeed, the sports market has witnessed a proliferation of digital offerings and solutions. However, there is still a lack of comprehensive understanding regarding how these digital tools are utilized. Questions arise regarding the usage patterns of digital tools in outdoor activities, the demographics of the application users, and the potential influence of digital tools on motivation. In the subsequent discussion, we will endeavor to comprehend

the underlying principles behind the use of digital tools, with a specific emphasis on trail running.

Traditionally, trail running has been regarded as an outdoor activity that is closely associated with nature and often valued for its disconnected experience [16]. However, it is important to note that the physical aspects of running, such as endurance, speed, and challenges posed by the trail, have always remained a focal point in the practice of trail running.

The rapid advances in digital technology in recent years, particularly in the form of smartphones, GPS devices, wearable fitness trackers, and mobile applications, have opened up new possibilities for trail runners. These technologies offer features such as route tracking, performance analysis, social interaction, and navigation, which were not widely available or accessible in the past. As technology has become an integral part of our daily lives, users now expect to have digital tools and applications available to enhance their experiences in various domains, including outdoor activities like trail running. The increasing use of digital devices and applications in other areas of life might have created a demand for similar digital solutions in the realm of outdoor sports. Digitalization in trail running presents potential benefits, such as improved safety through real-time tracking, enhanced training and performance analysis, better route planning, and the opportunity for social engagement and community building among trail runners.

Recognizing these potential benefits and discussing the implications of digitalization in trail running is a relatively new and evolving topic.

Digitalization in the Sports Sector

Digitalization is best exemplified by the consumption of digital services. For instance, in 2020, Amazon France reported a total revenue of 7.3 billion euros, as revealed by CEO Frederic Duval, compared to 5.9 billion euros in 2019 (Source: <https://fr.statista.com/statistiques/565402/amazon-recettes-annuelles-nettes/>, accessed on 18 March 2023). In the case of Netflix, the latest publicly available data on the number of subscribers in France dates back a year (nearly 8 million), but it is estimated to have surpassed 9 million in 2022 (Source: <https://www.lesnumeriques.com/pro/netflix-franchit-le-cap-des-10-millions-d-abonnes-en-france-n187407.html>, accessed on 7 March 2023). Another notable example is Instagram, which had over 21 million monthly active users in France in 2021, with 69% of them belonging to Generation Z (i.e., individuals born between 1997 and 2020) (Source: <https://datareportal.com/essential-instagram-stats>, accessed on 7 March 2023).

Despite being a relatively new field, the topic of digital use in everyday life has attracted considerable attention in the literature, with various perspectives being explored. The concept of “quantified self” [8,11,17–19] aims to measure and analyze factors such as step counts, heart rate, estimated physical effort, distance, elevation, speed, and daily active minutes using devices like pedometers and heart rate sensors. The rise of virtual communities [20] and thematic social networks [21,22] has spurred research on the use or non-use of these platforms. The field of gamification [8,23–25] focuses on making activities more enjoyable, primarily in the context of leisure pursuits. Lastly, the concept of “phygitalization” combines physical activities with virtual elements [26].

As mentioned earlier, the growing popularity of digital tools can be attributed, in part, to the availability of self-quantification tools [17]. However, as Lupton [27] explains through an ethnographic approach, the act of quantifying oneself is not a new phenomenon. What is novel is the ease of access to detailed quantified information [21]. Additionally, the pre-installed nature of applications on digital devices further enhances their accessibility [18].

Applications in the digital realm are constantly evolving, specializing, democratizing, and expanding their range of functions with increasing precision. However, according to a national survey conducted in 2018 [15], the usage of applications related to physical and outdoor activities among the French population is relatively low. Interestingly, the survey reveals that outdoor enthusiasts are not heavy consumers of tutorials or YouTube

channels [15]. On the contrary, the use of community apps is more prevalent in outdoor activities [15].

Gamification in physical activities can be implemented through various platforms such as Zwift for cycling, Strava for cycling or running, Nike+, urban'r, and more. These applications create user networks or utilize existing social networks to motivate individuals by offering rewards for achieving goals or by enhancing the user experience of tasks that are often perceived as challenging or unenjoyable. The aim is to encourage exercise, well-being, and active participation in physical activities by making them more enjoyable and, in some cases, more accessible.

Phygitalization. The recent digital revolution has compelled a reimagining of the retail landscape. In France, the sports sector has experienced a notable lack of digitalization, which was further highlighted by the onset of the SARS-CoV-2 pandemic in early 2021 [28]. Consequently, the outdoor event industry was hastily rethought and reorganized without a coherent strategy [29]. The implementation of health restrictions made it impossible to organize sports events in person, leading to the industry's need to adapt and reinvent itself. As a result, traditional sports events have been challenged, and virtual experiences have gained prominence [30].

The virtual activation of events has introduced a new dimension, creating a form of "mirror competition" for consumers. They now have the opportunity to compare themselves to others virtually or physically within real scenarios. Smartphones play a significant role in facilitating this connectivity, enabling consumers to navigate seamlessly between physical and virtual environments [31].

Trail running, as defined by the International Trail Association, is a foot race that takes place in natural environments such as mountains, deserts, forests, plains, etc. It is open to all participants and typically involves running on a minimum of paved roads (up to a maximum of 20% of the race distance) with semi or self-sufficiency. This sport caters to various desires, including having fun, achieving personal performance, exploring new places, reconnecting with nature, and sharing moments with friends [16]. Trail runners may seek camaraderie, exchange, self-improvement, and competition. These motivations can drive a greater use of digital tools for self-quantification, performance comparison, and analysis [32].

Simultaneously, these digital tools serve as an asset for territorial management, as they promote leisure and tourism development while ensuring environmental protection [6]. Public and local bodies often favor the utilization of digital tools for trail running activities. Trail running is primarily an autonomous activity, and runners typically do not rely on coaches for their practice [16]. Various training resources, such as web tutorials, YouTube channels, and community applications, help maintain their autonomy. However, the usage of community applications among joggers is relatively low, with only 9% utilizing them [15].

Trail running necessitates tangible infrastructure, including signposting, tourist maps, information boards, and danger alert signs, to ensure safe and organized activities in natural environments. Digital tools have the potential to not only replace physical infrastructure but also provide additional details about the trail and the activity, such as tourism information, physical performance tracking, and distance covered. In our attempt to illustrate how digital tools can substitute tangible infrastructure, we aim to explore different logics of digital tool use among trail runners.

Trail running has traditionally been associated with a disconnected experience in nature [16]. However, discussions around physical performance have always been significant [33]. The advances of technology now allow for accessible self-tracking, fulfilling a long-standing desire for measurement and performance [27]. Digitalization offers potential benefits, while trail running still maintains the essence of being immersed in nature and experiencing a disconnect from digital devices [12].

The purpose of this paper is to examine the utilization of digital tools by trail runners in various stages: before, during, and after their activity. Given that the modalities of trail

practices can potentially influence digital use, this paper also aims to profile different types of trail runners based on their digital-usage patterns. Our main focus is on applications specifically designed for outdoor activities, particularly running and trail running, as well as connected objects that are prominent in outdoor sports. The primary objective of this study is to identify and define potential logics of digital use in the context of trail running.

2. Materials and Methods

To gain insights into the logic of digital tool use in trail running, we decided to conduct a questionnaire survey. Considering the prevailing health situation due to the SARS-CoV-2 pandemic in the early months of 2021, we opted for an online questionnaire format.

Our study focused on trail runners in France. The data collection period started on 22 March 2021, and ended on 10 April 2021. We collected a total number of 1066 responses. After excluding partial answers, we obtained a sample of 699 complete and validated responses, which served as the basis for our analyses.

For data collection, the Lime Survey platform was utilized to create and administer the online survey or questionnaire. To ensure the clarity of the questions and response options, a pilot study involving 57 trail runners was conducted. The pilot study helped in identifying any potential issues or ambiguities in the questionnaire.

In order to gather a substantial number of responses, we utilized three main methods to distribute the questionnaire: (1) Trail runners' groups on social networks: We reached out to trail running communities on platforms like Facebook, specifically targeting groups focused on trail running. We also engaged with trail runners' groups on Strava, a popular social network for athletes. Additionally, we approached personal acquaintances ranging from amateur to professional trail runners. (2) Trail event organizers: We collaborated with organizers of trail events, requesting their assistance in distributing the questionnaire among their former participants. This allowed us to tap into a pool of experienced trail runners who had previously taken part in such events. (3) Trail teams and clubs: We established connections with various trail teams and clubs, aiming to reach their members and encourage them to participate in our study. By involving these organized groups, we were able to access a diverse range of trail runners.

By employing these three approaches, we sought to maximize our reach and ensure a broad representation of trail runners in France for our study.

The questionnaire was written in French and was divided into two parts. The first part focused on gathering information about the socio-demographic profile of the respondents and their trail running practices. The second part of the questionnaire delved into the usage of digital tools specifically designed for trail running. It examined how respondents utilized digital tools before, during, and after their trail running activities. This section aimed to understand the various functionalities and features of digital tools that were employed, such as tracking apps, navigation tools, performance analysis software, social platforms, and any other relevant applications or websites that facilitated their trail running experience.

The analysis of the data collected by questionnaire was organized in several steps with the aim of validating our scale [34] and classifying trail practitioners according to their digital use.

To achieve the first objective, we used Exploratory Factorial Analysis (EFA) [35] based on the covariance matrix and a principal component extraction method [35]. The SPSS software was used to rotate the solution using the varimax method with Kaiser normalization and record the factor scores following a regression method. This allowed us to find the underlying structure of the numerical usage as well as to obtain new normalized variables with a mean of $\bar{x} = 0$ and a standard deviation of $S = 1$. The reliability study was performed based on the validation of the internal consistency of each dimension, using Cronbach's alpha [36].

3. Results

3.1. Profile of Respondents

Table 1 provides an overview of the socio-demographic profile of the respondents. It indicates that nearly two-thirds of the sample is male, representing a higher proportion of women compared to the previous trail runner survey we are aware of (which reported 85% male participation, as noted in [37]).

Table 1. Demographic profile of respondents.

Demographic Profile	Frequencies	Percentage
Gender		
Male	443	63.4%
Female	256	36.6%
Average age	40.21 yrs	
Profession		
Craftsman, etc.	41	5.9%
Executive, etc.	287	41.1%
Middle-level profession	67	9.6%
Employee	160	22.9%
Worker	33	4.7%
Retired	20	2.9%
High school or university student	57	8.2%
Other inactive	34	4.9%

The average age of the respondents is slightly above 40 years (± 10.93), which is relatively high considering that trail running is typically adopted as a physical activity later in life. On average, individuals in our sample discovered trail running at the age of 31.55 (± 10.13) and began engaging in regular practice (at least once a week) at the age of 32.73 (± 9.72).

When examining the socio-professional profiles of the participants, it becomes evident that executives and individuals in higher intellectual professions make up 41% of the respondents. Additionally, over half of the respondents belong to higher socio-professional categories, including managers, senior and middle managers, as well as those in liberal professions. These findings align with the results reported by Chevallet et al. [37], where 51% of the respondents also fell within these same socio-professional categories.

The presence of a substantial proportion of trail runners from executive and higher intellectual professions, as well as higher socio-professional categories, suggests a pattern of engagement in trail running among individuals in more senior or intellectually demanding roles. This information contributes to our understanding of the socio-professional composition of trail runners and provides insights into the relationship between trail running and occupational profiles.

Regarding their place of residence, the vast majority of participants (96.4%) reside in France. The analysis of postal codes indicates that respondents are spread across various regions of the country, with a slight dominance in the Northern and Eastern regions, accounting for approximately 40% of the sample. This geographical distribution can be attributed to the distribution channels employed, which encompass both national social networks and more localized personal networks.

3.2. Modalities of Trail Running and Use of Digital Tools

Trail running is primarily considered a solitary activity, as indicated by nearly 60% of the respondents who reported running mainly alone (refer to Table 2). However, despite only 18.30% of the respondents training with their club, 47.40% of them are registered in a sports club. A fifth option was also provided to the respondents—"with sports groups from social networks"—but surprisingly, none of the participants chose this option.

Table 2. Modalities of trail running.

	Men	Women	Total
I usually run ...			
... in the plains	33%	16.7%	49.8%
... on medium mountains	22.3%	13.6%	35.9%
... on high mountains	6.2%	0.9%	2.7%
... in urban areas	6.2%	5.4%	11.6%
I am a member of a club of ...			
... athletics	35.6%	26.6%	62.2%
... train running	37.5%	24.2%	61.6%
I usually run ...			
... alone	41.1%	18.9%	59.9%
... with friends	11.9%	6.4%	18.3%
... with family	2.3%	3%	5.3%
... in a club	8.2%	8.3%	18.3%

In the digital age, where social networks are prevalent, we initially assumed that they would serve as a meeting place or a unifying force for leisure activities, including trail running. The absence of this response in the collected data does not necessarily imply that social networks are incapable of forming groups of runners. Without further investigation into this matter, drawing definitive conclusions becomes challenging.

Obviously, the regular training practice locations vary widely, particularly based on the runners' place of residence. Consequently, 49.8% of our respondents run in plain areas, while 11.6% prefer urban areas for their training. In contrast, 38.6% of the sample consists of trail runners who train in mountainous regions.

Regarding the use of digital tools specific to the activity, it is noteworthy that the majority of runners (95.1%) incorporate digital tools into their practice. Among them, 91.2% own and utilize a connected watch and/or GPS during their activities, while 21.3% use a cell phone. Additionally, a portion of runners (16.9%) are equipped with both of these tools during their sessions. Furthermore, among the runners who possess digital tools dedicated to their practice, 17.9% make use of paid applications.

3.3. The Main Modes of Digital Use among Trail Runners

The Exploratory Factor Analysis reveals an underlying structure of four dimensions (number suggested by the collapse plot) that organize the modalities of digital use by the trail runners (see Tables 3 and 4, and Appendix A Table A1). The first dimension is derived from the combination of items dealing with digital use intended for "playful visit" use and the study of its internal consistency returns a value $\alpha = 0.85$. The second dimension was constructed from the items relating to the digital "tourist discovery" and has an α value of 0.76. As for the third dimension, it was created mainly from the items dealing with the analysis of the effort, so we named this dimension "performance analysis", which has a Cronbach's alpha value of $\alpha = 0.62$. Finally, a fourth dimension "social" brings together items dealing with the social aspect of digital, with a Cronbach's alpha value of $\alpha = 0.65$.

Table 3. The different logic of digital use with Cronbach's Alpha.

Dimension	Cronbach's Alpha	Number of Items
Playful visit	0.849	7
Tourism discovery	0.795	6
Performance analysis	0.616	7
Social	0.652	4

Table 4. The four dimensions of digital use in trail practice.

	Playful Visit	Tourism Discovery	Performance Analysis	Social
Before the activity	Search for trails and information on the site; Dimensions of digital use in trail running.	Find a trail for running; Get information about the site; Make reservations (transportation, accommodation, catering, ...).	-	Organize runs with others; Meet other runners.
During the activity	Follow a trail and consult information on the site.	Find your way around the site.	Obtain information on the level of physical effort and pace.	Take and share photos or videos.
After the activity	Get information about the site, evaluate the site.	-	To analyze physical effort.	Share activities on social networks.
Digital tools ...	Mainly used to get information.	Discovery tools, location tools, tools to identify monuments and sites to visit and to access information about them.	Essential for sports activities. They generate additional motivation and are essential for competition.	Mainly to take and share photos and establish or maintain social links.
Special features	Importance of discovering nature; scarce use of digital tools for trail running	Search for new trails or alternative routes to places already known.	Accuracy of the analysis of the performance after the practice.	Use of social networks in relation to trail running.

These dimensions represent the different logics of digital use and are derived from the factor analysis that allowed us to study the variables that best characterize each dimension or logic. However, it is not a characterization of individual, thus it is possible for a respondent to be associated with several of these dimensions at the same time.

A visual examination of the table clearly indicates that only two out of the four logics are applicable before, during, and after practice. This is not the case for the logics of “tourist discovery” and “performance analysis”. While the desire to explore a location may necessitate preparations before or during the activity (such as finding directions), it is less relevant for later use. On the other hand, the logic of performance analysis does not involve the use of digital tools for preparatory purposes (although the same user may still prepare for their activity using one of the other three logics). Instead, it focuses on obtaining feedback on physical exertion during the activity and analyzing physiological data and the actual run itself (including distance, altitude, pace, etc.) after the effort has been made.

The analysis of the “playful visit” dimension highlights a notable departure from trail running itself. This particular logic focuses on gaining an understanding of the natural and historical surroundings in which the activity occurs. The emphasis is on approaching the environment in a playful manner, without any direct connection to the physical exertion involved in trail running.

Consequently, we can distinguish between the logic of “tourist discovery” and the logic of “playful visit” based on their utilization of digital tools. Prior to engaging in the activity, both logics employ digital tools for preparation. However, the logic of “tourist discovery” approaches this preparation from a logistical standpoint, encompassing tasks such as making reservations or gathering information about accommodations and catering. On the other hand, the logic of “playful visit” focuses on identifying or anticipating the playful elements inherent to the activity itself, such as treasure hunts or observing flora and fauna.

During the activity, the logic of “tourist discovery” primarily employs digital tools for location, orientation, and directions. Its main objective is to facilitate navigation and

provide assistance in finding specific points of interest. In contrast, the logic of “playful visit” utilizes digital tools with a perspective of enhancing the experiential aspect of the activity. This may include engaging in activities like geocaching, treasure hunts, scavenger hunts, and other playful elements that contribute to the overall experience.

When examining the logic of “performance analysis,” we observe a distinct deviation from the recreational and tourist aspects found in the previous dimensions. Unlike the focus on nature, reservations, and similar elements, this logic is entirely centered around performance and the analysis of physical effort. The primary objective is to assess and evaluate one’s performance during the activity.

In the context of performance analysis, the examination of the run or the site is limited to inquiries related to performance-related factors. For instance, the analysis may involve considerations such as the altitude and distance covered in relation to the duration of the run. The main goal is to gain insights into the individual’s athletic performance and gauge their progress or areas for improvement, without significant emphasis on recreational or tourist-related aspects.

Regarding the “social” logic, it becomes apparent that digital technology serves two primary purposes: establishing and maintaining connections with other runners, and sharing the activity on social networks. In the first scenario, it can be inferred that the activity is carried out in the company of other runners, and digital tools are utilized to plan and organize the activity collectively. This may involve coordinating meeting points, discussing routes, or exchanging information relevant to the group.

In the second scenario, digital tools are employed to share the trail running activities and the accompanying photos with a broader audience on social networks. The intention is not solely limited to individuals directly interested in trail running, but rather to a wider community or followers. The focus shifts from the immediate running group to a more public-facing approach, aimed at showcasing the experience, promoting the activity, or connecting with like-minded individuals beyond the immediate running circle.

3.4. The Most Popular Applications among Runners

Table 5 presents a summary of the applications mentioned by the respondents. Since the question was open-ended, and the answers were spontaneous, the frequency of each application mentioned may not accurately represent their actual usage. However, the table does provide some initial insights into the utilization of these applications in trail running, allowing for preliminary conclusions to be drawn.

Table 5. Applications mentioned by respondents.

Application	Frequencies	Percentages
Strava	338	48.35%
Garmin	255	36.48%
Suunto	83	11.87%
OpenRunner	23	3.29%
Polar Flow	22	3.15%
Nolio	18	2.58%
Adidas Runastic	18	2.58%
Visorando	8	1.14%
Decathlon Coach	7	1%
Station de Trail	6	0.86%

Out of the 539 respondents, 289 of them mentioned using only one application for trail running. Additionally, 198 respondents mentioned using two applications, while 37 respondents stated using three applications. It is worth noting that only a few respondents mentioned more than three applications, with just one individual mentioning six applications. However, these figures should be interpreted with caution. The fact that most respondents mentioned only one or two applications does not necessarily imply that their

usage is strictly limited to those applications alone. It should be noted that the survey did not explicitly ask respondents to mention more than one application, which may have influenced their responses.

The respondents consistently mentioned three applications as their preferred choices: Strava, Garmin, and Suunto. Notably, Strava is widely recognized as “The application n° 1 for runners and cyclists” and is specifically designed for outdoor activities. It offers features such as maps, satellite imagery, and tracking. Since 2017, Strava has also incorporated social sharing functionalities, effectively making it a thematic social network. According to an app analysis website (Source: <https://www.businessofapps.com/data/strava-statistics/>, accessed on 18 March 2023), Strava had 76 million users in 2021.

On the other hand, Garmin and Suunto are primarily renowned as manufacturers of GPS watches designed for sports purposes. While their names appear in the list of applications used, it is because these manufacturers also provide companion applications for visualizing routes and conducting performance analysis. The extent of these analysis capabilities may vary based on whether the user opts for the free or paid version of the application. Additionally, these GPS watches can easily synchronize with the Strava application, further suggesting that respondents mentioning these watch manufacturers and their apps may also be users of Strava or similar features. Therefore, it is likely that individuals who mentioned the applications associated with GPS watch manufacturers are also utilizing Strava or similar platforms alongside their connected watches.

Furthermore, it is important to note that while these applications mentioned by respondents offer various functionalities, they do not entirely encompass the features of a dedicated social network, although some come close. The collected responses indicate the existence of a social use of digital tools, referred to as the “social logic.” However, we do not have precise data on the extent to which this social logic is employed within trail running applications. In other words, we cannot measure whether trail runners also utilize other non-trail-related applications, such as Facebook, Instagram, Twitter, or other social media platforms, for social purposes.

4. Discussion

In 2018, a national survey showed that the utilization of digital tools in outdoor activities was relatively limited among the French population [15]. However, we assumed that technological advancements could potentially influence outdoor activities, prompting us to examine the impact of the SARS-CoV-2 pandemic-related lockdowns on the use of digital tools in outdoor pursuits [14]. Our objective was to gather precise information on the usage of digital tools by trail runners in France, with the overarching aim of mapping how these tools can serve as territorial infrastructure.

While our exploratory study may not provide comprehensive answers to all the questions surrounding the digitalization of trail running, it is evident that the use of digital tools is prevalent among trail runners. They rely on multiple applications specifically designed for outdoor running and utilize various devices to support their activities. Through our research, we identified four primary logics of digital use among trail runners: (1) playful visit, (2) tourism discovery, (3) performance analysis, and (4) social logic. These findings shed light on the diverse ways in which trail runners engage with digital tools in their pursuits.

It is crucial to emphasize that the previously defined logics of use are not rigid typologies that strictly categorize individuals. Different profiles of runners may adopt multiple logics simultaneously or in succession. Additionally, the dimensions are not mutually exclusive, meaning that a runner can adhere to multiple logics at once. Currently, we do not have a comprehensive understanding of how different runner profiles may exhibit varying tendencies in digital tool usage.

Furthermore, it should be noted that the logics of use are not fixed and can evolve over time, depending on the changing objectives or motivations of the runner. For instance, a runner’s preferences and priorities may shift, leading them to adopt different logics or

modify their digital tool usage accordingly. Moreover, different user profiles are likely to engage with digital tools in diverse ways, reflecting their individual preferences, goals, and characteristics.

The characteristics of trail running primarily indicate a solitary activity, supporting the suggestion put forth by Buron [16]. However, considering that over 95% of the respondents confirmed their use of digital tools during their trail running practice, it can be inferred that digital technology serves as an organizer and facilitator of the activity. Digital tools provide a new form of support and monitoring for trail running, offering an alternative to traditional frameworks like sports clubs or coaches.

According to our study, it was found that among train runners, the applications most commonly used were Strava, Garmin, and Suunto. Strava emerged as the most popular application among the respondents. There might be diverse reasons for this: (1) Social features: Even though social interactions may not appear to be the most popular feature, our study uncovered that they are an essential aspect of digital usage. (2) Data tracking and analysis: Our study, similar to the findings of Lupton [27], Vignal [32], and Buron [16], revealed that “performance analysis” is a significant feature for trail runners. This suggests that trail runners value the ability to analyze their performance data and track their progress, aligning with previous research in the field. (3) Segments and challenges: Strava’s segment feature allows users to compete with others on specific sections of routes, which adds a competitive element and motivates runners to improve their performance—in line with the “performance analysis” logic. (4) Integration with Devices: Strava seamlessly integrates with various GPS-enabled devices, including popular running watches and cycling computers. This compatibility makes it easy for users to sync their activities and access their data directly on the platform. The fact that the applications offered by Garmin and Suunto ranked second and third in popularity among trail runners demonstrates the significance of technical capabilities for this group. (5) Extensive User Base: Strava has amassed a large and active user base, creating a network effect as shows the “social” logic of digital use.

We acknowledge the presence of a potential bias resulting from the online data collection technique employed, which did not allow for sample control. However, it is important to highlight that despite this limitation, the substantial number of validated responses ($n = 699$) helps mitigate the potential bias and provides a reasonable level of confidence in the results. With a margin of error of 3.71 at a 95% confidence level, the findings can be considered statistically reliable within the given sample size.

Given the large sample size of 699 validated responses and the margin of error calculated with a 95% confidence level, it is reasonable to assert that the results generated from this sample can be generalized to a larger population, particularly trail runners in France. However, it is important to note that generalizability to other populations or contexts should be approached with caution, as factors such as cultural differences or specific characteristics of different trail running communities may influence the findings.

5. Conclusions

The study explored the utilization of digital technology among trail runners, offering insights into their preferences compared to the previous study on the use of digital in outdoor activities, which was conducted in 2018 [15]. It takes into consideration the advancements in digital technology, particularly since the outbreak of the SARS-CoV-2 pandemic [14]. Moreover, the findings are expected to forecast or describe an existing trend in the trail running community, as the use of digital devices by regular trail runners is likely to become more prevalent among a broader range of practitioners [9]. Additionally, gaining a more comprehensive understanding of the use of digital tools, which are regarded as sustainable territorial infrastructure, could potentially enhance the management of sites in a more sustainable manner.

The identification of the four primary purposes of digital use among trail runners (playful visit, tourism discovery, performance analysis, and social interaction), along with

the most commonly utilized applications and the frequency of their use, can serve as a basis for formulating recommendations aimed at promoting sustainable management of nature sites. Considering that a high percentage (95%) of trail runners in our study reported to use digital mobile devices and applications, it becomes evident that digital tools can be regarded as crucial components of sustainable outdoor infrastructure. The significance of these tools should not be overlooked or underestimated, as they play a substantial role in supporting and enhancing the trail running experience while promoting sustainability in outdoor activities.

The study also highlights several limitations that raise important questions. Firstly, the logics of digital use identified are not mutually exclusive, meaning that a user can switch between different logics. This prompts the question of which types of users are more likely to adopt specific logics and the conditions that lead to transitions between them. Secondly, the study did not investigate the specific ways in which respondents use the mentioned applications. This raises questions about how the cited digital tools are utilized and the reasons behind runners' choices. Do users employ one tool at a time or multiple tools simultaneously? Do they rely on a single device or a network of tools? Thirdly, the absence of reference to social networks, apart from Strava, despite the existence of a social dimension, is noteworthy. This prompts curiosity regarding the actual role of social media platforms such as Facebook, Twitter, Instagram, etc., among trail runners. Lastly, the study does not address the motivations of runners seeking a disconnected experience. The lack of exploration on this topic raises intrigue: is the notion of disconnection from digital technology a myth, or is it simply a methodological bias?

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Appendix A

The table below presents the 24 items that help define the four different logics of digital use. The propositions have been translated from French.

Table A1. Modalities of digital use among trail runners (Four dimensions revealed by Exploratory Factor Analysis).

Questionnaire Items	Playful Visit	Tourism Discovery	Performance Analysis	Social
Before my trail running practice, I use digital technology to find fun routes (treasure hunt, geocaching, scavenger hunt)	0.705			
Before my trail running practice, I use digital technology to learn about the wildlife and flora of the visited site	0.658			

Table A1. Cont.

Questionnaire Items	Playful Visit	Tourism Discovery	Performance Analysis	Social
During my trail running practice, I use digital technology to get information about the locations/monuments of the site	0.767			
During my trail running practice, I use digital technology to gather information about the wildlife and flora of the site	0.766			
During my trail running practice, I use digital technology to follow one of the fun routes (treasure hunt, geocaching, scavenger hunt)	0.760			
After my trail running practice, I use digital technology to gather information about the site I just visited	0.664			
After my trail running practice, I use digital technology to rate or review the completed route	0.533			
I use digital tools to discover new places (related or unrelated to my trail running practice)		0.658		
Before my trail running practice, I use digital technology to plan the route I will follow		0.783		
Before my trail running practice, I use digital technology to explore alternative routes to the ones I already know		0.774		
Before my trail running practice, I use digital technology to identify monuments/sites to visit		0.489		
Before my trail running practice, I use digital technology to make reservations (accommodation, transportation, restaurants, etc.)		0.463		
During my trail running practice, I use digital technology to navigate or orient myself in space		0.656		
Digital tools are essential for my trail running practice			0.723	
Digital tools provide me with additional motivation for my trail running practice			0.641	
I can participate in a competition without my digital tools			−0.529	
During my trail running practice, I use digital technology to monitor my physical effort level			0.702	
During my trail running practice, I use digital technology to track my speed or distance covered			0.452	
After my trail running practice, I use digital technology to analyze my physical effort in detail			0.706	
After my trail running practice, I use digital technology to briefly analyze my physical effort (time, distance, calories, elevation)			0.492	
Before my trail running practice, I use digital technology to schedule a time and meeting point with other runners				0.660
Before my trail running practice, I use digital technology to meet new runners				0.499
During my trail running practice, I use digital technology to take or share photos				0.703
After my trail running practice, I use digital technology to share my activity on social media				0.678

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