



A Bibliometric Analysis of Mindfulness and Acceptance Research in Sports from 1969 to 2021

Daniel Birrer¹ · Beatrice Scalvedi¹ · Nina Frings²

Accepted: 30 March 2023 / Published online: 3 May 2023
© The Author(s) 2023

Abstract

Objectives This study aimed to comprehensively summarize the historical developments, most prolific literature, countries, institutions, and journals related to mindfulness and acceptance research in sports from 1969 to 2021 as well as to identify active research areas and emerging trends, and anticipate future directions using bibliometrics.

Method Using “mindfulness *” OR “meditation *” AND “sport *” OR “athletic performance *” OR “athlete *” as search terms, we conducted a search of articles and review articles in the Web of Science core database, obtaining a descriptive summary of the relevant bibliometric data. Keyword co-occurrence networks were visualized using VOSviewer. CiteSpace was used to identify article citation bursts.

Results A total of 186 publications fulfilling the inclusion criteria were identified. Of these, 64 also included the keyword *acceptance*. The first article on mindfulness and sports was published in 1977. The first article with the additional search term “acceptance *” was published in 2004. The first randomized controlled trial (RCT) followed in 2014. An almost exponential growth in the number of publications started in 2014. The most prolific nation was initially the USA, while China has experienced the largest growth in recent years. Co-occurrence keyword analysis revealed that sport mindfulness research is focused on performance, flow, and acceptance. Recent trends reveal growing interest in impact mechanisms, self-compassion, and well-being, and a shift from review articles to RCTs. A future avenue might include neuroscientific studies.

Conclusions Mindfulness research in sports lags somewhat behind general mindfulness research. There is still a demand for high-quality RCTs.

Keywords Mindfulness · Acceptance · Knowledge map · Psychological flexibility · Consciousness

During the past two decades, mindfulness has rapidly become an important subject area across many subdisciplines of psychological science, including clinical, social, organizational, and cognitive science along with educational psychology and many others (Van Dam et al., 2017). In the course of this development, mindfulness- and acceptance-based interventions have also been proposed as beneficial in sports (Birrer et al., 2012). This growing interest has led to the publication of various papers in the field of sports, including meta-analyses (Bühlmayer et al., 2017; Noetel et al., 2019), systematic reviews (Sappington &

Longshore, 2015), and randomized controlled trials (RCTs) (Nien et al., 2020; Wolch et al., 2021).

Mindfulness is an umbrella term for a large number of practices, processes, and characteristics (Van Dam et al., 2017). Despite the widespread interest across different areas of psychology, there is no common understanding of the psychological construct of mindfulness (Quaglia et al., 2015; Van Gordon & Shonin, 2020). It originates from Buddhist philosophy and practice and became popular in Western psychology through its role in mindfulness-based stress reduction (MBSR; Kabat-Zinn, 1982). Most definitions of mindfulness from Western researchers and clinicians have used contemporary psychological terms. Although these definitions differ in many ways, there are some common features of the contemporary descriptions of mindfulness. Many describe mindfulness as a specific form of present-moment attention or present-moment awareness (the *what* element of mindfulness), incorporating two elements: the attention itself and the qualities

✉ Daniel Birrer
daniel.birrer@baspo.admin.ch

¹ Department of Elite Performance, Swiss Federal Institute of Sport Magglingen, 2532 Magglingen, Switzerland

² Faculty of Psychology, University of Basel, Basel, Switzerland

of attention, sometimes also referred to as the attitude part (the *how* element of mindfulness) (Baer, 2019). The *what* element is commonly described as paying attention in the present moment (Kabat-Zinn, 1982) and self-regulation of attention, so that it is focused on the immediate experience (Bishop et al., 2004), or the awareness of the present experience (Germer et al., 2005). The *how* element is commonly referred to as intentionality (on purpose) and being nonjudgmental, with an affectionate, compassionate quality and a sense of openhearted, friendly presence and interest (Kabat-Zinn, 1982, 2011), an orientation characterized by curiosity, openness, and acceptance (Bishop et al., 2004), or simple acceptance, which is seen as an extension of nonjudgment with an additional aspect of kindness (Germer et al., 2005).

Problems may arise from the way in which the concept of mindfulness is used in empirical studies. Mindfulness is referred to as a mental faculty that describes how well a person is able to remain consciously aware of the present-moment experience and consider the current conditions (Baer, 2019; Van Dam et al., 2017). Additionally, mindfulness can be a trait, one's predisposition to be mindful in daily life, or a state, that is, being mindful in the present moment (Baer, 2019) with different possible facets (e.g., awareness, acceptance, decentering; Gawrysiak et al., 2018). Mindfulness as a mental faculty—trait or state—is generally fostered through mindfulness/meditation practices, which are delivered in many shapes and forms. In this sense, a 30-min formal expert-guided exercise sitting on a cushion in a specific posture and attending to the breath, a 5-min exercise on a mobile app, or a 1-week meditation retreat can all be labeled mindfulness. Moreover, the term is used in various interventions and research programs, each with its own theoretical foundations, usually delivered as a part of multimodal treatments, but often in the form of mindfulness meditation.

The ongoing debate about (right) mindfulness is closely related to the intention to practice mindfulness. Dorjee (2010) views the intention to train as an important dimension of mindfulness. This intention to train or use mindfulness seems to be central to its application in sports (Birrer et al., 2012). Due to the development of sport psychology, which is also closely linked to the development of psychological skills training (PST), the intention to practice mindfulness is often linked to the intention to improve athletic performance (Birrer & Morgan, 2010). In addition to this focus on athletic performance enhancement, both applied use and research on the mindfulness concept in sports have developed another idiosyncrasy: Mindfulness is often used in conjunction with acceptance, frequently referred to as mindfulness- and acceptance-based interventions (MABI) (Henriksen et al., 2020). Acceptance is often understood as an important mechanism in mindfulness interventions (Hölzel et al., 2011) and as an integrated part of the traditional mindfulness concept. However, it is also sometimes viewed as an important

component of a sport-specific adaptation of acceptance commitment therapy (ACT) (Hayes, 2004). In short, the mindfulness concept seems particularly relevant to sports and athletic performance for two reasons. First, the ability to be exclusively in the present with one's attention promotes the recall of highly trained movements and actions. In addition, mindful awareness and acceptance of one's own physical and mental states means that mindful athletes refrain from engaging in internal reactivity toward unpleasant physical and mental states, are not preoccupied with internal defense mechanisms against unpleasant stimuli, and can instead focus on the task at hand (for a detailed discussion of the relevance of the mindfulness concept in sports, see Birrer et al., 2012).

Recently, two publications using bibliometrics (Baminiwatta & Solangaarachchi, 2021; Wang et al., 2021) highlighted the rapid increase in the number of mindfulness publications, with almost a sixfold increase in publications in the past 10 years. They also reported the most prolific articles, authors, journals, countries, and regions. Co-occurrence keyword analysis and publication burst analysis provided insights on recent and possible future trends.

With mindfulness becoming trendy, the explosive growth in the research literature, the lack of a common understanding of the concept, and the diverse use of the mindfulness concept in sports, new approaches are needed to review and analyze trends within the sports domain. This is particularly important since the application of bibliometrics has been limited to studies of mindfulness in general and has not focused on specific domains (Baminiwatta & Solangaarachchi, 2021; Wang et al., 2021). Therefore, this study aimed to perform a comprehensive bibliometric analysis of the mindfulness literature in sports to understand the evolutionary nuances of this research area from the beginning of the foundation of the European Federation of Sport Psychology (FEPSAC) in 1969 up to 2021. Specifically, we aimed to identify the most prolific literature, countries, institutions, and journals. Furthermore, we sought to outline the actual and evolved knowledge structure, shedding light on this emerging field by uncovering potential trends, anticipating future directions, and predicting the need for research over the next 10 years.

Method

Source of Data

Bibliometric researchers consider the Web of Science (WoS) to be a relevant database for bibliometric studies due its provision of a set of metadata, which is essential for this type of analysis (including abstracts, references, number of citations, lists of authors, institutions, countries, and the journal impact factor) (Carvalho et al., 2013). Therefore, the present study used bibliographic records obtained from

the WoS. More specifically, this study used the WoS Core Collection, which is a digital bibliometric platform that is internationally recognized among researchers as having high quality standards (Donthu et al., 2021).

Search Strategy and Data Retrieval

Science Citation Index Expanded (SCI-E) and Social Sciences Citation Index (SSCI) articles and review articles from 1969 to 2021 (31 December 2021) were searched using the terms “mindfulness*” OR “meditation*” AND “sport*” OR “athletic performance*” OR “athlete*” in the WoS core database. Then, we refined the search with AND “acceptance*.” The search was conducted between February and April 2022. Figure 1 presents an overview of the study screening and selection process. Original and review articles were selected for further analysis, and meeting abstracts, book chapters, corrections, and letters were excluded. Articles with no abstract available were also excluded because abstract screening was not possible. In addition, articles in which mindfulness or meditation was not an important focus and those in which the relation to sports was not apparent were excluded from further analysis. Bibliographic data were exported as full records with cited references.

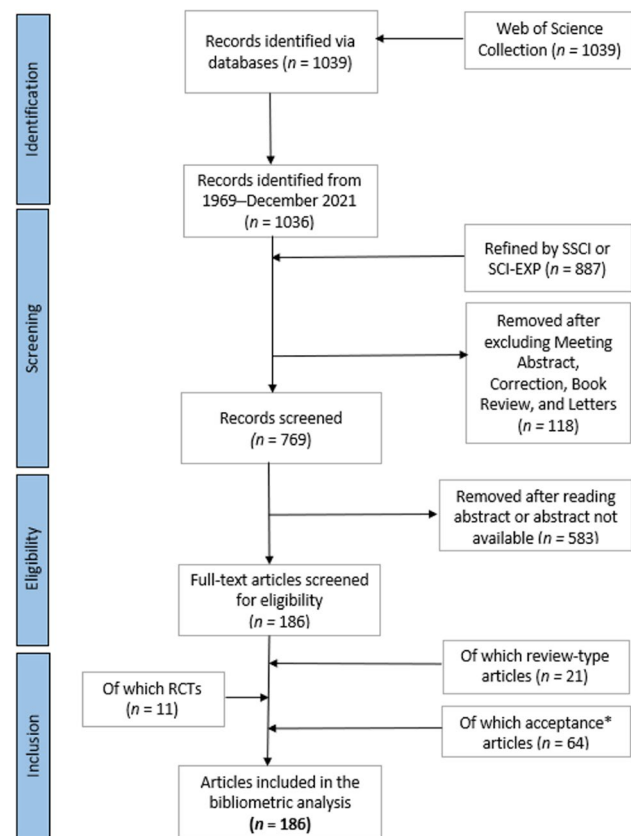


Fig. 1 Study screening and selection process

Data Analyses and Visualization

A general analysis was performed to summarize information about the annual publication distribution, the most cited publications, the most prominent countries, organizations, and journals. The WoS analysis tool was used, and the data were tabulated or presented graphically. VOSviewer (version 1.6.18) (van Eck & Waltman, 2010), a software program for creating and visualizing networks based on bibliometric data, was used for knowledge mapping, specifically for visualizing keyword co-occurrences and timeline views of clusters. In the VOSviewer definition, a cluster is a set of items closely associated with one another. VOSviewer constructs a figure in which labels and circles represent an entity, in our case keywords, where the size of the label and the circle reflect the keyword’s importance (e.g., how many times the keyword was mentioned). Additionally, the circles have different colors, which signify groups based on the default clustering results. Connections between circles denote the content-related affiliation between keywords (according to keyword co-occurrence). The line width of these connections represents the strength of the affiliation with a numerical value assigned. This numerical value indicates the number of publications in which two keywords occur together. VOSviewer also calculates a total link strength for a given keyword. Total link strength indicates the total strength of the links it has with all other keywords.

With its overlay visualization function, VOSviewer offers the possibility of displaying developments over time. We used this function to detect emerging fields and forecast possible trends. To be included in the analysis, the keywords had to appear at least seven times. However, because certain keywords have already been used as search terms or are not suitable for the detection of emerging fields or trends due to their general nature, unsuitable keywords were excluded from the analysis, such as sport, psychology, athletes, exercise, and soccer. CiteSpace (Chen, 2006) was used to detect publication citation bursts. Citation bursts indicate large changes in the number of citations within a particular timeframe.

Prior to analysis, the bibliographic data were checked for inconsistencies, and where appropriate, standardized and corrected. Inconsistencies were due to errors in the publication process, such as the same institution with different names (e.g., Beijing Sports University and Beijing Sport University) or the use of abbreviations or varying expressions for the same theory (e.g., COGNITIVE BEHAVIORAL THERAPY and Cognitive Behavioral Therapy and CBT). For example, cognitive and somatic anxiety were revised to anxiety, while Acceptance and Commitment Therapy and acceptance commitment therapy were revised to ACT. A list of revised terms is available

from the first author. Finally, to detect possible future trends, a brief analysis of the content of titles, abstracts, and keywords was performed on the articles from 2020 and 2021 to determine if key terms that were not present in the keyword analysis would emerge and could indicate new evolving research areas. If these reviews yielded initial promising results, the main findings, contributions, and future direction sections were examined for potentially new trends.

Results

General Analysis of Publications

A total of 186 papers published from 1969 to 2021 were identified on WoS. The first article was published in 1977 by Hickman et al. (1977) in the journal *Simulation and Gaming*. The paper titled “Psychophysical transformation through meditation and sport” describes how the use of mental and physical disciplines may aid the development of the body. This was followed by an article by Robertson (1983) titled “The short and long range effects of the

Transcendental Meditation technique on fractionated reaction time.” Both of these early publications had a marginal relation to sport. Following these two publications, there was another rather large time gap, as the next identified paper was published in 1991 (Hall & Hardy, 1991), so the former two articles were excluded from further bibliometric analyses. Hall and Hardy (1991) compared the efficacy of a transcendental meditation intervention and a visuomotor behavior-rehearsal intervention with a control group in terms of pistol shooting performance to assess the potential for performance enhancement provided by—as they called it—relaxation techniques.

The first article with the keywords mindfulness (OR meditation) AND acceptance in the sports domain was written by Gardner and Moore (2004), introducing an integration and adaptation of the ACT approach for use with an athletic population called the mindfulness–acceptance–commitment (MAC) approach. This has been the most frequently cited article (see Table 1) and demonstrates the early integration and thus the importance of the ACT approach in the sport setting. Of the 186 articles analyzed, 64—one-third of all published articles—included acceptance as an additional keyword (Fig. 1).

Table 1 The 10 most frequently cited mindfulness and sport articles (1968 to 2021)

| Rank | Authors | Citations | Average/year | Journal | Title |
|------|--------------------------|-----------|--------------|--|---|
| 1 | Gardner and Moore (2004) | 174 | 9.7 | <i>Behavior Therapy</i> | A mindfulness–acceptance–commitment-based approach to athletic performance enhancement: theoretical considerations |
| 2 | Peng et al. (1999) | 143 | 6.8 | <i>International Journal of Cardiology</i> | Exaggerated heart rate oscillations during two meditation techniques |
| 3 | Kee and Wang (2008) | 115 | 8.2 | <i>Psychology of Sport and Exercise</i> | Relationships between mindfulness, flow dispositions and mental skills adoption: a cluster analytic approach |
| 4 | Birrer and Morgan (2010) | 112 | 9.3 | <i>Scandinavian Journal of Medicine & Science in Sport</i> | Psychological skills training as a way to enhance an athlete’s performance in high-intensity sports |
| 5 | Aherne et al. (2011) | 103 | 9.5 | <i>Sport Psychologist</i> | The effect of mindfulness training on athletes’ flow: an initial investigation |
| 6 | Birrer et al. (2012) | 99 | 9.9 | <i>Mindfulness</i> | Mindfulness to enhance athletic performance: theoretical considerations and possible impact mechanisms |
| 7 | Mosewich et al. (2013) | 87 | 9.7 | <i>Journal of Sport & Exercise Psychology</i> | Applying self-compassion in sport: an intervention with women athletes |
| 8 | Gardner and Moore (2012) | 87 | 8.7 | <i>Canadian Psychology-Psychologie Canadienne</i> | Mindfulness and acceptance models in sport psychology: a decade of basic and applied scientific advancements |
| 9 | Bühlmayer et al. (2017) | 65 | 13.0 | <i>Sports Medicine</i> | Effects of mindfulness practice on performance-relevant parameters and performance outcomes in sports: a meta-analytical review |
| 10 | Morgan (1995) | 53 | 2.0 | <i>Sports Medicine</i> | Anxiety and panic in recreational scuba divers |

Annual Comparative Analysis of Mindfulness and Acceptance Publications

The number of publications remained less than five per year until 2014. Subsequently, the number of publications increased by an average of 35% per year from 2014 to 2021, with some decreases and increases over the years. The largest relative increase in the number of publications occurred between 2015 (7 publications) and 2016 (18 publications). While the number of publications per year grew relatively steadily except for small declines in 2017 and 2021 (Fig. 2), the number of annual citations fluctuated considerably. The highest number of total annual citations (292) occurred in 2016.

The Most Frequently Cited Articles

Table 1 presents the top 10 most frequently cited publications on mindfulness in sports. The total number of citations, and the citations per publication can be used to analyze the impact of published papers. The most frequently cited publication (174 times) was “A mindfulness-acceptance-commitment-based approach to athletic performance enhancement: Theoretical considerations” (Gardner & Moore, 2004) which provided a theoretical argument for MAC-based performance enhancement as an innovative approach for improving athletic performance and engagement in sport psychology. The publication with the highest average number of citations per year was “Effects of mindfulness practice on performance-relevant parameters and performance outcomes in sports: A meta-analytical review,” written by Bühlmayer et al. (2017). The article by Mosewich et al. (2013) is the first paper investigating self-compassion in the sports domain, and marks the beginning of a later trend toward mental health and self-compassion topics over time.

Three of the 10 most frequently cited articles were empirical research papers (Aherne et al., 2011; Mosewich et al., 2013; Peng et al., 1999), six were meta-analytic or theoretical reviews (Birrer & Morgan, 2010; Birrer et al., 2012; Bühlmayer et al., 2017; Gardner & Moore, 2004, 2012; Morgan, 1995), and one paper presented a cluster analysis of relevant concepts (Kee & Wang, 2008).

The Most Productive Countries

Table 2 shows the most productive countries in terms of the number of publications, how often these publications were cited, and the leading institution per country in terms of the number of publications. These figures are helpful to analyze the impact of countries on developing research. Of the 25 countries that contributed to the literature since 1969, the top five most productive countries produced 68% of all publications. The United States of America (USA) had by far the highest research output with 50 publications, followed by Australia, England, the People’s Republic of China, and Sweden. The relative amount of citations per publication for the USA (18.6) and Australia (18.5) was second and third highest of the top 10 countries, but they only amounted to roughly half of the relative citation productivity of Switzerland (35.8), which produced nine publications that have been cited 322 times. Looking at the time course of publications across countries revealed that the USA was continuously one of the most prolific countries.

In the early 1990s, Canada and Norway appeared with their first publications, and by the early 2000s, Europe began to establish itself as a productive region. The first paper from Asia was published in the late 2000s by Kee and Wang (2008), which was also the third most frequently cited publication. Between 2012 and 2016, Australia started to

Fig. 2 Annual distribution of mindfulness and sport publications. Note: If there was a large time gap, some years were summarized into one block

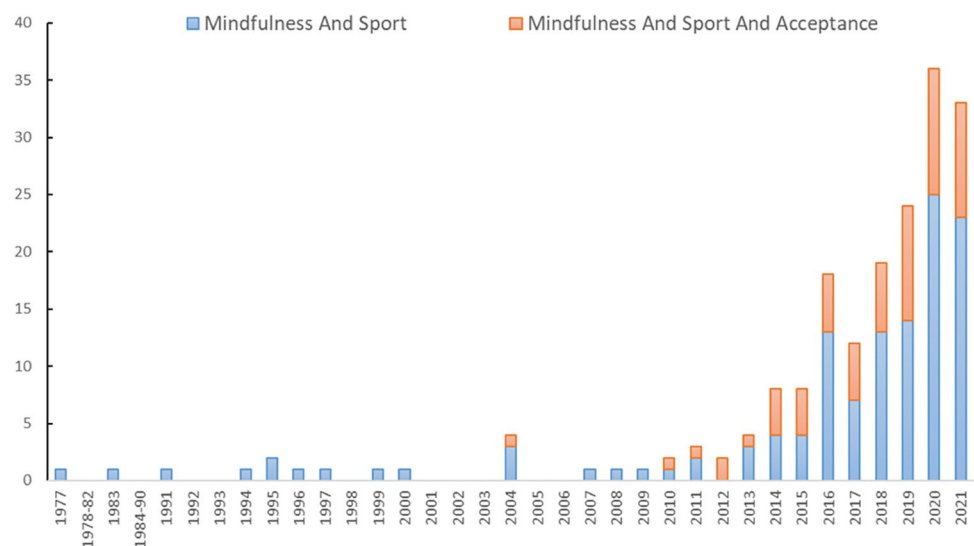


Table 2 The 10 most productive countries and the leading institution of each country in the number of mindfulness and sport articles (1969 to 2021)

| Rank | Country | Publications | Citations | Citations/publication | Leading institute of each country (publications) |
|------|----------------------------|--------------|-----------|-----------------------|--|
| 1 | USA | 50 | 932 | 18.6 | Catholic University of America (4) |
| 2 | Australia | 24 | 443 | 18.5 | University of Queensland (4) |
| 3 | England | 21 | 167 | 8.0 | Liverpool John Moores University (3) |
| 4 | People's Republic of China | 18 | 147 | 8.2 | Education University of Hong Kong EDUHK (9) |
| 5 | Sweden | 13 | 185 | 14.2 | Karlstad University (7) |
| 6 | Canada | 11 | 174 | 15.8 | University of Alberta (3) |
| 7 | Switzerland | 9 | 322 | 35.8 | Swiss Federal Institute of Sport Magglingen (6) |
| 8 | Germany | 9 | 133 | 14.8 | Goethe University Frankfurt (2) |
| 9 | Turkey | 9 | 20 | 2.2 | Gazi University (7) |
| 10 | Norway | 8 | 136 | 17.0 | Norwegian School of Sport Sciences (5) |

Note: Iran also has 8 publications, but less citations than Norway

emerge as a strong region for publications, and the People's Republic of China also entered the research scene focused on mindfulness and acceptance in sports. In the last few years, the USA was still the most influential country, with 33 publications from 2017 to 2021, and Europe maintained its status as the most productive region, with 64 publications from European institutions. Nevertheless, the country that showed the biggest growth was the People's Republic of China, with 15 publications in the last 5 years.

The Most Productive Institutions

In some countries such as the USA, Australia, or England, publications were distributed over several institutes, whereas other countries such as Switzerland or Turkey showed clear leading institutes in terms of the relative number of publications (Table 2). The Education University of Hong

Kong was the most prolific institution, further highlighting the recent proliferation of publications in the People's Republic of China.

The Most Productive Journals

Table 3 presents the top 10 journals in terms of total number of articles published that address mindfulness and meditation in sports, as well as the number of citations generated by the particular journal's articles, the consequent citations per article, the most frequently cited article of each journal, and the number of citations of the most frequently cited publication per journal. These figures can be used to analyze the impact of journals in this research field. Seventy-one journals had at least one publication on mindfulness and sports. *Sport Psychologist*, a journal focused on applied research, published the most articles (15) matching the

Table 3 Top 10 journals that published articles on mindfulness in sport (1969 to 2021)

| Rank | Journal | Article number | Citations | Citations/articles | Most frequently cited article | Citations of the most frequently cited article |
|------|--|----------------|-----------|--------------------|-------------------------------|--|
| 1 | <i>Sport Psychologist</i> | 15 | 248 | 16.5 | Aherne et al. (2011) | 103 |
| 2 | <i>Journal of Clinical Sport Psychology</i> | 14 | 147 | 10.5 | Gustafsson et al. (2015) | 40 |
| 3 | <i>Frontiers in Psychology</i> | 13 | 57 | 4.4 | Mohammed et al. (2018) | 11 |
| 4 | <i>Psychology of Sport and Exercise</i> | 12 | 293 | 24.4 | Kee and Wang (2008) | 115 |
| 5 | <i>Mindfulness</i> | 9 | 218 | 24.2 | Birrer et al. (2012) | 99 |
| 6 | <i>Journal of Applied Sport Psychology</i> | 7 | 62 | 8.9 | Ivarsson et al. (2015) | 38 |
| 7 | <i>International Journal of Sport and Exercise Psychology</i> | 6 | 55 | 9.2 | Gross et al. (2018) | 48 |
| 8 | <i>International Journal of Sport Psychology</i> | 6 | 24 | 4.0 | Scott-Hamilton et al. (2016) | 6 |
| 9 | <i>International Journal of Environmental Research and Public Health</i> | 5 | 17 | 3.4 | Li et al. (2019) | 14 |
| 10 | <i>Current Psychology</i> | 5 | 11 | 2.2 | Tingaz et al. (2020) | 4 |

search criteria, followed closely by the *Journal of Clinical Sport Psychology* (14 articles), *Frontiers in Psychology* (13 articles), and *Psychology of Sport and Exercise* (12 articles). *Psychology of Sport and Exercise* accounts for the most citations (293) generated by the particular journal's articles. *Psychology of Sport and Exercise* and *Mindfulness* are the journals with the highest numbers of citations per article and therefore can also be seen as the most influential journals so far. Four journals produced at least 10 publications, accounting for 29% of all publications. The top 10 journals accounted for 50% of all publications.

Keyword Co-occurrence (Network) Analysis

Keywords capture the highly concentrated essence of literature research, and their co-occurrence frequency can indicate dynamic trends in the respective field (van Eck & Waltman, 2010). After the keywords were cleaned and merged with different spellings, abbreviations, or the same meaning, 603 keywords remained for analysis. Fifty-four keywords were used seven times or more. After irrelevant keywords were deleted, such as psychology or sports, 32 keywords remained for keyword co-occurrence analysis. The top 20 co-occurring keywords are shown in Table 4. Mindfulness (102) and performance (57) were the most frequent, followed by psychometric (48), meditation (47), flow (39), acceptance (33),

anxiety (34), and stress (37). The least frequent co-occurring keywords in the top 20 list were CBT (10), mental health (14), MSPE (15), and psychological skills (16). MSPE stands for mindfulness sports performance enhancement, another sport-specific intervention program based on ACT.

However, the number of mentions of a keyword alone only gives a limited picture of the keyword co-occurrence analysis. The VOSviewer network analysis feature makes it possible to identify clusters of keywords to which the items have been assigned. Four clusters were identified and visualized using this network analysis feature (Fig. 3). The first cluster depicted in red included ten keywords (meditation, flow, acceptance, stress, stress reduction, performance enhancement, enhancement, health, burnout, therapy). This cluster seems to be a bit heterogeneous. Nevertheless, a key feature of this cluster might be the aspects of flow and acceptance. The second cluster (in green color) consisted of the keywords mindfulness, depression, mental health, CBT, ACT, well-being, self-compassion, questionnaire, sport injuries, and stress regulation. The second cluster was characterized by keywords related to mental health and specific therapies/schools. The third cluster, colored in blue, included the keywords performance, psychometric, anxiety, attention, emotion regulation, scales, MAC, mechanisms, and self-regulation. This third cluster seems to represent a branch of keywords related to impact mechanisms, presumably with the outcome variable performance and additional keywords, such as anxiety, emotion regulation, and attention as possible mediators. The smallest and fourth cluster colored in yellow consisted of the keywords MSPE, psychological skills, and relaxation. We named this cluster the PST branch (PST for psychological skills training), which also represents an early phase of sport mindfulness research.

VOSviewer's overlay visualization function offers the possibility to display a time course in color. This makes it possible to illustrate the time course of the emerging keywords. The overlay visualization (Fig. 4) shows that the first frequently used keywords were psychological skills training, relaxation, and meditation (colored in dark blue). Later, terms such as stress, attention, CBT, and acceptance were added (colored in blue-green). Then, was an apparent shift from psychometric aspects to performance and (impact) mechanisms, such as attention, emotion, and self-regulation (colored in green). Finally, there was a shift to issues related to well-being, mental health, and self-compassion (colored in yellow).

VOSviewer also offers the possibility to display connections between self-selected keywords and other keywords. We did this for the keywords performance (a central aspect in the research of the mindfulness concept in sports) and mechanisms (another important concept). Figure 5 shows the fragment of the overlay visualization for the term performance. It can be seen that, in the early phase of the research, performance was often mentioned

Table 4 Top 20 co-occurring keywords (1969 to 2021)

| Rank | Keywords | Co-occurrence frequency | Total link strength |
|------|-------------------------|-------------------------|---------------------|
| 1 | Mindfulness | 102 | 561 |
| 2 | Performance | 57 | 312 |
| 3 | Psychometric | 48 | 304 |
| 4 | Meditation | 47 | 282 |
| 5 | Flow | 39 | 266 |
| 6 | Acceptance | 33 | 236 |
| 7 | Anxiety | 34 | 212 |
| 8 | Stress | 37 | 207 |
| 9 | Depression | 21 | 150 |
| 10 | Stress reduction | 20 | 149 |
| 11 | Performance enhancement | 20 | 139 |
| 12 | Mechanisms | 22 | 139 |
| 13 | Attention | 20 | 101 |
| 14 | Emotion regulation | 16 | 94 |
| 15 | Health | 15 | 91 |
| 16 | Scales | 14 | 89 |
| 17 | Psychological skills | 16 | 86 |
| 18 | MSPE | 15 | 86 |
| 19 | Mental health | 14 | 84 |
| 20 | CBT | 10 | 75 |

Fig. 3 Keyword co-occurrence clusters in the mindfulness and sport literature (constructed using VOSviewer v.1.6.18 for the sample, $n = 603$, f (frequency) > 7). Four clusters are depicted in different colors. The size of the circles represents the total link strength. The line width of the connections between circles represents the strength of the respective affiliation

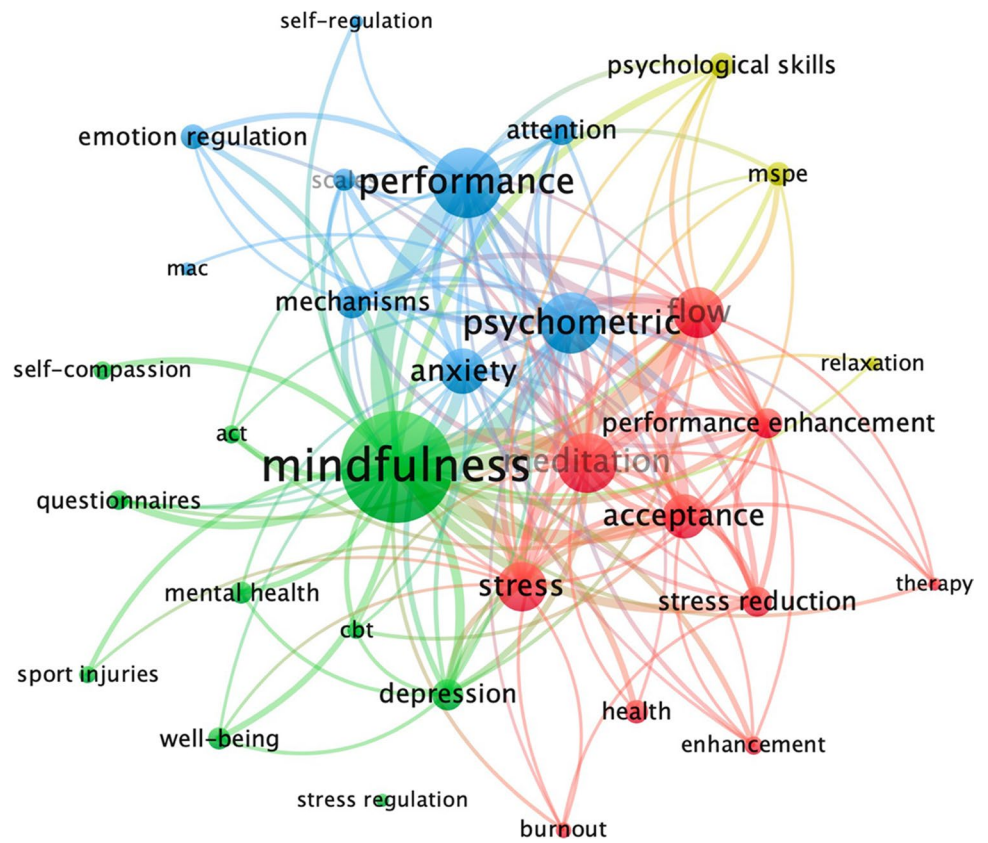


Fig. 4 Overlay visualization of the most frequent keywords (constructed using VOSviewer v.1.6.18 for the sample, $n = 603$, f (frequency) > 7), where the score of the item is its average publication year

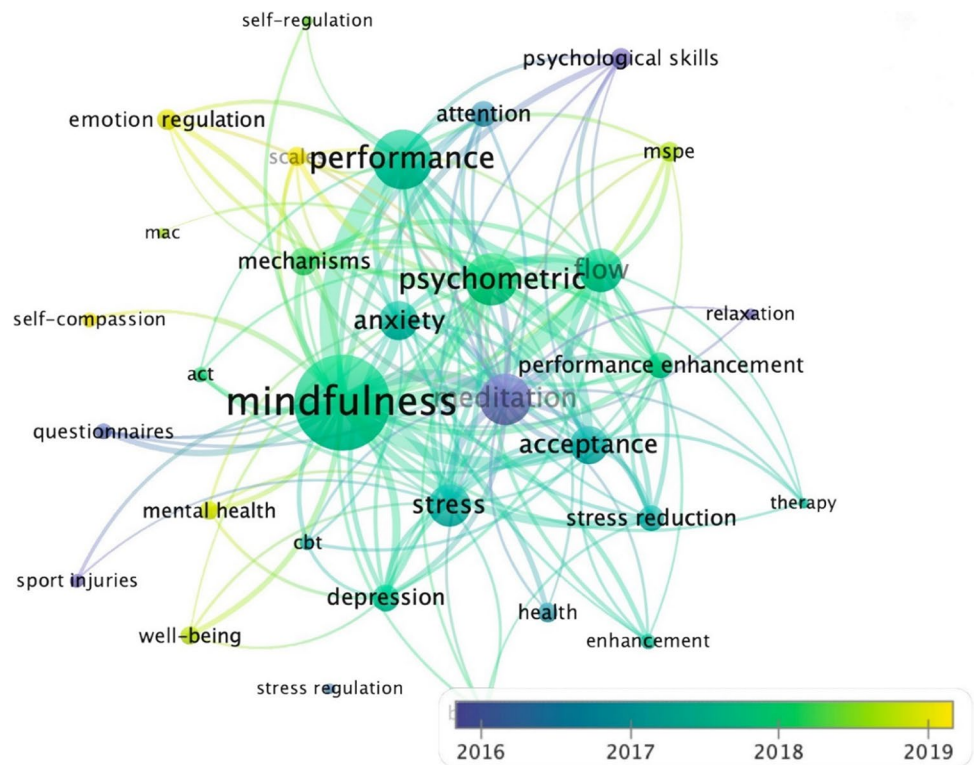
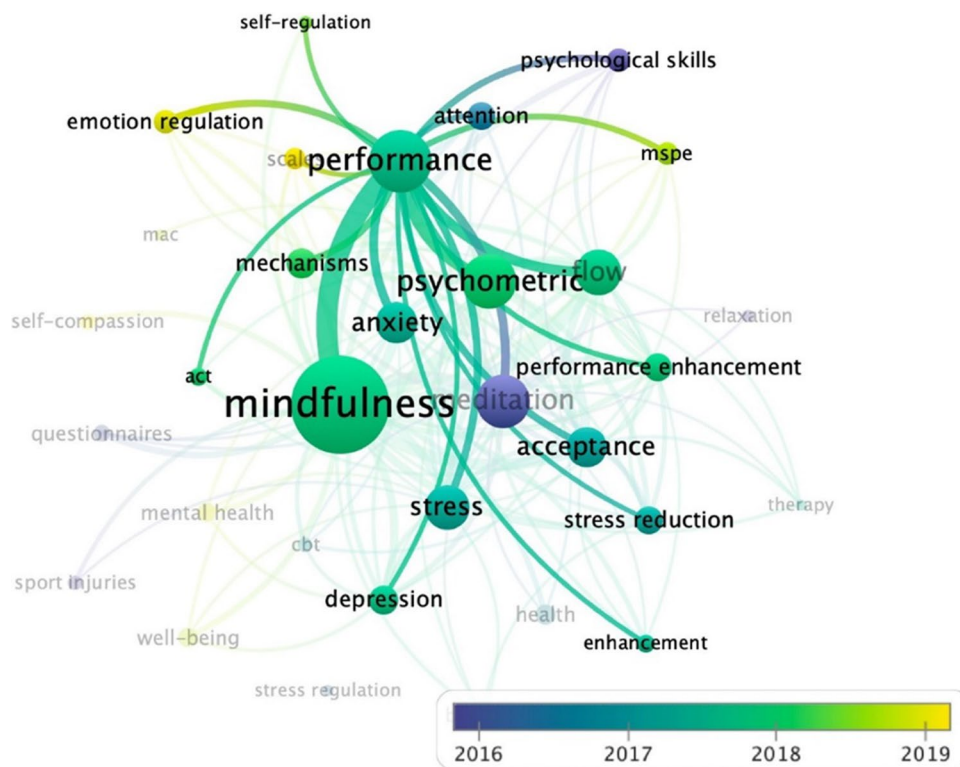


Fig. 5 The fragment of the overlay visualization for the term “performance”



with the keywords meditation, psychological skills, and attention. Later, the keywords more often included the terms acceptance, stress, and anxiety, followed by flow, psychometric, and ACT. In the last phase, the terms self-regulation and emotion regulation appeared.

A similar—but not the same—picture can be seen with the fragmentation of the keyword mechanisms. In the first period, this keyword appeared in connection with meditation, followed by acceptance and stress. Subsequently, it was connected with the terms anxiety, flow, and performance. In the last period, the keyword mechanisms was associated with emotion regulation and scale (Fig. 6).

Citation Bursts

Past trends can be detected by analyzing citation bursts, which suggest increased scholarly attention to the respective publications. The top 10 citation bursts detected and visualized using CiteSpace in the period 2012–2021 are depicted in Fig. 7. The first two articles with citation bursts focused on the psychometric properties of two measurements of mindfulness or related concepts (Baer et al., 2008; Bond et al., 2011). Sappington and Longshore’s (2015) article has had an especially long-lasting citation burst. This burst started briefly in 2017 and is still ongoing. Other articles also have ongoing citation bursts. Notable among them is the article by Creswell (2017), which was not from the sports context and generally described mindfulness interventions and their effects

based on a review of RCTs. The burst of this article started in 2018 shortly after its publication and continues today. One of the two articles with the strongest citation bursts was a RCT investigating the effects of MAC interventions (Gross et al., 2018), and the other presented two studies using a cross-sectional design and a longitudinal design respectively, examining a proposed theoretical model of mindfulness mechanisms in sports (Josefsson et al., 2017).

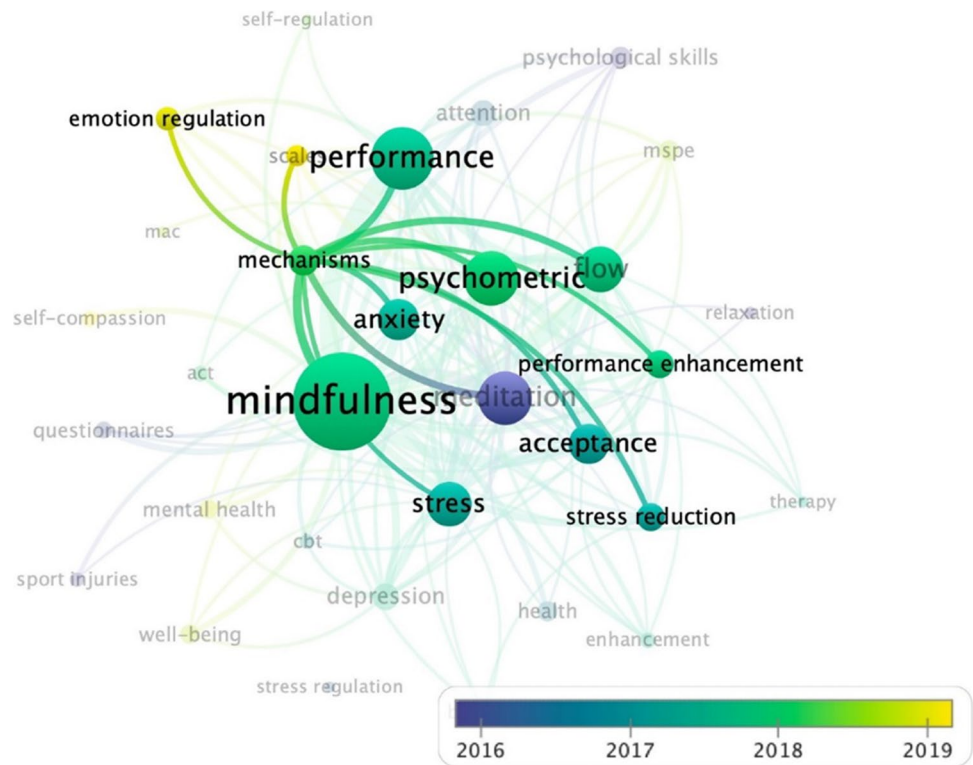
Advanced Search and Content Analysis

In order to detect emerging trends, a brief analysis of the content was performed on the titles and abstracts of the articles published in 2020 and 2021. Reading only a paper’s abstract, main findings, and contributions and analyzing its content can give an understanding of its value for further study. Two emerging fields were detected. The first is research on the role of mindfulness in fatigue, recovery, and sleep (e.g., Coimbra et al., 2021; Lever et al., 2021). The second potentially emerging field is neuroscientific aspects of mindfulness in the context of sports (e.g., Lu et al., 2021; Nien et al., 2020).

Discussion

This study provided an overview of the evolution of publications on mindfulness and sports in the past three decades by identifying the development of publications as well as the most

Fig. 6 The fragment of the overlay visualization for the term “mechanisms”



prolific countries, regions, prolific institutions, and journals across the years. Additionally, it offered some insights on the existing knowledge structure as well as an overview of the evolutionary nuances of topics and research interests related to this field.

Bibliographic data from the WoS Core Collection revealed that the first identified article on mindfulness OR meditation in the sport domain was published in 1977 (Hickman et al., 1977). In comparison and also according to the WoS database, the first identified article outside of sports on meditation OR mindfulness was published in 1963 (Wang et al., 2021), while

the first identified article outside of sports on mindfulness was published in 1966 (Baminiwatta & Solangaarachchi, 2021). The observed trend of more publications on mindfulness and sports over the years matches the general trend in mindfulness and meditation publications (Baminiwatta & Solangaarachchi, 2021; Wang et al., 2021), but of course, it is less pronounced as the topic becomes narrower. The increase in the number of mindfulness and meditation articles from 131 in 2000 to 2978 in 2020 (Wang et al., 2021) was much larger on an absolute basis than the increase from one to 32 papers found with the specified search criteria regarding mindfulness and

Top 10 References with the Strongest Citation Bursts

| References | Year | Strength | Begin | End | 2012 - 2021 |
|--|------|----------|-------|------|-------------|
| Baer et al. (2008). https://doi.org/10.1177/1073191107313003 | 2008 | 3.43 | 2016 | 2017 | |
| Bond et al. (2011). https://doi.org/10.1016/j.beth.2011.03.007 | 2011 | 3.36 | 2016 | 2018 | |
| Sappington & Longshore (2015). https://doi.org/10.1123/jcsp.2014-0017 | 2015 | 3.74 | 2017 | 2021 | |
| Gardner & Moore (2012). https://doi.org/10.1037/a0030220 | 2012 | 3.55 | 2017 | 2018 | |
| Creswell (2017). https://doi.org/10.1146/annurev-psych-042716-051139 | 2017 | 3.95 | 2018 | 2021 | |
| Gross et al. (2018). https://doi.org/10.1080/1612197X.2016.1250802 | 2018 | 5.98 | 2019 | 2021 | |
| Josefsson et al. (2017). https://doi.org/10.1007/s12671-017-0711-4 | 2017 | 5.98 | 2019 | 2021 | |
| Zhang et al. (2016). https://doi.org/10.1016/j.psychsport.2015.09.005 | 2016 | 4.91 | 2019 | 2021 | |
| Scott-Hamilton et al. (2016). https://doi.org/10.7352/IJSP.2016.47.103 | 2016 | 3.85 | 2019 | 2021 | |
| Röthlin et al. (2016). https://doi.org/10.1007/s12671-016-0512-1 | 2016 | 3.62 | 2019 | 2021 | |

Fig. 7 Top 10 references with the strongest citation bursts (2012–2021). The duration of the burst is indicated by the red line along the time line. The darker blue line indicates the publication year. Note: The graphic was automatically generated by CiteSpace, and therefore,

the references do not conform to the APA format. Note. The graphic was automatically generated by CiteSpace. Readers are referred to the corresponding doi numbers. Zhang et al. (2016) and Röthlin et al. (2016) are not mentioned in the article text.

sports. The increase in the number of publications seems to mirror a general trend within the mindfulness field and shows that while the first publications regarding mindfulness and sports appeared in the 1990s, the amount only began to increase steadily around 2014. In contrast, the exponential growth of the general mindfulness literature was evident from 2006 onwards (Baminiwatta & Solangaarachchi, 2021). In this sense, the mindfulness publications in sports are around 10 years behind the general psychology literature.

Nevertheless, the absolute number of publications in the field of sports seems to be rather low compared to the number of publications in the general mindfulness literature as a comparison with the studies of Baminiwatta and Solangaarachchi (2021) (186 vs. 16,581) and Wang et al. (2021) (186 vs. 19,753) shows. This might be due to the restrictive selection criterion of checking whether mindfulness and sports were an important focus in the article, as only 186 of the 769 screened articles remained for further examination. However, because of the extensive number of publications, the authors of both bibliometric studies of the general mindfulness literature did not attempt to peruse each article to check whether mindfulness was an important focus of each article. For example, one of the most frequently cited articles in both studies was a review from Deci and Ryan (2008) on self-determination theory, discussing both mindfulness and sports only as a minor correlate of motivation or an applied domain of self-determination theory. This suggests that the numbers of publications in the general mindfulness literature might be somewhat overestimated by Wang et al. (2021) and Baminiwatta and Solangaarachchi (2021).

Interestingly, the three most productive countries identified in the mindfulness literature in the sports domain (USA, Australia, and England) match the three most prolific countries identified by Wang et al. (2021), with England and Australia changing rank. Seven of the 10 most prolific countries identified by Wang et al. (2021) were also in the top 10 most prolific countries for mindfulness publications in sport. However, as in the general mindfulness literature, a trend of increasing contributions to the mindfulness literature in sports by Asian countries, especially China, is observable. In the last 5 years, China contributed 15 publications to the research on mindfulness and sports and thus contributed the second most number of articles to the publication output, right after the USA with 33 publications during this period.

Unsurprisingly, the majority of the most prolific journals identified were situated within the sport research area. However, the two journals that published the most mindfulness and meditation articles from 1900 to 2021 (Baminiwatta & Solangaarachchi, 2021; Wang et al., 2021), *Mindfulness* and *Frontiers in Psychology*, were also within the top five most productive journals identified in the present study. In terms of citation rates per published article, the

most influential journals were *Psychology of Sport and Exercise* and *Mindfulness*, with the average number of citations per contribution exceeding 24.

Citation bursts reflect a sharp increase in the interest in a particular research topic. Two articles (Baer et al., 2008; Creswell, 2017) that were identified as having citation bursts in the sports domain were also among the top 25 references with the strongest citation bursts in the bibliometric analysis of Baminiwatta and Solangaarachchi (2021), showing a small overlap in cited references for mindfulness publications. Two of the top 10 articles with citation bursts focused on the psychometric properties of a mindfulness measurement instrument (Baer et al., 2008; Bond et al., 2011), three were reviews, one of which was a review of RCTs employing mindfulness interventions outside sport, three were cross-sectional studies and two were RCTs within the sport domain. This might demonstrate the increased interest in enhancing the scientific evidence on mindfulness- and acceptance-based interventions in sport.

A comparison of the top 20 co-occurring keywords in the publication of Wang et al. (2021) and the current study provides insight into the different research foci and perspectives. Six of the top 20 co-occurring keywords in the mindfulness sports literature were not present in the study of Wang et al. (2021): performance (ranked 2), psychometric (rank 3), flow (rank 5), performance enhancement (rank 11), scales (rank 16), and MSPE (rank 18). Clinical expressions were used less often as keywords than in the general mindfulness literature. This shows that mindfulness research in the sport domain is more focused on mindfulness as a means of performance enhancement. This suggests that the intention to practice mindfulness is often connected to the wish to enhance one's self-regulation and performance. The fact that MSPE, a keyword with this precise connotation, was in the top 20 illustrates this notion.

As mentioned above, one branch of sport mindfulness research is associated with ACT or sport-specific adaptations of ACT. This is also reflected in the fact that acceptance as a keyword is used more frequently in sport mindfulness research than in the general mindfulness literature. Furthermore, although measurement issues appear similarly in the general mindfulness literature and the sport-specific literature, they are more often addressed in the latter. One reason for this could be that some sport researchers believe that there is a need for sport-specific measurement tools due to sport's uniqueness. In fact, two sport-specific instruments for measuring habitual mindfulness have been developed and published (Thienot et al., 2014; Zhang et al., 2017), but neither made it into the top ten most frequently cited articles nor the one with the strongest citation burst in the sport-specific mindfulness literature.

Two of the top 20 keywords in the general mindfulness literature (Wang et al., 2021)—RCT and

meta-analyses—were not in the top 20 of the sport-specific mindfulness literature. This illustrates that sport mindfulness research is still in an early stage. This notion is confirmed by the analysis of citation bursts, which showed that scholars have a great interest in RCTs. This suggests that there is still a lack of high-quality studies in the sport-related mindfulness literature, and such studies will continue to be in demand in the future. Possible reasons for this could be that the state of research in the field of sport lags somewhat behind the general mindfulness research. In addition, it is difficult to conduct RCTs in the field of sports because it is problematic to justify why a certain group of athletes should only receive a control treatment.

The fact that flow is increasingly appearing as a term in the sport mindfulness literature deserves special consideration. The terms flow and mindfulness seem very similar at first glance. They both have been associated with mental health and optimal functioning, and both are pleasurable states. Confirming this, a considerable amount of scientific evidence exists showing that cultivating mindfulness causes athletes to experience more flow (summarized by Bühlmyer et al., 2017). However, at second glance, mindfulness and flow differ in key ways. Mindfulness cultivates the ability to be intentionally and consciously present in the here and now, with full awareness of external and internal events, moment to moment. Flow, on the other hand, involves a state of self-forgetfulness, a loss of the sense of time, and a merging of action and consciousness (Jackson & Csikszentmihalyi, 1999). These components of flow can be subsumed under the aspects of absorption or immersion (Sheldon et al., 2015).

In particular, these flow aspects of merging action and consciousness, self-forgetfulness, and loss of the sense of time are incompatible with mindfulness. In contrast, the felt control facet of flow is non-associated or positively associated with mindfulness. Moreover, according to Sheldon et al. (2015), different brain areas are involved in the flow state and the mindfulness state, which suggests a clear differentiation between the two constructs. This distinction is so far not recognized in the mindfulness sports literature and should be made in future research.

Co-citation clusters and their temporal progression in the early period provided further insights on the development of scientific interest in mindfulness and meditation in sport. The clusters generated by VOSviewer were reasonably easy to interpret (Fig. 3). The first rather heterogeneous cluster (colored in red), which includes the keywords flow, acceptance, stress, and stress reduction, characterizes a particular branch of research related to the study of flow states. The second cluster (colored in green) and the main keyword mindfulness seem to be thematically characterized

by the keywords mental health and therapeutic directions. It also includes CBT and ACT. This indicates that, in addition to the focus on performance, mental health has gained importance in sport mindfulness research. The third cluster is characterized by the keywords performance and psychometric. In this cluster, one main aspect seems to involve mechanisms of action of mindfulness interventions on sports performance. It includes keywords like anxiety, self-regulation, emotion regulation, and attention. This reflects the idea that mindfulness training leads to better emotion regulation, better attention control, and thus to better athletic performance (Birrer et al., 2012).

Overlay visualization shows the tendencies of new emerging trends and past trends (Fig. 4). Here, it shows that in the beginning phase of research in the sport domain, mindfulness research was characterized by terms such as psychological skills training, relaxation, and meditation. In the beginning years, mindfulness was seen as a technique like other psychological skills that could be used to enhance self-regulation and performance (Birrer & Morgan, 2010). Later, terms like stress, attention, CBT, and acceptance received more attention in the sport-specific mindfulness literature. Subsequently, there might have been a shift toward psychometric aspects, as well as performance and impact mechanisms such as attention, emotion regulation, and self-regulation in general. This is consistent with the recently increasing interest in impact mechanisms and moderators in the general mindfulness research (Baminiwatta & Solangaarachchi, 2021). The most recent shift has involved a focus on well-being, mental health, and self-compassion. These keywords mark the current trend in the mindfulness research in sports, illustrating that the primary research foci of the general mindfulness literature (mental health, quality of life; Wang et al., 2021) have also received more attention in the sports domain. However, overlay visualization shows the mean publication year of respective keywords. This means that early trends and the newest trends can be easily interpreted, but not the keywords depicted in green (Fig. 4). These keywords may have been used more frequently in a relatively limited time period. However, they may also have been used repeatedly over a longer period of time, such as mindfulness, which was understandably used most frequently and, of course, over the entire time period. Thus, these keywords could be called evergreens. This is the case for mindfulness, and it might also be true for performance, psychometric, and flow, which again confirms that the term performance is central to sport mindfulness research, most commonly as an outcome variable. Moreover, it can be hypothesized that psychometric issues do not seem to have been solved, as they appeared repeatedly as keywords over the whole time period, which might reflect a lack of conceptual clarity in the mindfulness research. This tendency can also be found in bibliometric studies in the general mindfulness literature.

The fragments of overlay visualization for the terms performance and mechanisms (Figs. 5 and 6) shed light on the newly emerging trends and past trends of these two keywords. In the early stage of research, the keyword performance was highly interconnected with the keywords meditation, psychological skills, and attention. In the most recent period, this interconnection shifted to the terms anxiety, self-regulation, and emotion regulation. This is in line with the fragment of the keyword mechanisms. In the early stage, acceptance and stress and stress reduction were seen as possible impact mechanisms, while in the most recent period, emotion regulation received more attention. Although, as stated above, the flow aspects of merging action and consciousness, self-forgetfulness, and loss of the sense of time are incompatible with mindfulness, the keyword flow has been steadily interconnected with the keywords performance and mechanisms in the literature on mindfulness and sports.

In addition to an increasing interest in mechanisms and moderators, the recent trends (2016–2021) in the general mindfulness literature revealed a growing interest in long-term meditation, neuroscientific studies, and smartphone/online delivery of interventions (Baminiwatta & Solangaarachchi, 2021). The growing interest in the neurobiological and neuroscientific basis of mindfulness was not reflected in an increased appearance of corresponding keywords and was only apparent in our extended analysis of the abstracts and content of the latest studies. For example, similar to the frequently cited review article by Tang et al. (2015), a review on neuroscientific findings of mindfulness studies in sports has recently been published (Bondár et al., 2021). The trend of interest in long-term meditation and smartphone/online delivery of interventions was not detected in the current study, although the first publications on online interventions are emerging (Lasnier & Durand-Bush, 2022). However, our extended analysis of the abstracts and content of the most recent literature revealed a possible trend that does not seem to be present in the general mindfulness research, namely, research on the role of mindfulness in fatigue, recovery, and sleep.

Although a key feature of mindfulness is conscious attention in the present moment, the term consciousness did not appear in either the general mindfulness or sports-specific literature. This is surprising since a considerable amount of general mindfulness articles were published in *Consciousness and Cognition* (Baminiwatta & Solangaarachchi, 2021), and using the citations per article as an indication of a journal's influence, *Consciousness and Cognition* can be called the third most influential journal (Wang et al., 2021).

Finally, the concept of mindfulness is used in three distinct ways: (1) as a set of skills that develop with practice and help one to be in a mindful state, (2) as a dispositional

or trait-like general tendency to be mindful in everyday life, and (3) as a mindfulness practice that develops this set of skills. Therefore, the following three different research directions can also be observed:

- (1) Induction studies, where researchers induce a state of mindfulness and investigate the influence of this state of mindfulness on, e.g., performance.
- (2) Cross-sectional studies, where researchers are interested in the impact of trait mindfulness on, e.g., performance and its mediators.
- (3) Intervention studies, where researchers investigate the influence of mindfulness practice and its impact on outcome variables, preferably with RCTs.

All three forms of research are present in the sport-related mindfulness literature. However, high-quality intervention studies are still in the minority.

Limitations and Future Research

This paper provides insights on the emerging field of mindfulness research in sports as well as on recent and possible future trends. Keywords and co-occurring keyword analysis showed that one-third of the research is related to acceptance, and ACT and its sport-specific adaptations (MAC and MSPE) are highly represented in the sport-specific mindfulness literature. Although mindfulness and ACT share many similarities, it is plausible that they do not work through the same impact mechanisms, which is one of the recent research trends. Future research should explicitly indicate what type of interventions were studied and whether it is a classic mindfulness intervention or a sport-specific ACT intervention. In the latter case, a key point would be to ascertain exactly how much mindfulness/meditation practice was conducted in the intervention and what additional variables changed as a result of the intervention. Further, more emphasis should be placed on what type of mindfulness meditation was conducted, as different forms of practice seem to have different effects (Lippelt et al., 2014; Tang et al., 2015). However, this will require conceptual clarity about the mindfulness construct. In addition, it will also require a clear understanding of the mechanisms through which MABI affect specific outcome variables, such as performance, well-being, and mental health. Indeed, some of the emerging trends go in this direction. For example, emotion regulation is a recent topic with regard to the impact mechanisms in the relation between mindfulness and performance, and self-compassion is a relative new topic in the sports domain, mostly connected with mental health and well-being. Research on the neuroscientific basis of mindfulness in connection with behavioral data could be helpful for advancing the understanding of this issue. The

first trends in this direction can be observed in the most recent literature.

Measurement issues were present from the inception of mindfulness research in sports until the most recent period. This indicates that a common understanding of the psychological construct of mindfulness is still lacking. It is thus essential to pay more attention to the definition of mindfulness, its components, and how mindfulness is fostered. For example, Birrer et al. (2021) suggested that the mindfulness components present-moment awareness, meta-cognitive awareness, and acceptance are three impact mechanisms through which mindfulness affects performance, mental health, and well-being, which also have been investigated in the non-sport-specific mindfulness research (Gawrysiak et al., 2018). In this vein, mindfulness research would benefit from addressing conceptual issues more systematically and persistently. Of course, this approach would also require that further progress be made in the development of mindfulness measurement instruments.

Finally, future research would benefit from an increased focus on the role of human consciousness and its neuroscientific underpinnings in clarifying the mindfulness concept. This would also be consistent with the trend of interweaving neuroscientific and neurobiological findings with behavioral data.

Several limitations of this bibliometric analysis should be noted. This study used the WoS Core Collection with the search terms “mindfulness,” “meditation,” and “sport”—and in an additional step, “acceptance”—to identify mindfulness and acceptance studies in the sport domain. With both mindfulness and meditation as terms, the search results might be overestimated. Although mindfulness is generally fostered through mindfulness meditation, mindfulness and meditation are not the same and especially early research was on transcendental meditation, e.g., Hall and Hardy (1991). However, the search yielded 769 articles, which were examined to determine whether mindfulness meditation and sports were important foci in each article. This reduced the number of articles to 186, which is a relatively small number for bibliometric analysis. Further, in recent years, an increasing number of articles have been published online first. Hence, the publication figures for the last two to three publication years evaluated could be somewhat distorted.

As a form of quantitative analysis, bibliometrics are grounded in titles, abstracts, keywords, references, publication year, author affiliation, and author names. No other content-related information, such as effect sizes or relationships of different variables, are considered. This limits the information to bibliometric variables and their development over time. Although bibliometrics can predict the status and development of a specific field, the predictions are limited to

certain quantitative indicators. Nevertheless, bibliometrics can offer some helpful information on a specific research topic.

Author Contribution D.B.: conceptualization, methodology, validation, investigation, formal analysis, writing—original draft, writing—review and editing, visualization. B.S.: conceptualization, methodology, validation, investigation, formal analysis, writing—review and editing, visualization. N.F.: methodology, investigation, writing—original draft, writing—review and editing, visualization.

Funding Open access funding provided by Bern University of Applied Sciences

Data Availability All data are openly available in the Web of Science core database and CiteSpace.

Declarations

Conflict of Interest The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Aherne, C., Aidan, P. M., & Lonsdale, C. (2011). The effect of mindfulness training on athletes' flow: An initial investigation. *The Sport Psychologist*, 25, 177–189. <https://doi.org/10.1123/tsp.25.2.177>
- Baer, R. (2019). Assessment of mindfulness by self-report. *Current Opinion in Psychology*, 28, 42–48. <https://doi.org/10.1016/j.copsyc.2018.10.015>
- Baer, R. A., Smith, G. T., Lykins, E., Button, D., Krietemeyer, J., Sauer, S., Walsh, E., Duggan, D., & Williams, J. M. G. (2008). Construct validity of the Five Facet Mindfulness Questionnaire in meditating and nonmeditating samples. *Assessment*, 15(3), 329–342. <https://doi.org/10.1177/1073191107313003>
- Baminiwatta, A., & Solangaarachchi, I. (2021). Trends and developments in mindfulness research over 55 years: A bibliometric analysis of publications indexed in web of science. *Mindfulness*, 12(9), 2099–2116. <https://doi.org/10.1007/s12671-021-01681-x>
- Birrer, D., & Morgan, G. (2010). Psychological skills training as a way to enhance an athlete's performance in high-intensity sports. *Scandinavian Journal of Medicine & Science in Sports*, 20, 78–87. <https://doi.org/10.1111/j.1600-0838.2010.01188.x>
- Birrer, D., Röthlin, P., & Morgan, G. (2012). Mindfulness to enhance athletic performance: Theoretical considerations and possible impact mechanisms. *Mindfulness*, 3(3), 235–246. <https://doi.org/10.1007/s12671-012-0109-2>

- Birrer, D., Röthlin, P., & Morgan, G. (2021). Helping athletes flourish using mindfulness and acceptance approaches – an introduction and mini review. *Sport & Exercise Medicine Switzerland*, 69(2), 29–34. <https://doi.org/10.34045/SEMS/2021/18>
- Bishop, S. R., Lau, M., Shapiro, S., Carlson, L., Anderson, N. D., Carmody, J., Segal, Z. V., Abbey, S., Speca, M., Velting, D., & Devins, G. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice*, 11, 230–241. <https://doi.org/10.1093/clipsy.bph077>
- Bond, F. W., Hayes, S. C., Baer, R. A., Carpenter, K., Orcutt, H. K., Waltz, T., & Zettle, R. D. (2011). Preliminary psychometric properties of the Acceptance and Action Questionnaire-II: A revised measure of psychological flexibility and acceptance. *Behavior Therapy*, 42(4), 676–688. <https://doi.org/10.1016/j.beth.2011.03.007>
- Bondár, R. Z., Bertollo, M., di Fronso, S., & Robazza, C. (2021). Mindfulness to performance enhancement: A systematic review of neural correlates. *International Review of Sport and Exercise Psychology*. <https://doi.org/10.1080/1750984X.2021.1949742>
- Bühlmayer, L., Birrer, D., Röthlin, P., Faude, O., & Donath, L. (2017). Effects of mindfulness practice on performance-relevant parameters and performance outcomes in sports: A meta-analytical review. *Sports Medicine*, 47(11), 2309–2321. <https://doi.org/10.1007/s40279-017-0752-9>
- Carvalho, M. M., Fleury, A., & Lopes, A. P. (2013). An overview of the literature on technology roadmapping (TRM): Contributions and trends. *Technological Forecasting and Social Change*, 80(7), 1418–1437. <https://doi.org/10.1016/j.techfore.2012.11.008>
- Chen, C. (2006). CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. *Journal of the American Society for Information Science and Technology*, 57(3), 359–377. <https://doi.org/10.1002/asi.20317>
- Coimbra, D. R., Bevilacqua, G. G., Pereira, F. S., & Andrade, A. (2021). Effect of mindfulness training on fatigue and recovery in elite volleyball athletes: A randomized controlled follow-up study. *Journal of Sports Science and Medicine*, 20(1), 1–8. <https://doi.org/10.52082/jssm.2021.1>
- Creswell, J. D. (2017). Mindfulness interventions. *Annual Review of Psychology*, 68(1), 491–516. <https://doi.org/10.1146/annurev-psych-042716-051139>
- Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology/psychologie Canadienne*, 49(3), 182–185. <https://doi.org/10.1037/a0012801>
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285–296. <https://doi.org/10.1016/j.jbusres.2021.04.070>
- Dorjee, D. (2010). Kinds and dimensions of mindfulness: Why it is important to distinguish them. *Mindfulness*, 1(3), 152–160. <https://doi.org/10.1007/s12671-010-0016-3>
- Gardner, F. L., & Moore, Z. E. (2004). A mindfulness-acceptance-commitment-based approach to athletic performance enhancement: Theoretical considerations. *Behavior Therapy*, 35, 707–723. [https://doi.org/10.1016/S0005-7894\(04\)80016-9](https://doi.org/10.1016/S0005-7894(04)80016-9)
- Gardner, F. L., & Moore, Z. E. (2012). Mindfulness and acceptance models in sport psychology: A decade of basic and applied scientific advancements. *Canadian Psychology-Psychologie Canadienne*, 53(4), 309–318. <https://doi.org/10.1037/a0030220>
- Gawrysiak, M. J., Grasseti, S. N., Greeson, J. M., Shorey, R. C., Pohl, R., & Baime, M. J. (2018). The many facets of mindfulness and the prediction of change following mindfulness-based stress reduction (MBSR). *Journal of Clinical Psychology*, 74(4), 523–535. <https://doi.org/10.1002/jclp.22521>
- Germer, C. K., Siegel, R. D., & Fulton, P. R. (2005). *Mindfulness and psychotherapy*. Guilford Press.
- Gross, M., Moore, Z. E., Gardner, F. L., Wolanin, A. T., Pess, R., & Marks, D. R. (2018). An empirical examination comparing the mindfulness-acceptance-commitment approach and psychological skills training for the mental health and sport performance of female student athletes. *International Journal of Sport and Exercise Psychology*, 16(4), 431–451. <https://doi.org/10.1080/1612197X.2016.1250802>
- Gustafsson, H., Davis, P., Skoog, T., Kentta, G., & Haberl, P. (2015). Mindfulness and its relationship with perceived stress, affect, and burnout in elite junior athletes. *Journal of Clinical Sport Psychology*, 9(3), 263–281. <https://doi.org/10.1123/jcsp.2014-0051>
- Hall, E. G., & Hardy, C. J. (1991). Ready, aim, fire – relaxation strategies for enhancing pistol marksmanship. *Perceptual and Motor Skills*, 72(3), 775–786. <https://doi.org/10.2466/PMS.72.3.775-786>
- Hayes, S. C. (2004). Acceptance and commitment therapy, relational frame theory, and the third wave of behavioral and cognitive therapies. *Behavior Therapy*, 35(4), 639–665. [https://doi.org/10.1016/S0005-7894\(04\)80013-3](https://doi.org/10.1016/S0005-7894(04)80013-3)
- Henriksen, K., Haberl, P., Baltzell, A., Hansen, J., Birrer, D., & Larsen, C. H. (2020). Mindfulness and acceptance approaches: Do they have a place in elite sport? In K. Henriksen, J. Hansen, & C. Hvid Larsen (Eds.), *Mindfulness and acceptance in sport: How to help athletes perform and thrive under pressure* (pp. 1–16). Routledge.
- Hickman, J. L., Murphy, M., & Spino, M. (1977). Psychophysical transformations through meditation and sport. *Simulation & Games*, 8(1), 49–60. <https://doi.org/10.1177/003755007781004>
- Hölzel, B. K., Lazar, S. W., Gard, T., Schuman-Olivier, Z., Vago, D. R., & Ott, U. (2011). How does mindfulness meditation work? Proposing mechanisms of action from a conceptual and neural perspective. *Perspectives on Psychological Science*, 6(6), 537–559. <https://doi.org/10.1177/1745691611419671>
- Ivarsson, A., Johnson, U., Andersen, M. B., Fallby, J., & Altemyr, M. (2015). It pays to pay attention: A mindfulness-based program for injury prevention with soccer players. *Journal of Applied Sport Psychology*, 27(3), 319–334. <https://doi.org/10.1080/10413200.2015.1008072>
- Jackson, S. A., & Csikszentmihalyi, M. (1999). *Flow in sports*. Human Kinetics.
- Josefsson, T., Ivarsson, A., Lindwall, M., Gustafsson, H., Stenling, A., Böröy, J., Mattsson, E., Carnebratt, J., Sevhol, S., & Falkevik, E. (2017). Mindfulness mechanisms in sports: Mediating effects of rumination and emotion regulation on sport-specific coping. *Mindfulness*, 8(5), 1354–1363. <https://doi.org/10.1007/s12671-017-0711-4>
- Kabat-Zinn, J. (1982). An outpatient program in behavioural medicine for chronic pain patients based on the practice of mindfulness meditation: Theoretical considerations and preliminary results. *General Hospital Psychiatry*, 4, 33–47. [https://doi.org/10.1016/0163-8343\(82\)90026-3](https://doi.org/10.1016/0163-8343(82)90026-3)
- Kabat-Zinn, J. (2011). Some reflections on the origins of MBSR, skillful means, and the trouble with maps. *Contemporary Buddhism*, 12(01), 281–306. <https://doi.org/10.1080/14639947.2011.564844>
- Kee, Y. H., & Wang, C. K. (2008). Relationships between mindfulness, flow dispositions and mental skills adoption: A cluster analytic approach. *Psychology of Sport and Exercise*, 9(4), 393–411. <https://doi.org/10.1016/j.psychsport.2007.07.001>
- Lasnier, J., & Durand-Bush, N. (2022). The impact of an online sport psychology intervention for middle-distance runners: Should self-regulation or mindfulness be prioritized? *The Sport Psychologist*, 1–11. <https://doi.org/10.1123/tsp.2021-0180>
- Lever, J. R., Murphy, A. P., Duffield, R., & Fullagar, H. H. K. (2021). A combined sleep hygiene and mindfulness intervention to improve sleep and well-being during high-performance youth

- tennis tournaments. *International Journal of Sports Physiology and Performance*, 16(2), 250–258. <https://doi.org/10.1123/ijsp.2019-1008>
- Li, C. X., Zhu, Y. X., Zhang, M. G., Gustafsson, H., & Chen, T. (2019). Mindfulness and athlete burnout: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, 16(3), 449. <https://doi.org/10.3390/ijerph16030449>
- Lippelt, D. P., Hommel, B., & Colzato, L. S. (2014). Focused attention, open monitoring and loving kindness meditation: effects on attention, conflict monitoring, and creativity—a review. *Frontiers in Psychology*, 5, 1083. <https://doi.org/10.3389/fpsyg.2014.01083>
- Lu, Q. Y., Li, P. L., Wu, Q., Liu, X. H., & Wu, Y. H. (2021). Efficiency and enhancement in attention networks of elite shooting and archery athletes. *Frontiers in Psychology*, 12, 638822. <https://doi.org/10.3389/fpsyg.2021.638822>
- Mohammed, W. A., Pappous, A., & Sharma, D. (2018). Effect of Mindfulness Based Stress Reduction (MBSR) in increasing pain tolerance and improving the mental health of injured athletes. *Frontiers in Psychology*, 9, 722. <https://doi.org/10.3389/fpsyg.2018.00722>
- Morgan, W. P. (1995). Anxiety and panic in recreational scuba-divers. *Sports Medicine*, 20(6), 398–421. <https://doi.org/10.2165/00007256-199520060-00005>
- Mosewich, A. D., Crocker, P. R., Kowalski, K. C., & DeLongis, A. (2013). Applying self-compassion in sport: An intervention with women athletes. *Journal of Sport & Exercise Psychology*, 35(5), 514–524. <https://doi.org/10.1123/jsep.35.5.514>
- Nien, J. T., Wu, C. H., Yang, K. T., Cho, Y. M., Chu, C. H., Chang, Y. K., & Zhou, C. L. (2020). Mindfulness training enhances endurance performance and executive functions in athletes: An event-related potential study. *Neural Plasticity*, 2020, 1–12. <https://doi.org/10.1155/2020/8213710>
- Noetel, M., Ciarrochi, J., Van Zanden, B., & Lonsdale, C. (2019). Mindfulness and acceptance approaches to sporting performance enhancement: A systematic review. *International Review of Sport and Exercise Psychology*, 12(1), 139–175. <https://doi.org/10.1080/1750984X.2017.1387803>
- Peng, C. K., Mietus, J. E., Liu, Y. H., Khalsa, G., Douglas, P. S., Benson, H., & Goldberger, A. L. (1999). Exaggerated heart rate oscillations during two meditation techniques. *International Journal of Cardiology*, 70(2), 101–107. [https://doi.org/10.1016/S0167-5273\(99\)00066-2](https://doi.org/10.1016/S0167-5273(99)00066-2)
- Quaglia, J. T., Brown, K. W., Lindsay, E. K., Creswell, J. D., & Goodman, R. J. (2015). From conceptualization to operationalization of mindfulness. In K. W. Brown, J. D. Creswell, & R. M. Ryan (Eds.), *Handbook of mindfulness. Theory, research, and practice* (pp. 151–170). Guilford Press.
- Robertson, D. W. (1983). The short and long range effects of the transcendental meditation technique on fractionated reaction time. *The Journal of Sports Medicine and Physical Fitness*, 23(1), 113–120.
- Röthlin, P., Horvath, S., Birrer, D., & Holtforth, M. G. (2016). Mindfulness promotes the ability to deliver performance in highly demanding situations. *Mindfulness*, 7(3), 727–733. <https://doi.org/10.1007/s12671-016-0512-1>
- Sappington, R., & Longshore, K. (2015). Systematically reviewing the efficacy of mindfulness-based interventions for enhanced athletic performance. *Journal of Clinical Sport Psychology*, 9(3), 232–262. <https://doi.org/10.1123/jcsp.2014-0017>
- Scott-Hamilton, J., Schutte, N. S., Moyle, G. M., & Brown, R. E. (2016). The relationships between mindfulness, sport anxiety, pessimistic attributions and flow in competitive cyclists. *International Journal of Sport Psychology*, 47(2), 103–121. <https://doi.org/10.7352/IJSP.2016.47.103>
- Sheldon, K. M., Prentice, M., & Halusic, M. (2015). The experiential incompatibility of mindfulness and flow absorption. *Social Psychological and Personality Science*, 6(3), 276–283. <https://doi.org/10.1177/1948550614555028>
- Tang, Y. Y., Hölzel, B. K., & Posner, M. I. (2015). The neuroscience of mindfulness meditation. *Nature Reviews Neuroscience*, 16(4), 213–225. <https://doi.org/10.1038/nrn3916>
- Thienot, E., Jackson, B., Dimmock, J., Grove, J. R., Bernier, M., & Fournier, J. F. (2014). Development and preliminary validation of the mindfulness inventory for sport. *Psychology of Sport and Exercise*, 15(1), 72–80. <https://doi.org/10.1016/j.psychsport.2013.10.003>
- Tingaz, E. O., Ekiz, M. A., & Çakmak, S. (2020). Examination of mindfulness and impulsiveness in university student-athletes in terms of sports injury development history. *Current Psychology*, 41(8), 5134–5142. <https://doi.org/10.1007/s12144-020-01024-4>
- Van Dam, N. T., van Vugt, M. K., Vago, D. R., Schmalzl, L., Saron, C. D., Olenzki, A., Meissner, T., Lazar, S. W., Kerr, C. E., Gorchov, J., Fox, K. C. R., Field, B. A., Britton, W. B., Brefczynski-Lewis, J. A., & Meyer, D. E. (2017). Mind the hype: A critical evaluation and prescriptive agenda for research on mindfulness and meditation. *Perspectives on Psychological Science*, 13(1), 36–61. <https://doi.org/10.1177/1745691617709589>
- van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523–538. <https://doi.org/10.1007/s11192-009-0146-3>
- Van Gordon, W., & Shonin, E. (2020). Second-generation mindfulness-based interventions: Toward more authentic mindfulness practice and teaching. *Mindfulness*, 11(1), 1–4. <https://doi.org/10.1007/s12671-019-01252-1>
- Wang, Y., Liao, L., Sun, Y., Wang, N., Wang, J., & Luo, F. (2021). A bibliometric visualization analysis of mindfulness and meditation research from 1900 to 2021. *International Journal of Environmental Research and Public Health*, 18(24), 13150. <https://doi.org/10.3390/ijerph182413150>
- Wolch, N. J., Arthur-Cameselle, J. N., Keeler, L. A., & Suprak, D. N. (2021). The effects of a brief mindfulness intervention on basketball free-throw shooting performance under pressure. *Journal of Applied Sport Psychology*, 33(5), 510–526. <https://doi.org/10.1080/10413200.2020.1720044>
- Zhang, C. Q., Si, G. Y., Duan, Y. P., Lyu, Y. J., Keatley, D. A., & Chan, D. K. C. (2016). The effects of mindfulness training on beginners' skill acquisition in dart throwing: A randomized controlled trial. *Psychology of Sport and Exercise*, 22, 279–285. <https://doi.org/10.1016/j.psychsport.2015.09.005>
- Zhang, C. Q., Chung, P. K., & Si, G. (2017). Assessing acceptance in mindfulness with direct-worded items: The development and initial validation of the athlete mindfulness questionnaire. *Journal of Sport and Health Science*, 6(3), 311–320. <https://doi.org/10.1016/j.jshs.2015.09.010>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.