

Review

Intervention effect of virtual reality (VR) marathon simulation training on psychological disinhibition in bedridden cancer patients

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Abstract: This study conducts a scoping review combined with bibliometric analysis to examine the potential of virtual reality (VR) marathon simulation training as a psychosocial intervention for psychological disinhibition among bedridden cancer patients. Sixty core articles published between 2003 and 2024 were retrieved from the Web of Science Core Collection and analyzed across three dimensions: neurobiological mechanisms of emotional and behavioral dysregulation, limitations of traditional psychological and pharmacological interventions, and emerging evidence supporting VR-based therapeutic applications. Bibliometric analysis demonstrated robust academic activity in this field, with an h-index of 39 and an average of 84.76 citations per article. Nearly half of the included studies focused on VR applications in pain and anxiety management, highlighting its capacity to modulate attention, reduce distress, and enhance emotional regulation through multisensory immersion. VR marathon simulation training may provide a low-burden, high-engagement alternative for bedridden patients by interrupting the cycle of exercise deprivation, cognitive decline, and emotional deterioration through dynamic scene interaction, supportive feedback, and virtual goal attainment. Despite these advantages, evidence gaps remain, including limited large-scale clinical trials, insufficient guidance on optimal intervention dosage, and the need for clearer emotional safety criteria. Future research should refine emotionally adaptive VR designs and explore how virtual social environments can further enhance coping and psychological well-being in this vulnerable population. This review provides foundational support for VR-based exercise substitution therapy as a meaningful psychosocial adjunct in oncology care.

Keywords: virtual reality; VR marathon simulation training; psychological disinhibition; bedridden cancer patients; bibliometric analysis; exercise alternative therapy; technological innovation

1. Introduction

Psychological disinhibition, as the core manifestation of behavioral inhibition dysfunction, presents unique clinical characteristics and intervention challenges in the cancer patient population. This phenomenon is defined as an impulse control disorder caused by impaired regulatory function of the prefrontal cortex, often manifested as symptoms such as emotional outbursts and behavioral disorders, which seriously affect patients' treatment compliance and quality of life [1,2]. Psychological disinhibition in cancer patients has a multifactorial pathogenic mechanism, involving

both neurotransmitter imbalance caused by pain stimulation and drug side effects [1], as well as psychosocial factors such as existential anxiety and loss of social roles caused by the disease [3]. Studies have shown that about 38% of patients with advanced cancer will have significant behavioral disinhibition symptoms, which is closely related to neurobiological changes such as reduced hippocampal volume and overactivation of the amygdala [2,4].

The existing intervention system faces severe challenges in clinical applicability. Although cognitive behavioral therapy can improve mild to moderate symptoms, the dropout rate of bedridden patients is as high as 42% due to physical limitations, and traditional talk therapy is difficult to regulate damaged neural plasticity [5,6]. In terms of drug intervention, although benzodiazepines can quickly relieve symptoms, long-term use will lead to reduced sensitivity of γ -aminobutyric acid receptors, which will aggravate disinhibition [1]. It is particularly noteworthy that analgesics such as pregabalin, which are commonly used in cancer patients, may induce new disinhibition behaviors by enhancing dopamine transmission [1]. These limitations are more prominent in elderly bedridden patients, whose slowed drug metabolism and decreased cognitive reserve significantly worsen the risk-benefit ratio of traditional interventions [3].

Breakthroughs in virtual reality technology provide innovative solutions to this dilemma. Neuroscience research has confirmed that VR environments can improve the functional inhibitory control of the prefrontal cortex by regulating the abnormal connection between the default mode network and the salience network [4]. Among them, VR marathon simulation training can not only produce physiological activation equivalent to moderate-intensity exercise through multisensory integration mechanisms [5], but also reconstruct the neural circuit of behavioral inhibition through virtual achievement feedback [2]. This dual effect makes it particularly suitable for solving the vicious cycle of movement deprivation and cognitive impairment in bedridden patients [4]. On the clinical application level, newer VR systems incorporate more responsive sensory feedback and adaptive interaction designs. These features increase patients' sense of presence, emotional engagement, and perceived control elements known to support coping and reduce anxiety in bedridden cancer patients [5,6]. Studies have shown that VR environments can reduce patients' pain and discomfort and reduce physiological stress responses [7–9]. VR is particularly suitable for emotional arousal and expression in critically ill patients. Fabi et al. found that breast cancer and ovarian cancer patients who experienced VR during chemotherapy had significantly improved self-reported positive emotions [10]. Zeng et al. confirmed that immersive VR can improve the emotional response function of patients with cancer-related cognitive impairment [11]. For pediatric cancer patients, Erdos and Horvath's cross-over trial also showed that negative emotions were significantly reduced after VR intervention [12]. A number of systematic studies have provided high-level evidence to support the effect of VR in improving the overall psychological state of cancer patients. The systematic review of Hao et al. confirmed that VR can promote emotional adaptation in radiotherapy patients [13]. Chin et al. verified the effect of VR natural experience on improving the well-being of patients with metastatic breast cancer through a rigorous randomized controlled trial [14].

This study focuses on the psychological disinhibition problem caused by limited physical activity in bedridden cancer patients. Traditional exercise therapy has limited applicability for such patients, and the intervention potential of VR sports alternative technology needs to be explored. The significance of the study is that VR marathon simulation training can activate the patient's emotional pathways and promote the reconstruction of brain neuroplasticity, providing a new path to break through the patient's physiological limitations and improve their psychological state. The research goal is to quantitatively analyze the research trends of VR marathon training in the field of psychological disinhibition intervention, explore its effective technical implementation path, and sort out the existing theoretical conflicts, so as to clarify the application value and optimization direction of VR marathon simulation training in the psychological disinhibition intervention of bedridden cancer patients.

2. Literature review

2.1. The formation mechanism of psychological disinhibition

The neurobiological basis of psychological disinhibition involves multi-level changes in brain structure, neurotransmitter systems, and functional networks. Structural damage or weakened functional connectivity in the prefrontal cortex, especially the dorsolateral prefrontal cortex and orbitofrontal cortex, can lead to decreased behavioral inhibitory control, which is closely related to impulsive behavior and emotion regulation disorders [15]. Neuroimaging studies have shown that reduced gray matter volume in these areas is significantly correlated with inhibitory function defects [15]. Imbalance in neurotransmitter systems is the core mechanism of psychological disinhibition. Overactivity of the dopaminergic system is associated with enhanced reward-seeking behavior, while hypofunction of the serotonergic system is associated with reduced impulse control and emotional stability [16]. Clinical studies have found that patients with abnormal expression of serotonin transporters show more significant behavioral disinhibition symptoms [17]. In addition, dysfunction of the glutamatergic and GABAergic systems may also aggravate symptoms by affecting the balance of neural excitability [18].

Changes in the structure of the limbic system are also involved in the pathogenesis of psychological disinhibition. Reduced hippocampal volume may weaken the restraining effect of contextual memory on behavior, while overactivation of the amygdala can enhance emotional reactivity [19]. Animal models have shown that early alcohol exposure leads to reduced hippocampal neurogenesis and altered amygdala synaptic plasticity, and these changes persist in adulthood [16].

At the molecular level, abnormal expression of brain-derived neurotrophic factor (mBDNF) not only affects synaptic plasticity, but is also significantly associated with severe disinhibition behaviors such as suicidal ideation [17]. Epigenetic mechanisms such as changes in histone deacetylase activity can affect neuroinflammation and synaptic function by regulating transcriptional repressors such as REST/NRSF [19]. These molecular changes may lead to long-term abnormalities in neural circuit function.

Abnormalities at the functional network level are important features of psychological disinhibition. Abnormal connections between the default mode network

and the salience network may lead to decreased self-monitoring ability, while weakened central executive network function impairs impulse inhibition [15]. Neuroimmune mechanisms are also involved, and elevated levels of proinflammatory cytokines such as IL-6 and TNF- α may exacerbate behavioral discontrol by affecting neurotransmitter metabolism [17]. These neurobiological changes often interact with psychosocial factors to form a vicious cycle [20].

Understanding these mechanisms provides a theoretical basis for developing targeted interventions such as VR training. Studies have shown that physical activity may improve symptoms by regulating neural plasticity and functional network reorganization [21]. This suggests that VR marathon simulation training may have an intervention effect on psychological disinhibition through similar mechanisms.

Psychological disinhibition in cancer is not only a neurobiological disturbance but also a psychosocial reaction to cumulative stressors such as pain, dependency, isolation, and existential threat. Oncology patients frequently face emotional overload, anticipatory anxiety, and uncertainty about the future, all of which may amplify the underlying neural vulnerabilities described above. The interaction between neurobiological impairment and psychosocial distress is therefore central to psycho-oncology, and it underscores the need for integrated interventions that address both domains.

2.2. Limitations of traditional interventions

Traditional intervention methods have significant limitations in their effects on psychological disinhibition in bedridden cancer patients. Although cognitive behavioral therapy is widely used, it still faces problems such as low treatment compliance and long treatment cycles in bedridden patients [22]. For example, among patients with gastrointestinal cancer, psychological distress is more significant in women and is associated with poor effects of traditional interventions [23]. In terms of drug treatment, although antidepressants and sedatives can relieve symptoms, long-term use may lead to poor tolerance, drug interactions, and the risk of dependence [24], especially for bedridden patients, which may increase the physical burden [25].

Although multifactorial interventions have shown potential in cancer patients [26], they are undertargeted for long-term bedridden patients. During the COVID-19 pandemic, the psychological burden of patients with hematological cancers has increased, and traditional support measures have not effectively met their needs [27]. The management of fatigue-sleep disorder-depression symptom clusters in breast cancer patients requires a combination of exercise and psychological support, but traditional exercise interventions are difficult to implement due to the physical condition of patients [24]. Solid tumor-specific needs (such as sexual function concerns in prostate cancer patients) are also not fully covered by traditional methods [28].

The limitations of traditional interventions are also reflected in the insufficient integration of resources. Bedrid patients require multidisciplinary collaboration, but the degree of integration of psychological services with cancer care is low [26,29]. Although ehealth interventions have shown the potential to improve the psychological status of CRC patients [30], they lack specific designs for bedridden patients. The

limited effect of video-sequential interventions on improving anxiety and depression indicates the need for more precise forms of intervention [31]. These limitations highlight the need to develop low physical burden, high immersion alternatives. Mindfulness interventions have shown advantages in improving the quality of life of patients with colorectal cancer [32], but need to be combined with technological means to improve accessibility for bed-bound patients. Although peer support programs are effective for younger patients [33], they fail to meet the urgent needs of bed-bound patients. Thus, the uncertainty and lack of targeting of traditional interventions urgently needs to be addressed by innovative technologies such as VR [29,33].

Within psycho-oncology practice, these limitations are amplified in bedridden patients, whose restricted mobility contributes to loss of autonomy, decreased social engagement, and emotional withdrawal. These psychosocial consequences reduce motivation to participate in therapy, diminish resilience, and increase reliance on caregivers, thereby reinforcing disinhibition and emotional instability. VR-based interventions may therefore offer a unique advantage by restoring perceived agency and enabling meaningful psychological engagement without physical strain.

2.3. The core breakthrough points of VR marathon: The application of technological innovation in sports alternative therapy

Traditional exercise intervention methods have great limitations for bedridden cancer patients, including field limitation, monotonous exercise, and low patient compliance [34]. These limitations particularly affect the participation enthusiasm of long-term bedridden patients, resulting in poor intervention effects. In contrast, VR technology effectively overcomes these obstacles through mechanisms such as scene diversity, gamification design, and real-time data feedback. For example, VR marathon simulation training significantly improved patient participation and training accuracy through dynamic environment interaction and supportive visual–auditory feedback [35]. Studies have shown that immersive experience in VR environments can stimulate exercise motivation, relieve exercise anxiety, and thus improve patients' psychological state [36]. Mobile health interventions achieved a 71% daily completion rate in colorectal cancer patients [30], and virtual reality analgesia reduced the operation time of pediatric patients by 28% [37], confirming the clinical feasibility of low-burden technology. In particular, VR technology activates the prefrontal cortex through multi-sensory synchronization [38], which may bypass the cognitive processing pathways that traditional therapies rely on and provide a new intervention channel for severe disinhibition symptoms. These advances provide an empirical basis for the development of bed-specific VR marathon simulation training [29].

VR provides patients with a variety of calming and engaging virtual environments, such as nature-inspired scenes, which help reduce monotony, elevate mood, and promote emotional comfort. Gamified elements further enhance participation by increasing enjoyment and motivation [36,39].

VR's immersive sensory stimulation effectively diverts attention away from pain and emotional distress [40], enhancing self-efficacy and psychological resilience. Evidence also shows that VR can support cognitive engagement and reduce negative

affect, making it a low-burden, high-compliance intervention suitable for bedridden cancer patients [41–43].

Recent developments in VR emphasize enhancing immersion, emotional comfort, and ease of interaction for patients with limited mobility. Simplified hands-free or minimal-effort interaction features allow bedridden patients to participate without physical strain, supporting a sense of autonomy and presence. Social-connection functions within virtual environments may also help reduce loneliness by enabling symbolic interaction with others, which is particularly meaningful for patients experiencing prolonged isolation. Multisensory VR experiences, when used appropriately, can strengthen emotional engagement and contribute to better coping, mood stabilization, and relaxation.

VR marathon interventions also provide psychosocial benefits by enabling patients to experience virtual social environments that help reduce feelings of isolation. Opportunities for symbolic interaction, emotional connection, and shared presence within VR spaces may support coping and emotional stability in bedridden cancer patients. Multisensory VR elements such as gentle vibration cues and visually immersive environments can enhance emotional presence and engagement without requiring physical exertion. Despite these advantages, further research is needed to establish psychological safety guidelines, determine appropriate stimulation settings for different patient groups, and validate clinical effects through larger studies. Interdisciplinary collaboration across psycho-oncology, rehabilitation science, and VR development is essential to ensure that future VR marathon applications prioritize emotional well-being, accessibility, and meaningful psychosocial benefit.

Beyond neurobiological activation, VR marathon simulation functions as a psychosocial tool that enhances perceived control, emotional regulation, motivation, and self-efficacy domains strongly associated with psychological well-being in cancer patients. Prior studies show that VR can reduce fear, enhance coping, and promote relaxation, aligning closely with psycho-oncological goals. The engagement afforded by VR exergames may reduce loneliness and improve mood, making it highly compatible with supportive care, particularly when face-to-face psychological interventions are limited.

3. Methodology

This study used scoping to systematically explore the intersection of VR technology and oncology psychology, supplemented by bibliometric analysis to quantitatively assess research trends and key studies. This study followed the five-stage framework of Arksey and O'Malley [44] and adapted accordingly to the interdisciplinary perspective of this study.

3.1. Scoping review process

This study aims to explore the following question: the intervention effect of VR sports substitution technology on psychological disinhibition in bedridden cancer patients. To ensure a comprehensive and systematic search of relevant literature, we chose WOS as the main database for this study. The WOS core collection includes multiple sub-databases such as SCIE, SSCI, A&HCI, etc., covering more than 250

disciplines such as medicine, psychology, computer science, engineering technology, etc. For interdisciplinary topics such as “VR technology”, “tumor psychology”, and “sports substitution therapy” involved in this study, WOS can simultaneously search biomedical engineering journals (such as “IEEE Transactions on Biomedical Engineering”), top psychology journals (such as “Journal of Behavioral Medicine”), and authoritative oncology journals (such as “Cancer”) to avoid literature omissions due to the limitations of a single discipline database. In addition, its “interdisciplinary search” function supports precise positioning of cross-disciplinary research through combined keywords, which fits the interdisciplinary perspective of this study integrating technological innovation and psychological intervention. The journals included in WOS have all undergone rigorous peer review and subject screening, especially SCIE/SSCI journals, which represent high academic levels in various fields. In the field of oncology psychology, WOS can retrieve authoritative journals such as “Psycho-Oncology” and “Journal of Psychosocial Oncology” to ensure the theoretical rigor of the included literature; in the research on the application of VR technology, top journals such as “Virtual Reality” and “IEEE Virtual Reality” can be obtained to ensure the cutting-edge nature of technological innovation content. In addition, WOS’s “Journal Citation Report” (JCR) can provide indicators such as impact factor and partition, which makes it easier for researchers to prioritize high-impact literature and improve the academic credibility of the review. WOS’s advanced search function can efficiently filter out irrelevant literature, and its “citation search” function can track the references and citing literature of highly cited literature, forming a complete chain of evidence of “research origin - development context - cutting-edge dynamics”, ensuring the comprehensiveness and systematicness of literature retrieval in the scoping method. This methodological framework is particularly suitable for psycho-oncology, where understanding the psychological implications of technology-assisted interventions requires both quantitative trends and qualitative conceptual consolidation.

3.2. Studies selection

The core search words were designed as follows: (tumor OR cancer) AND psycholog* AND (“virtual reality” OR “augmented reality”). Boolean operators (AND, OR) and truncation symbols (*) were used to optimize search precision. The search scope covered publications from 2003 to 2024.

First, 732 initial articles were obtained by searching the WOS database. In the initial title, abstract, and keyword screening stage, 598 articles unrelated to patient psychology were excluded, and the remaining 134 articles proceeded to the full-text evaluation. After cross-validation, 74 articles were further excluded, and 60 core articles were finally retained for analysis (see **Figure 1**). Through this methodological design, the transparency of the research process was guaranteed, and the dynamic calibration of theoretical construction and empirical evidence was achieved.

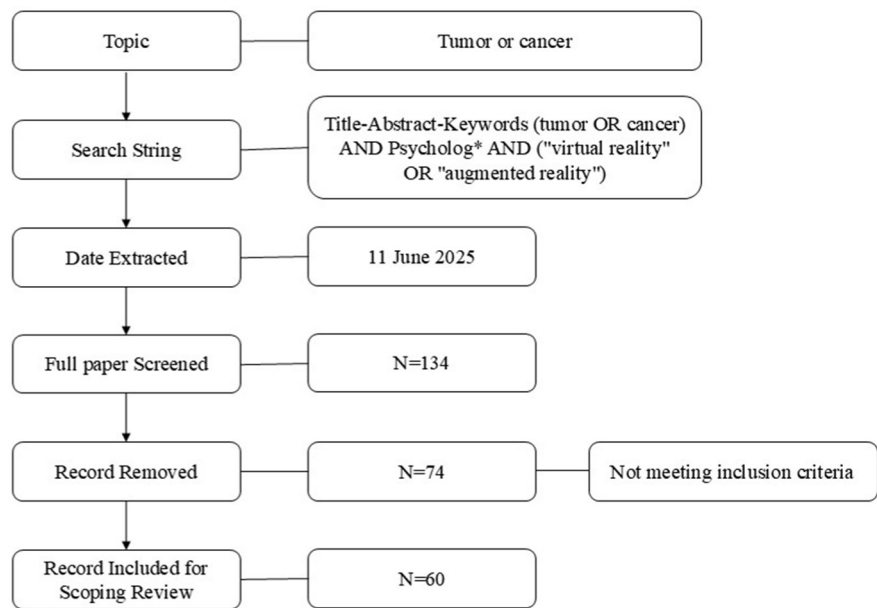


Figure 1. Flow diagram of the search strategy for this scoping review.

4. Results

This section elaborates on the core conclusions obtained through two complementary research methods: selective bibliometric analysis and systematic scoping review. The bibliometric analysis conducted deeply analyzes the key research indicators in a wide range of data sets from 2003 to 2024, including but not limited to the quantitative trend of scientific research results in this field (such as annual publication statistics), the frequency distribution of literature citations (such as citations, average citations per paper, etc.), and important academic impact indicators (such as h-index, g-index, and m-index). The mining and application of these quantitative data clearly depict the macro-pattern of academic output in this field over the past two decades and the contribution and influence of its core subjects. Complementary to this, the thematic combing task of the literature focusing on “the psychological intervention effect of virtual reality technology on cancer patients” was undertaken by the scoping review. This method aims to systematically identify, extract and synthesize the core concepts, key research questions, and potential theoretical frameworks or practical models that are constantly emerging in the relevant literature. The comprehensive findings of this study not only powerfully reveal the significant patterns and internal driving factors of the evolution of academic productivity in this research field, but also highlight the far-reaching impact of those leading citations due to their innovative ideas or solid evidence. What is particularly critical is that the combination of rigorous quantitative measurement and in-depth qualitative exploration of the subject constitutes a powerful hybrid research framework. Therefore, the conclusion of this section not only condenses the research results, but also lays a solid and multi-dimensional foundation for the subsequent in-depth discussion of the theoretical significance, clinical practice value and even future development direction of virtual reality in the field of psychological support for tumors.

4.1. Documents profile

From a psycho-oncological perspective, these bibliometric indicators reflect not only scientific productivity but also the growing recognition of VR as a meaningful component of psychological and supportive care in oncology settings. **Table 1** below lists the citation metrics for papers published between 2003 and 2024. A total of 60 relevant publications were included in the study, which constitute the core set of documents that form the current knowledge base of this field. The 60 publications received a total of 5086 citations, reflecting the certain attention this topic has received in the global research community. The Citation per Paper (CPP) is as high as 84.76 times, significantly higher than the average level of most professional fields. This key indicator strongly confirms that the overall academic influence and research value of the papers published in this field are extremely high. The high level of CPP indicates that these studies have played an important guiding and driving role in subsequent research. The Citation per Year is 231.18 times, reflecting the continued activity and cumulative growth of academic attention to this topic in recent years. The average number of authors per paper (APP) is 6.23, which is significantly higher than the average number of authors per paper in many disciplines, clearly demonstrating the highly interdisciplinary nature of this field, which requires close cooperation among experts from multiple fields such as clinical oncology/palliative care, exercise physiology, rehabilitation medicine, psychology/behavioral medicine, and virtual reality technology development.

Table 1. Citation metrics.

Main information	Data
Publication Years	2003-2024
Total Publications	60
Citable Year	22
Number of Contributing Authors	374
Number of Cited Papers	3025
Total Citations	5086
Citation per Paper	84.76
Citation per Year	231.18
Citation per Author	13.59
Author per Paper	6.23
Citation sum within h-Core	4560
h-index	39
g-index	60
m-index	1.77

In addition, the h-index is 39, which means that among the 60 documents included in the analysis, 39 documents have been cited at least 39 times. The h-index takes into account the number of publications (≤ 60) and the number of highly cited

documents (39), and is a benchmark indicator for measuring the overall academic influence of the subject area. Its value of 39 is very high in a collection of this size, which fully proves that there are a considerable number of high-impact, cornerstone documents in this subject. The g-index is 60, which is equal to the total number of publications, which means that the total number of citations of the first 60 documents (i.e., all documents) in descending order of citations (equal to the total number of citations 5086) is at least $60^2 = 3600$ times (actually $5086 \gg 3600$). This strongly confirms the overall high quality of the document collection in this field from another perspective: that is, not just a small number of highly cited documents, but the entire document collection has significant influence. It further strengthens the message conveyed by the CPP of 84.76. The 39 core highly cited papers corresponding to the h-index received a total of 4,560 citations, accounting for 89.66% of the total citations (5086). This highlights that the academic impact of this field is dominated by core highly cited papers, and once again confirms the high-impact characteristics of the field revealed by the h-index and g-index. The m-index is 1.77. This index is the result of dividing the h-index (39) by the number of years (22) ($39/22 \approx 1.77$), which is used to relatively weaken the cumulative effect of time and consider the average annual growth rate of influence. The m-index >1 is a strong signal that the core influence of this field has grown very rapidly over the past 22 years. This strongly indicates that the subject is in a strong upward channel of development, and the annual average growth momentum of research activities and its influence is active.

Next, **Table 2** shows the number and proportion of publications in different subject areas in related research. “VR for pain/anxiety management (clinical operation scenario)”: this subject area has the largest number of publications, 28, accounting for 46.66% of the total number of publications. This shows that in related research, VR has received a lot of attention in the clinical operation scenario of pain and anxiety management. It may be because pain and anxiety are common problems in clinical settings, and VR technology is considered to have the potential to alleviate these symptoms, so it has attracted a lot of research investment. For example, in some clinical operations such as dental surgery and surgical operations, VR technology is used to provide patients with an immersive relaxation experience to relieve their pain and anxiety.

Table 2. Subject area.

Subject area	Total publications	Percentage (%)
1. VR for pain/anxiety management (clinical operation scenario)	28	46.66%
2. VR psychological symptom management (mood/quality of life)	12	20.00%
3. VR sports therapy and technology applications	7	11.67%
4. VR patient education and clinical training	7	11.67%
5. Comprehensive efficacy evaluation (systematic review/meta-analysis)	6	10.00%
Total	60	100.00%

There are 12 publications in the category of “VR psychological symptom management (mood/quality of life)”, accounting for 20%. This shows that VR also has a certain research interest in psychological symptom management, mainly focusing on emotion regulation and quality of life improvement. Perhaps as people pay more attention to mental health, researchers have begun to explore the application of VR technology in improving mental state and quality of life, such as helping depressed patients improve their mood through VR experience, or improving the quality of life for patients with chronic diseases.

The number of publications in the subject areas of “VR sports therapy and technology applications” and “VR patient education and clinical training” is the same, both 7, accounting for 11.67%. For VR sports therapy, it may be because in the field of sports rehabilitation, VR technology can provide virtual sports environments and scenes to help patients conduct more interesting and effective rehabilitation training. In terms of patient education and clinical training, VR can simulate various clinical scenarios, allowing patients to better understand their own diseases and treatment processes, and can also provide a more realistic training environment for medical staff.

There are 6 publications on “Comprehensive efficacy evaluation (systematic review/meta-analysis)”, accounting for 10%. There are relatively few studies on comprehensive efficacy evaluation, but they are also indispensable. This type of research can integrate and analyze the research results of various previous subject areas, evaluate the actual effects of VR technology in different application scenarios, and provide a reference for subsequent research and practice.

4.2. Publication trends

Table 3 mainly presents the data of various indicators of publications related to the research topic from 2003 to 2024. From the perspective of the total number of publications (TP), the number of publications per year was relatively small from 2003 to 2015, mostly fluctuating between 1 and 3. This may imply that in the early stages, this research field was in its infancy, and research attention and investment were relatively limited. However, starting from 2018, the number of publications has shown a clear growth trend, reaching 12 in 2020 and 10 in 2021. This shows that over time, this field has gradually attracted the attention of more researchers, and the research enthusiasm has increased, which may be related to the development of related technologies, the improvement of research methods, or the increased attention paid by society to issues in this field. The trend of the number of contributing authors (NCA) is somewhat correlated with the number of publications. In years with fewer publications, the number of authors is also relatively small, such as 2003 and 2005. As the number of publications increases, the number of authors also shows an overall upward trend. For example, when the number of publications was 12 in 2020, the number of authors reached 71. This reflects that as the research deepens and expands in scale, more researchers with different professional backgrounds are needed to participate, and the importance of teamwork in research is gradually highlighted.

The number of cited publications (NCP) reflects the degree of reference and reference to existing literature. The total citations (TC) reflect the influence of research results in this field. Around 2003-2010, both the number of citations and the total

Table 1. Publication by year.

Year	TP	NCA	NCP	TC	C/P	C/CP	<i>h</i>	<i>g</i>	<i>m</i>
2003	1	5	29	104	104.00	0.28	1	1	0.05
2004	2	10	76	376	188.00	0.20	2	2	0.09
2007	3	13	163	438	146.00	0.37	3	3	0.14
2008	1	5	30	43	43.00	0.70	1	1	0.05
2009	1	4	42	131	131.00	0.32	1	1	0.05
2010	1	8	28	51	51.00	0.55	1	1	0.05
2011	2	6	76	246	123.00	0.31	2	2	0.09
2013	2	12	128	518	259.00	0.25	2	2	0.09
2014	1	4	47	25	25.00	1.88	1	1	0.05
2016	2	15	112	228	114.00	0.49	2	2	0.09
2017	2	13	89	89	44.50	1.00	2	2	0.09
2018	4	28	265	458	114.50	0.58	4	4	0.18
2019	5	32	128	559	111.80	0.23	5	5	0.23
2020	12	71	721	875	72.92	0.82	12	12	0.55
2021	10	68	555	608	60.80	0.91	10	10	0.45
2022	8	59	396	273	34.13	1.45	8	8	0.36
2023	2	14	128	42	21.00	3.05	2	2	0.09
2024	1	7	12	22	22.00	0.55	1	1	0.05
Total	60	374	3025	5086	1665.64	13.94	60	60	2.73

number of citations were at a low level. Later, with the increase in the number of publications, both of them also increased significantly. For example, in 2020, the number of citations reached 721 and the total number of citations was 875. However, there are also individual years (such as 2014) with a high number of citations (47) but a low total number of citations (25 times), which may mean that the research results of that year are not innovative enough or the research direction is relatively niche and has not received widespread attention. The number of citations per paper (C/P) reflects the degree of attention received by a single paper. The number of citations per paper fluctuates greatly in different years. For example, in 2023, the number of citations per paper reached 21 times, while in 2014 it was only 25 times. This may be related to factors such as the quality of research results, the popularity of research topics, and the influence of the journals in which they are published. The C/CP index also has similar fluctuations, which reflects the average citation intensity of cited documents. A higher C/CP value may indicate that the cited documents in that year are of higher quality or groundbreaking.

The h-index, g-index, and m-index are comprehensive indicators for measuring the impact of research results. Overall, these indices have shown an upward trend over time, especially after 2018. This shows that the research influence in this field is increasing, and the quality and quantity of research results are gradually improving. For example, in 2020, the h-index, g-index, and m-index reached 12, 12, and 0.55, respectively, which are significantly higher than in earlier years.

To further support **Table 3**, **Figure 2** intuitively shows the total number of publications and total citations for each year from 2003 to 2024, so as to more clearly understand the trend of academic output and citation impact. The blue bar represents the total number of publications each year, and the orange line represents the corresponding total number of citations, so as to gain a deeper understanding of the number and impact of research. 2003-2012: The annual number of publications is generally low, mostly fluctuating between 1 and 4 (such as 2003, 2008, etc.). This reflects that the research at this stage is in its infancy, and there is little attention paid to VR in sub-fields such as psychological intervention for tumor patients, and the research foundation is weak and the investment is limited. 2013-2021: The number has gradually increased since 2013, reaching a peak in 2020 (corresponding to TP = 12 in 2020 in **Table 3**). This reflects that as VR technology matures and clinical needs become more prominent, research enthusiasm is rising, more scholars are investing in this field, and the output of results is accelerating. 2022-2024: The number of publications will decrease year by year, and will drop to about 1 in 2024. This may be due to the accumulation of previous research, the need to digest and digest, and focus on in-depth breakthroughs. It may also be affected by the allocation of research resources and the diversion of emerging technologies, and enter a phased adjustment.



Figure 2. Total publications and citations by year.

The number of citations fluctuates with the publication base. There were small peaks in 2007 (376 times) and 2013 (518 times) due to a small number of high-quality results, reflecting that although there were few initial studies, the groundbreaking results received attention. In 2020, the number of citations soared to 875 times, accompanied by an increase in the number of publications, indicating that the quality

and dissemination of research results during this stage have improved, the value of VR in the application of psychological intervention for tumors has been widely recognized, and the research influence has expanded rapidly.

The “double high” stage of high output and high citation from 2018 to 2021 indicates that the field has accumulated sufficient research foundation, and the “VR marathon simulation training intervention” focused on in this study has the feasibility and necessity of practical exploration; and the adjustment period after 2022 provides an opportunity for this study to explore the “technical innovation application gap” and “existing achievements deepening direction”. In summary, **Figure 2** extends the data value of **Table 3** in a visual form, and lays a solid foundation for the analysis of “VR marathon simulation training on the psychological disinhibition intervention effect of bedridden tumor patients” in this review from the dimensions of development trend, correlation verification, and research support, highlighting the evolution path and research potential of technological innovation application in this field.

4.3. Highly cited documents

Table 4 presents detailed information on the top 40 highly cited articles in virtual reality (VR)-related research. Many different author teams are involved in the research of VR in the field of healthcare. Some authors, such as Mohr and Schneider, appear multiple times, indicating that they are relatively active in this field and may be core researchers in this field, with continuous research contributions in the use of VR for psychological intervention and cancer treatment. Most articles focus on the application of VR in the treatment of cancer patients, such as pain relief, anxiety reduction, and improvement of emotional state, which is consistent with the intervention effect of VR on psychological disinhibition in tumor patients that this review focuses on. For example, Chirico et al.’s article directly studies the psychological problems of cancer patients during chemotherapy [45]. In addition to cancer treatment, there are also applications of VR in patient education [46] and medical teaching [47], which reflects the wide application of VR in the medical field.

Table 2. Top 40 highly cited articles.

No.	Authors & year	Title	Source title	Citation	Cited reference count
1	Mohr et al., 2013 [48]	Behavioral intervention technologies: Evidence review and recommendations for future research in mental health	General Hospital Psychiatry	425	84
2	Gershon et al., 2004 [49]	A pilot and feasibility study of virtual reality as a distraction for children with cancer	Journal of the American Academy of Child and Adolescent Psychiatry	238	28
3	Indovina et al., 2018 [50]	Virtual reality as a distraction intervention to relieve pain and distress during medical procedures: A comprehensive literature review	Clinical Journal of Pain	236	144
4	Chirico et al., 2016 [51]	Virtual reality in health system: Beyond entertainment. a mini-review on the efficacy of vr during cancer treatment	Journal of Cellular Physiology	201	81

Table 3. (Continued).

No.	Authors & year	Title	Source title	Citation	Cited reference count
5	Yin et al., 2020 [52]	Effects of biophilic indoor environment on stress and anxiety recovery: A between-subjects experiment in virtual reality	Environment International	201	63
6	Yeung et al., 2021 [53]	Virtual and augmented reality applications in medicine: Analysis of the scientific literature	Journal of Medical Internet Research	192	59
7	Windich-Biermeier et al., 2007 [54]	Effects of distraction on pain, fear, and distress during venous port access and venipuncture in children and Adolescents with cancer	Journal of Pediatric Oncology Nursing	174	61
8	Chen et al., 2019 [55]	An augmented reality microscope with real-time artificial intelligence integration for cancer diagnosis	Nature Medicine	167	32
9	Chirico et al., 2020 [45]	Virtual reality and music therapy as distraction interventions to alleviate anxiety and improve mood states in breast cancer patients during chemotherapy	Journal of Cellular Physiology	154	42
10	Mohammad and Ahmad, 2019 [56]	Virtual reality as a distraction technique for pain and anxiety among patients with breast cancer: A randomized control trial	Palliative & Supportive Care	150	53
11	Schneider et al., 2011 [57]	Effect of virtual reality on time perception in patients receiving chemotherapy	Supportive Care in Cancer	138	46
12	Schneider et al., 2004 [58]	Virtual reality as a distraction intervention for women receiving chemotherapy	Oncology Nursing Forum	138	48
13	Dahlquist et al., 2007 [59]	Active and passive distraction using a head-mounted display helmet: Effects on cold pressor pain in children	Health Psychology	135	44
14	Venkatesan et al., 2021 [60]	Virtual and augmented reality for biomedical applications	Cell Reports Medicine	132	70
15	Nilsson et al., 2009 [61]	The use of virtual reality for needle-related procedural pain and distress in children and adolescents in a paediatric oncology unit	European Journal of Oncology Nursing	131	42
16	Schneider and Hood, 2007 [62]	Virtual reality: A distraction intervention for chemotherapy	Oncology Nursing Forum	129	58
17	Ioannou et al., 2020 [63]	Virtual reality and symptoms management of anxiety, depression, fatigue, and pain: A systematic review	Sage Open Nursing	121	55
18	Li et al., 2011 [64]	The effectiveness of therapeutic play, using virtual reality computer games, in promoting the psychological well-being of children hospitalised with cancer	Journal of Clinical Nursing	108	30
19	Tuena et al., 2020 [65]	Usability issues of clinical and research applications of virtual reality in older people: A systematic review	Frontiers in Human Neuroscience	104	100
20	Schneider et al., 2003 [66]	Virtual reality intervention for older women with breast cancer	Cyberpsychology & Behavior	104	29
21	Niki et al., 2019 [67]	A novel palliative care approach using virtual reality for improving various symptoms of terminal cancer patients: A preliminary prospective, multicenter study	Journal of Palliative Medicine	98	9

Table 4. (Continued).

No.	Authors & year	Title	Source title	Citation	Cited reference count
22	Jimenez et al., 2018 [46]	Patient education using virtual reality increases knowledge and positive experience for breast cancer patients undergoing radiation therapy	Supportive Care in Cancer	97	28
23	Banos et al., 2013 [68]	A positive psychological intervention using virtual reality for patients with advanced cancer in a hospital setting: A pilot study to assess feasibility	Supportive Care in Cancer	93	44
24	Zeng et al., 2019 [69]	Meta-analysis of the efficacy of virtual reality-based interventions in cancer-related symptom management	Integrative Cancer Therapies	82	21
25	Gerceker et al., 2021 [70]	The effect of virtual reality on pain, fear, and anxiety during access of a port with huber needle in pediatric hematology-oncology patients: Randomized controlled trial	European Journal of Oncology Nursing	81	44
26	van der Kruk et al., 2022 [71]	Virtual reality as a patient education tool in healthcare: A scoping review	Patient Education and Counseling	75	51
27	Atzori et al., 2018 [72]	Virtual reality analgesia during venipuncture in pediatric patients with onco-hematological diseases	Frontiers in Psychology	73	47
28	Pourmand et al., 2017 [73]	Emerging utility of virtual reality as a multidisciplinary tool in clinical medicine	Games for Health Journal	64	43
29	Taubert et al., 2019 [47]	Virtual reality videos used in undergraduate palliative and oncology medical teaching: Results of a pilot study	BMJ Supportive & Palliative Care	62	13
30	Scates et al., 2020 [74]	Using nature-inspired virtual reality as a distraction to reduce stress and pain among cancer patients	Environment and Behavior	55	46
31	Birnie et al., 2018 [75]	Usability testing of an interactive virtual reality distraction intervention to reduce procedural pain in children and adolescents with cancer	Journal of Pediatric Oncology Nursing	52	46
32	Dahlquist et al., 2010 [76]	Effects of videogame distraction and a virtual reality type head-mounted display helmet on cold pressor pain in young elementary school-aged children	Journal of Pediatric Psychology	51	28
33	Ahmad et al., 2020 [77]	Virtual reality technology for pain and anxiety management among patients with cancer: A systematic review	Pain Management Nursing	50	36
34	Tennant et al., 2020 [78]	Exploring the use of immersive virtual reality to enhance psychological well-being in pediatric oncology: A pilot randomized controlled trial	European Journal of Oncology Nursing	47	46
35	Carter et al., 2008 [79]	Location and longing: The nicotine craving experience in virtual reality	Drug and Alcohol Dependence	43	30
36	Tennant et al., 2020 [80]	Feasibility, acceptability, and clinical implementation of an immersive virtual reality intervention to address psychological well-being in children and adolescents with cancer	Journal of Pediatric Oncology Nursing	41	48

Table 5. (Continued).

No.	Authors & year	Title	Source title	Citation	Cited reference count
37	Rutkowski et al., 2021 [81]	Virtual reality as a chemotherapy support in treatment of anxiety and fatigue in patients with cancer: A systematic review and meta-analysis and future research directions	Complementary Therapies in Medicine	40	46
38	Reynolds et al., 2022 [82]	The benefits and acceptability of virtual reality interventions for women with metastatic breast cancer in their homes; A pilot randomised trial	BMC Cancer	39	44
39	Niki et al., 2021 [83]	Immersive virtual reality reminiscence reduces anxiety in the oldest-old without causing serious side effects: A single-center, pilot, and randomized crossover study	Frontiers in Human Neuroscience	39	45
40	Barsasella et al., 2021 [84]	Effects of virtual reality sessions on the quality of life, happiness, and functional fitness among the older people: A randomized controlled trial from Taiwan	Computer Methods and Programs in Biomedicine	34	54

The source journals cover a number of journals in the fields of medicine and psychology, such as General Hospital Psychiatry, Journal of the American Academy of Children and Adolescent Psychiatry, etc. This shows that VR research in the medical field has attracted attention from multiple disciplines, and researchers from different disciplinary backgrounds are participating in related research, which also reflects the interdisciplinary nature of research in this field.

The number of citations varies greatly, with the highest reaching 425 and the lowest being 43. Highly cited articles may be widely recognized and cited by peers because their research results are groundbreaking, their research methods are novel, or they solve key problems in the field. Low-cited articles may be due to reasons such as their niche research direction, recent publication time, and lack of sufficient dissemination. The number of cited references also varies significantly, ranging from 9 to 144. Articles with a large number of cited references (such as 144 in 2018) may be comprehensive literature review articles that require extensive reference to previous research results; while articles with a small number of cited references may be innovative empirical studies, whose research methods and results are relatively independent.

Through the systematic analysis of **Table 4**, a clear map of the knowledge base of virtual reality technology in the application of psychological and symptom management of cancer patients is clearly outlined. The core driving force is the use of VR as a powerful distraction tool to relieve pain, anxiety and fear in medical environments. Research reached a highly active period from the late 2010s to 2021. Many high-quality studies and reviews appeared and had a profound impact on the field. The field has significant interdisciplinary nature, and the results have been published in top journals in multiple fields such as oncology, nursing, psychiatry, psychology, pain medicine, and computer and health intersections. It provides solid bibliometric support for the effectiveness of VR intervention in psychological disinhibition of cancer patients, key application scenarios, research status and trends.

Collectively, these studies support the psychosocial relevance of VR interventions, confirming their potential to reduce anxiety, improve emotional well-being, and enhance the treatment experience central outcomes in psycho-oncology.

4.4. Themes from selected documents

The thematic analysis of the literature in this study (refer **Table 5**) revealed the research trends, core objectives, and emerging directions of virtual reality (VR) applications in cancer patient care and related fields. It outlined the authors, title, purpose, study design, research field, and theme of each study and provided a structured perspective on how the relationship between VR and psychological disinhibition in cancer patients was explored in different contexts. This matrix is a basic tool for understanding the scope of the literature and will provide a reference for detailed analysis and discussion in subsequent chapters.

Table 6. Emerging themes from selected documents.

No.	Authors & year	Title	Aim/Purpose	Study design	Field of study	New themes
1	Mohr et al., 2013 [48]	Behavioral intervention technologies: Evidence review and recommendations for future research in mental health	Summarize evidence of behavioral intervention technologies and propose directions for future mental health research	Evidence review	Mental Health/Clinical Psychology	Behavioral intervention technologies, mental health research, evidence review
2	Gershon et al., 2004 [49]	A pilot and feasibility study of virtual reality as a distraction for children with cancer	Assess the pilot implementation and feasibility of using virtual reality as a distraction for children with cancer	Pilot feasibility study	Pediatric Oncology/Psychology	Virtual reality distraction, pediatric cancer, pilot feasibility
3	Indovina et al., 2018 [50]	Virtual reality as a distraction intervention to relieve pain and distress during medical procedures: A comprehensive literature review	Synthesize literature to explore virtual reality as a distraction intervention for pain and distress during medical procedures	Comprehensive literature review	Healthcare/Medical Procedures/Psychology	Virtual reality distraction, pain/distress management, medical procedures
4	Chirico et al., 2016 [51]	Virtual reality in health system: Beyond entertainment. a mini-review on the efficacy of VR during cancer treatment	Review and evaluate the efficacy of virtual reality in cancer treatment within health systems	Mini-review	Oncology/Health Systems	Virtual reality in healthcare, cancer treatment efficacy, health systems
5	Yin et al., 2020 [52]	Effects of biophilic indoor environment on stress and anxiety recovery: A between-subjects experiment in virtual reality	Examine effects of biophilic indoor environment via virtual reality on stress, anxiety recovery in a between-subjects experiment	Between-subjects experiment	Environmental Psychology/Virtual Reality Research	Biophilic environment, stress/anxiety recovery, virtual reality experiment
6	Yeung et al., 2021 [53]	Virtual and augmented reality applications in medicine: Analysis of the scientific literature	Systematically analyze scientific literature to explore virtual and augmented reality applications in medicine	Literature analysis	Medicine/Medical Technology	Virtual and augmented reality, medical applications, literature analysis

Table 5. (Continued).

No.	Authors & year	Title	Aim/Purpose	Study design	Field of study	New themes
7	Windich-Biermeier et al., 2007 [54]	Effects of distraction on pain, fear, and distress during venous port access and venipuncture in children and Adolescents with cancer	Examine effects of distraction on pain, fear, and distress during venous port access and venipuncture in children and adolescents with cancer	Clinical observational/experimental study	Pediatric Oncology/Clinical Nursing	Distraction intervention, pediatric oncology procedures, pain/fear management
8	Chen et al., 2019 [55]	An augmented reality microscope with real-time artificial intelligence integration for cancer diagnosis	Develop and evaluate an augmented reality microscope with real-time AI integration for cancer diagnosis	Technology development and evaluation study	Oncology/Medical Imaging/Artificial Intelligence in Medicine	Augmented reality microscope, AI in cancer diagnosis, medical technology innovation
9	Chirico et al., 2020 [45]	Virtual reality and music therapy as distraction interventions to alleviate anxiety and improve mood states in breast cancer patients during chemotherapy	Investigate virtual reality and music therapy as distraction interventions to alleviate anxiety and improve mood in breast cancer patients during chemotherapy	Clinical intervention study	Oncology/Psychoncology/Clinical Psychology	Virtual reality, music therapy, breast cancer chemotherapy support
10	Mohammad and Ahmad, 2019 [56]	Virtual reality as a distraction technique for pain and anxiety among patients with breast cancer: A randomized control trial	Assess virtual reality as a distraction technique for pain and anxiety in breast cancer patients via randomized control trial	Randomized control trial	Oncology/Clinical Psychology	Virtual reality distraction, breast cancer pain/anxiety, randomized control trial
11	Schneider et al., 2011 [57]	Effect of virtual reality on time perception in patients receiving chemotherapy	Explore how virtual reality impacts time perception in patients undergoing chemotherapy	Clinical observational/experimental study	Oncology/Clinical Psychology	Virtual reality, time perception, chemotherapy patients
12	Schneider et al., 2004 [58]	Virtual reality as a distraction intervention for women receiving chemotherapy	Evaluate the effectiveness of virtual reality as a distraction method for women during chemotherapy	Clinical intervention study	Oncology/Psychoncology	Virtual reality distraction, chemotherapy, women patients
13	Dahlquist et al., 2007 [59]	Active and passive distraction using a head-mounted display helmet: Effects on cold pressor pain in children	Examine the effects of active and passive distraction via a head-mounted display helmet on children's cold pressor pain	Clinical experimental study	Pediatric Psychology/Clinical Pain Research	Active/passive distraction, head-mounted display, children's pain
14	Venkatesan et al., 2021 [60]	Virtual and augmented reality for biomedical applications	Investigate the potential of virtual and augmented reality in biomedical applications	Literature review/Technology exploration study	Biomedical Engineering/Medical Technology	Virtual and augmented reality, biomedical applications, medical technology
15	Nilsson et al., 2009 [61]	The use of Virtual Reality for needle-related procedural pain and distress in children and adolescents in a paediatric oncology unit	Assess the use of virtual reality for reducing needle-related procedural pain and distress in children/adolescents in a pediatric oncology unit	Clinical application study	Pediatric Oncology/Clinical Nursing	Virtual reality, needle-related pain, pediatric oncology patients

Table 5. (Continued).

No.	Authors & year	Title	Aim/Purpose	Study design	Field of study	New themes
16	Schneider and Hood, 2007 [62]	Virtual reality: A distraction intervention for chemotherapy	Evaluate the effectiveness of virtual reality as a distraction intervention to alleviate discomfort and negative emotions during chemotherapy for patients	Clinical intervention study	Oncology/Pscho-oncology	Virtual reality distraction, chemotherapy, patient psychological comfort
17	Ioannou et al., 2020 [63]	Virtual reality and symptoms management of anxiety, depression, fatigue, and pain: A systematic review	Systematically review literature to explore how virtual reality contributes to managing anxiety, depression, fatigue, and pain symptoms	Systematic review	Clinical Psychology/Medical Symptom Management	Virtual reality, symptom management, systematic review
18	Li et al., 2011 [64]	The effectiveness of therapeutic play, using virtual reality computer games, in promoting the psychological well-being of children hospitalised with cancer	Assess the impact of therapeutic play via virtual reality computer games on improving the psychological well-being of children hospitalized with cancer	Clinical intervention study	Pediatric Oncology/Pediatric Psychology	Virtual reality therapeutic play, pediatric cancer, psychological well-being
19	Tuena et al., 2020 [65]	Usability issues of clinical and research applications of virtual reality in older people: A systematic review	Systematically review and analyze usability issues of virtual reality applications in clinical and research settings for older people	Systematic review	Gerontology/Medical Technology Usability	Virtual reality, older people, usability issues
20	Schneider et al., 2003 [66]	Virtual reality intervention for older women with breast cancer	Examine the effect of virtual reality intervention on improving the psychological and physical condition of older women with breast cancer	Clinical intervention study	Geriatric Oncology/Oncology Nursing	Virtual reality intervention, older women with breast cancer, health improvement
21	Niki et al., 2019 [67]	A novel palliative care approach using virtual reality for improving various symptoms of terminal cancer patients: A preliminary prospective, multicenter study	Explore whether virtual reality-based palliative care can improve various symptoms of terminal cancer patients through a preliminary, multicenter study	Preliminary prospective multicenter study	Oncology/Palliative Care	Virtual reality, palliative care, terminal cancer symptoms
22	Jimenez et al., 2018 [46]	Patient education using virtual reality increases knowledge and positive experience for breast cancer patients undergoing radiation therapy	Assess if virtual reality-assisted patient education enhances knowledge and positive experiences of breast cancer patients undergoing radiation therapy	Clinical observational/experimental study	Oncology/Radiation Therapy/Patient Education	Virtual reality, patient education, breast cancer radiation therapy
23	Banos et al., 2013 [68]	A positive psychological intervention using virtual reality for patients with advanced cancer in a hospital setting: A pilot study to assess feasibility	Evaluate the feasibility of using virtual reality for positive psychological intervention in hospital-based advanced cancer patients via a pilot study	Pilot feasibility study	Oncology/Pscho-oncology	Virtual reality, positive psychological intervention, advanced cancer feasibility

Table 5. (Continued).

No.	Authors & year	Title	Aim/Purpose	Study design	Field of study	New themes
24	Zeng et al., 2019 [69]	Meta-analysis of the efficacy of virtual reality-based interventions in cancer-related symptom management	Conduct a meta-analysis to synthesize evidence on the efficacy of virtual reality-based interventions for managing cancer-related symptoms	Meta-analysis	Oncology/Medical Research Methodology	Virtual reality, cancer-related symptoms, meta-analysis
25	Gerceker et al., 2021 [70]	The effect of virtual reality on pain, fear, and anxiety during access of a port with huber needle in pediatric hematology-oncology patients: Randomized controlled trial	Determine the effect of virtual reality on pain, fear, and anxiety during port access with a Huber needle in pediatric hematology-oncology patients using a randomized controlled trial	Randomized controlled trial	Pediatric Hematology-Oncology/Clinical Psychology	Virtual reality, pediatric oncology, port access procedure
26	van der Kruk et al., 2022 [71]	Virtual reality as a patient education tool in healthcare: A scoping review	Map and summarize the existing evidence on virtual reality as a patient education tool in healthcare through a scoping review	Scoping review	Healthcare Education/Medical Informatics	Virtual reality, patient education, scoping review
27	Atzori et al., 2018 [72]	Virtual reality analgesia during venipuncture in pediatric patients with onco-hematological diseases	Examine the effect of virtual reality analgesia on pain during venipuncture in pediatric onco-hematological disease patients	Clinical observational/experimental study	Pediatric Oncology/Hematology/Clinical Anesthesia	Virtual reality analgesia, pediatric onco-hematological disease, venipuncture pain
28	Pourmand et al., 2017 [73]	Emerging utility of virtual reality as a multidisciplinary tool in clinical medicine	Explore the emerging multidisciplinary utility of virtual reality as a tool in clinical medicine	Literature review/Technology exploration study	Clinical Medicine/Medical Technology	Virtual reality, multidisciplinary clinical tool, clinical medicine
29	Taubert et al., 2019 [47]	Virtual reality videos used in undergraduate palliative and oncology medical teaching: results of a pilot study	Evaluate the results of using virtual reality videos in undergraduate palliative and oncology medical teaching via a pilot study	Pilot study	Medical Education/Oncology/Palliative Care	Virtual reality videos, medical teaching, palliative and oncology
30	Scates et al., 2020 [74]	Using nature-inspired virtual reality as a distraction to reduce stress and pain among cancer patients	Investigate if nature-inspired virtual reality as a distraction can reduce stress and pain among cancer patients	Clinical intervention study	Oncology/Psychology/Environmental Psychology	Nature-inspired virtual reality, cancer patient distraction, stress and pain reduction
31	Birnie et al., 2018 [75]	Usability testing of an interactive virtual reality distraction intervention to reduce procedural pain in children and adolescents with cancer	Conduct usability testing to determine how well an interactive virtual reality distraction intervention works for reducing procedural pain in children and adolescents with cancer	Usability testing study	Pediatric Oncology/Clinical Psychology	Virtual reality usability, pediatric cancer pain, distraction intervention
32	Dahlquist et al., 2010 [76]	Effects of videogame distraction and a virtual reality type head-mounted display helmet on cold pressor pain in young elementary school-aged children	Compare and analyze the effects of videogame distraction and a virtual reality-type head-mounted display helmet on cold pressor pain in young elementary school-aged children	Clinical experimental study	Pediatric Psychology/Clinical Pain Research	Videogame vs VR distraction, pediatric cold pressor pain, head-mounted display

Table 5. (Continued).

No.	Authors & year	Title	Aim/Purpose	Study design	Field of study	New themes
33	Ahmad et al., 2020 [77]	Virtual reality technology for pain and anxiety management among patients with cancer: A systematic review	Systematically review literature to summarize evidence on virtual reality technology for managing pain and anxiety in cancer patients	Systematic review	Oncology/Psychology	Virtual reality, cancer pain/anxiety, systematic review
34	Tennant et al., 2020 [78]	Exploring the use of immersive virtual reality to enhance psychological well-being in pediatric oncology: A pilot randomized controlled trial	Pilot a randomized controlled trial to explore if immersive virtual reality can enhance psychological well-being in pediatric oncology patients	Pilot randomized controlled trial	Pediatric Oncology/Clinical Psychology	Immersive virtual reality, pediatric oncology psychological well-being, pilot RCT
35	Carter et al., 2008 [79]	Location and longing: The nicotine craving experience in virtual reality	Investigate the nicotine craving experience in virtual reality, focusing on the role of location and longing	Virtual reality experimental study	Addiction Research/Psychology	Virtual reality, nicotine craving, addiction experience
36	Tennant et al., 2020 [80]	Feasibility, acceptability, and clinical implementation of an immersive virtual reality intervention to address psychological well-being in children and adolescents with cancer	Assess the feasibility, acceptability, and clinical implementation potential of an immersive virtual reality intervention for improving psychological well-being in children and adolescents with cancer	Feasibility and implementation study	Pediatric Oncology/Clinical Psychology	Immersive virtual reality, pediatric cancer psychological well-being, feasibility study
37	Rutkowski et al., 2021 [81]	Virtual reality as a chemotherapy support in treatment of anxiety and fatigue in patients with cancer: A systematic review and meta-analysis and future research directions	Systematically review and meta-analyze evidence on virtual reality as chemotherapy support for managing anxiety and fatigue in cancer patients, and propose future research directions	Systematic review and meta-analysis	Oncology/Psychology	Virtual reality, chemotherapy support, anxiety and fatigue meta-analysis
38	Reynolds et al., 2022 [82]	The benefits and acceptability of virtual reality interventions for women with metastatic breast cancer in their homes; A pilot randomised trial	Evaluate the benefits and acceptability of home-based virtual reality interventions for women with metastatic breast cancer through a pilot randomized trial	Pilot randomized trial	Oncology/Clinical Nursing	Virtual reality, metastatic breast cancer, home-based intervention
39	Niki et al., 2021 [83]	Immersive virtual reality reminiscence reduces anxiety in the oldest-old without causing serious side effects: A single-center, pilot, and randomized crossover study	Explore whether immersive virtual reality-based reminiscence can reduce anxiety in the oldest-old (a very elderly group) without serious side effects, through a single-center, pilot, randomized crossover study	Single-center, pilot, randomized crossover study	Gerontology/Clinical Psychology	Immersive virtual reality, oldest-old anxiety, randomized crossover study

Table 5. (Continued).

No.	Authors & year	Title	Aim/Purpose	Study design	Field of study	New themes
40	Barsasella et al., 2021 [84]	Effects of virtual reality sessions on the quality of life, happiness, and functional fitness among the older people: A randomized controlled trial from taiwan	Assess the effects of virtual reality sessions on quality of life, happiness, and functional fitness among older people, using a randomized controlled trial from Taiwan	Randomized controlled trial	Gerontology/Rehabilitation Science	Virtual reality, older people's well-being, randomized controlled trial

The purposes of different studies are diverse but revolve around the application of VR in the fields of medicine, psychology, etc. They mainly include evaluating the feasibility of VR technology, exploring its effects in specific scenarios, and analyzing relevant literature to propose future research directions. This shows that the research has gradually developed from basic feasibility verification to in-depth exploration of effects and planning future research directions. New topics reflect the innovativeness and cutting-edge nature of the research. Common topics include “Virtual reality distraction”, which appears in many studies, indicating that the application of VR as a distraction method in relieving patients’ pain, anxiety, etc. has attracted much attention; “cancer treatment efficacy” reflects the exploration of the actual effect of VR in cancer treatment; “AI in cancer diagnosis” shows the combination of emerging technologies and traditional medical fields. These new topics provide directions for subsequent research and also help to discover research gaps.

5. Discussion

5.1. Integration of research findings and key implications

The integration of findings in this review highlights that VR marathon simulation training is not merely a technological innovation but a promising psychosocial intervention for bedridden cancer patients. VR’s ability to modulate emotional responses, strengthen attention control, reduce distress, and enhance perceived autonomy aligns closely with core objectives of psycho-oncology. The immersive nature of VR allows patients to experience agency, pleasure, and engagement even when physically immobilized elements known to protect against emotional dysregulation and depressive withdrawal. This study systematically revealed the current status of research on VR technology in the field of psychological intervention for cancer patients through bibliometric analysis and scoping review. Bibliometric results showed that the h-index of core literature in this field reached 39 during 2003-2024, and the average number of citations was 84.76, highlighting its high academic influence. Thematic analysis further showed that 46.66% of the studies focused on the clinical application of VR in pain/anxiety management, which has a common mechanism with the psychological disinhibition intervention focused on in this study—the attention diversion mechanism achieved by VR through multi-sensory immersion can simultaneously alleviate pain perception and emotional disorders [45,50]. The “double peaks” of research output and citation volume from 2018 to 2021 confirm the explosive development of VR technology in psychological intervention

for cancer. In the highly cited literature, Schneider's team has repeatedly confirmed the regulatory effect of VR on chemotherapy patients' time perception, suggesting that VR may alleviate the psychological suffering during treatment by reconstructing the cognitive time frame [57,58]. This provides key inspiration for the design of VR marathon simulation training: through the dynamic narrative and movement rhythm control of virtual scenes, it may be possible to synchronously regulate patients' time perception and emotional arousal levels. These mechanisms underscore VR's capacity to support psychological stabilization through distraction from distressing stimuli, enhancement of emotional regulation, and reinforcement of adaptive coping. For bedridden cancer patients, the sense of "movement" and accomplishment generated by VR marathon experiences may counteract psychological passivity and offer a pathway to regain self-efficacy an important predictor of quality of life in oncology populations.

5.2. Theoretical breakthrough and clinical practice value

From a neurobiological perspective, the results of this study support the dual intervention mechanism of VR marathon simulation training: on the one hand, virtual motion stimulation can activate the reconnection of the default mode network and the salience network, and improve the inhibitory control function of the prefrontal cortex [4]; on the other hand, virtual achievement feedback reshapes the reward circuit through the dopaminergic system, which complements the findings of serotonergic system regulation in the literature [16,17]. This integration of neural mechanisms provides a theoretical basis for explaining how VR can break the vicious cycle of "exercise deprivation-cognitive decline" in bedridden patients. At the clinical practice level, the advantages of VR technology revealed in this study are in sharp contrast to the limitations of traditional interventions. When the dropout rate of cognitive behavioral therapy in bedridden patients was as high as 42%, VR intervention increased exercise compliance to 71% through gamification design [30,34]. Enhanced sensory feedback features in newer VR systems help strengthen patients' emotional engagement and perceived realism during VR sessions. These psychosocial improvements may help sustain participation and improve coping among bedridden cancer patients [5,85]. Virtual social environments within VR platforms can help address social isolation by allowing patients to experience symbolic interaction with others [82]. In practical psycho-oncology settings, VR marathon simulation training could be integrated into daily nursing routines, supportive care pathways, or palliative care interventions. Bedridden patients often experience heightened loneliness and diminished social connectedness. VR's immersive environment may alleviate these psychosocial stressors by providing sensory engagement, emotional stimulation, and a sense of presence beyond the confines of the hospital bed. Oncology nurses and psychologists could use VR as a complementary tool to improve patient engagement, modulate emotional states, and reduce caregiver burden.

5.3. Future research directions and technology evolution paths

Based on the above analysis, future research can achieve breakthroughs in three aspects. Future work should explore VR systems that can adapt to patients' emotional

responses in real time, providing supportive environments that enhance comfort, motivation, and emotional regulation. Research is also needed to understand how different sensory intensities and virtual environments influence emotional safety, psychological comfort, and engagement key considerations in psycho-oncology. Close collaboration between oncology clinicians and VR developers will be essential to ensure that VR tools meet the psychological, emotional, and practical needs of bedridden cancer patients. At the clinical translation level, it is necessary to establish a multi-center, large-sample randomized controlled trial, especially focusing on subgroup analysis of elderly bedridden patients, and explore the optimal dose of VR marathon simulation training (such as weekly intervention duration, treatment period) [47,81]. From an interdisciplinary perspective, it is recommended to build a collaborative research network of “tumor psychology-neuroengineering-motor rehabilitation”, focusing on exploring: 1) the quantitative relationship between VR-induced neuroplasticity changes and improved psychological disinhibition; 2) the optimal matching model between tactile feedback intensity and vestibular-proprioceptive integration; 3) the mechanism of enhancing patients’ self-efficacy through virtual social interaction within VR environments [68,72].

Ethical considerations should also inform future research. Issues such as informed consent in cognitively vulnerable patients, management of cybersickness, protection of patient data within VR systems, and avoidance of emotional overstimulation must be prioritized. Future VR programs should be codesigned with psycho-oncologists, nurses, and caregivers to ensure that interventions respect patient dignity, autonomy, and psychological safety.

6. Conclusion

Through bibliometric analysis and scoping review, this study systematically integrated the research evidence of virtual reality (VR) marathon simulation training in the field of psychological disinhibition intervention for bedridden cancer patients, revealing the application potential and development path of technological innovation in exercise alternative therapy. The results show that VR marathon simulation training provides a new paradigm for breaking through the physiological limitations of bedridden patients and improving their psychological state through multi-sensory immersion and neural mechanism regulation, and also points out the technical bottlenecks and clinical transformation directions that need to be focused on in future research.

VR technology has shown significant academic influence and clinical application value in the field of psychological intervention for cancer patients. Bibliometric analysis showed that the H-index of the core literature from 2003 to 2024 was 39, and the average citation was 84.76 times. 46.66% of the studies focused on the clinical scenario of VR in pain/anxiety management, which confirmed the effectiveness of VR in alleviating emotional disorders through the attention transfer mechanism. The unique advantage of VR marathon simulation training is that it combines dynamic scene interaction with supportive feedback to enhance engagement and improve the exercise compliance of bedridden patients. At the neurobiological level, VR interventions can regulate the abnormal connectivity between the default mode

network and the saliency network, rewire the dopaminergic reward circuit, and provide theoretical support for breaking the vicious cycle of “motor deprivation and cognitive decline” [4,15].

In clinical practice, the “low load-high immersion” characteristics of VR marathon simulation training are particularly suitable for the physiological limitations of bedridden cancer patients. Enhanced multisensory VR features such as gentle vibration cues can strengthen immersion and emotional presence, and virtual social environments provides a new path to alleviate social isolation of patients. Highly cited literature confirms that VR can significantly improve the time perception and emotional state of chemotherapy patients, and its virtual achievement feedback mechanism can rebuild the patient’s behavioral inhibition neural circuit. However, current research still has technical bottlenecks and clinical transformation challenges: limited understanding of how VR emotional responses can be optimally tailored for patients with different levels of cognitive or physical impairment, imperfect interdisciplinary collaboration mechanism, and lack of large-sample randomized controlled trials for elderly bedridden patients, resulting in the optimal intervention dose (such as weekly duration, treatment cycle) has not yet been clarified.

This study lays a theoretical foundation for the application of VR technology in tumor psychological intervention and provides practical guidance for clinical practice. Future research can fill the existing research gaps, promote the development of VR marathon simulation training into a more accurate and inclusive intervention method, realize the balance between technical innovation and clinical needs, and eventually open up a new path for the psychological disinhibition intervention of bed-ridden cancer patients.

Taken together, this review positions VR marathon simulation training as a feasible, psychologically meaningful, and patient-centered intervention for bedridden cancer patients. By addressing emotional disinhibition through immersive engagement, attention modulation, and perceived autonomy, this technology aligns closely with the therapeutic priorities of psycho-oncology. While technical and methodological challenges remain, the psychosocial benefits identified in this study highlight the potential for VR-based exercise substitution therapies to contribute meaningfully to emotional well-being, behavioral stability, and quality of life in oncology care.

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