Current Sexual Health Reports
https://doi.org/10.1007/s11930-023-00374-x

Virtual Reality Therapy for Sexual Dysfunctions: a Scoping Review

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Accepted: 6 October 2023

Abstract

Purpose of Review Despite the growing body of research on virtual reality (VR) applications in psychology, there remains a scarcity of studies in sexology. This scoping review comprehensively assesses the size, nature, and scope of the literature on VR-based research on sexual dysfunctions and their related issues (e.g., sexual response, sexual satisfaction, and sexual skills) to identify promising VR applications in sex therapy. This review included empirical, theoretical, and review publications, as well as ongoing research. It systematically identified papers published between 1993 and 2023 using *Scopus*, *PsycINFO*, and *PubMed*. To ensure completeness, a secondary search on *Google Scholar* and an examination of references was also conducted in eligible papers. Forty-three papers were included in this review.

Recent Findings Results reveal a consistent increase in the number of papers over the past decade, with four main domains investigated: sexual dysfunctions ($n = 15$), sexual responsiveness ($n = 14$), sexual victimization ($n = 11$), and sexual skills ($n = 3$).

Summary Empirical reports reviewed suggest that VR represents a promising avenue to explore sexual arousal and improve sexual skills, as well as to alleviate symptoms of sexual dysfunctions and related factors, such as experiences of sexual assault. Yet, to move forward, several issues in prior research must be addressed, including the use of outdated technologies, the lack of operationalization of conceptual frameworks and targeted mechanisms in sexual dysfunctions, the predominance of proof-of-concept studies, as well as limited diversity in sample composition.

Keywords Virtual reality · Sexual dysfunctions · Scoping review · Sex therapy

Introduction

In the past three decades, psychology has undergone a remarkable surge in research that employs virtual reality (VR), with numerous applications for the assessment, conceptualization, and treatment of mental health conditions [1, 2]. VR is an immersive technology that uses computer-generated simulations to replicate real-life experiences by engaging users with multisensorial information, including visual, audio, and haptic stimuli [3, 4]. VR systems encompass both software and hardware components. They generally incorporate graphic and modeling software to define and generate virtual environments, input tools that facilitate user interaction within the simulation (e.g., VR controllers), and output tools to provide visual and audio stimuli (e.g., VR headsets with head-mounted displays) [5].

Meta-analyses support the efficacy of VR-based psychological treatments, notably for anxiety, eating, or depressive disorders [6–9]. Such treatments are primarily grounded in the theoretical principles and techniques of exposure therapy (i.e., VR exposure-based therapy [VRET]) [2, 10]. During VRET, patients are immersed in simulations that depict virtual representations of the apprehended situations, indirectly activating memories or associations linked to conditioned fear and negative outcome expectancies [10]. This activation partly relies on the ability of VR to induce a state of *presence*: that is, a complex subjective perception characterized by the feeling of being "here" within a virtual environment [3]. Over time, virtual environments

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Published online: 13 November 2023

have become more realistic, versatile, and interactive, which in turn improved VRET outcomes [5, 11].

In their systematic review, Freeman et al. [2] identified 285 empirical studies utilizing VR in mental health, with the majority (67%) focusing on anxiety-related disorders. Still, only 1% of the studies reviewed explored the use of VR for the treatment of sexual dysfunctions (SD), and none of them used evidence-based techniques, such as VRET. This lack of research is problematic, considering that, in the general population, up to 1 in 5 individuals report at least one persistent (≥ 6 months) and clinically distressing SD in a giving year [12, 13]. Therefore, our comprehension of the effectiveness and adequacy of VR-based therapy is limited for a substantial proportion of the population and highlights the need to examine whether VR sex therapy could be an innovative option for SD.

This paper aims to (1) review the empirical and theoretical literature exploring the use of VR in SD and related topics, (2) identify promising directions for the advancement of VR-assisted therapy approaches for individuals experiencing SD, and (3) critically examine the limitations of current VR applications within the realm of clinical sexology. By doing so, this review will help to establish the current state of knowledge on VR in sex therapy, identify future applications, and develop cohesive and targeted interventions on the factors contributing to the development and maintenance of SD.

Methods

A scoping review [14] of the research on the use of VR in SD from 1993 to 2023 was conducted (i.e., last update: April 2023). This review followed guidelines proposed by Arskey and O'Malley [15] in their five-stage methodological framework for scoping reviews: (1) identifying the research question, (2) identifying relevant papers, (3) report selection, (4) charting the data, and (5) collating, summarizing, and reporting the results.

Search Strategy

Relevant publications were systematically identified through *Scopus*, *PsycINFO*, and *PubMed.* The search strategy was based on variations and Boolean connections of VR/VR-related concepts (e.g., virtual reality, immersive environment, and virtual agents) and sexual functioning (e.g., arousal, erection, orgasm, and genital pain). We also adopted a broad approach regarding the use of VR in the context of sexual difficulties, including indicators or constructs known to be associated with SD (e.g., sexual response and sexual satisfaction). Considering the strong association between sexual victimization and impaired sexual functioning [16, 17], especially among individuals consulting in sex therapy [18, 19], this review also comprehensively examined the published research utilizing immersive environments with victims of sexual abuse/assault in order to identify potential interventions targeting trauma-related mechanisms in SD. References were then collated into EndNote v.20.

Inclusion and Exclusion Criteria

To be included in this review, publications had to (1) be empirical studies using VR with individuals experiencing SD or examining related issues and concepts (e.g., vaginismus, sexual aversion, and sexual response) or theoretical papers and reviews addressing the utilization, effects, or (dis) advantages of VR in SD; (2) focus on outcomes among adults; and (3) be published in English between 1993 and 2023 (i.e., last 30 years). Manuscripts only focusing on virtual simulations for the diagnosis and surgical treatment of urological conditions were excluded (e.g., tumor volume assessment for gynecological cancers or training exercises for cystourethroscopy).

Article Selection

To identify eligible publications, the titles and abstracts of each paper found using the search strategy described above ($n = 143$) were first screened for relevance. Eligible publications ($n = 68$) were then subjected to a full review to determine their suitability for final inclusion. To ensure the completeness and identify other relevant papers, an additional search was performed on *Google Scholar* using the same search syntax, along with an exploration of eligible papers' reference list and reporting of ongoing research known to the authors ($n = 15$). Through this process, a total of 43 papers were included in the review (see Fig. 1 for details).

Results

Publication Characteristics

Among the 43 publications included, there were 30 empirical papers, 6 reviews or theoretical articles, and 7 reports from ongoing research or research proposals. The empirical reports presented data from 1643 participants aged 18 years or older across 28 original empirical studies. Out of 28, 14 quantitative studies relied on quasi-experimental design (50%) and 11 used experimental design (39%). Three qualitative studies were found (11%). All studies used convenience samples (varying from 4 to 160 participants) and were conducted in Western countries: Canada ($n = 12$), USA ($n = 11$), Italy ($n = 8$), Germany ($n = 4$), Netherlands ($n = 3$), Czech Republic ($n = 2$), Austria ($n = 1$), Spain ($n = 1$),

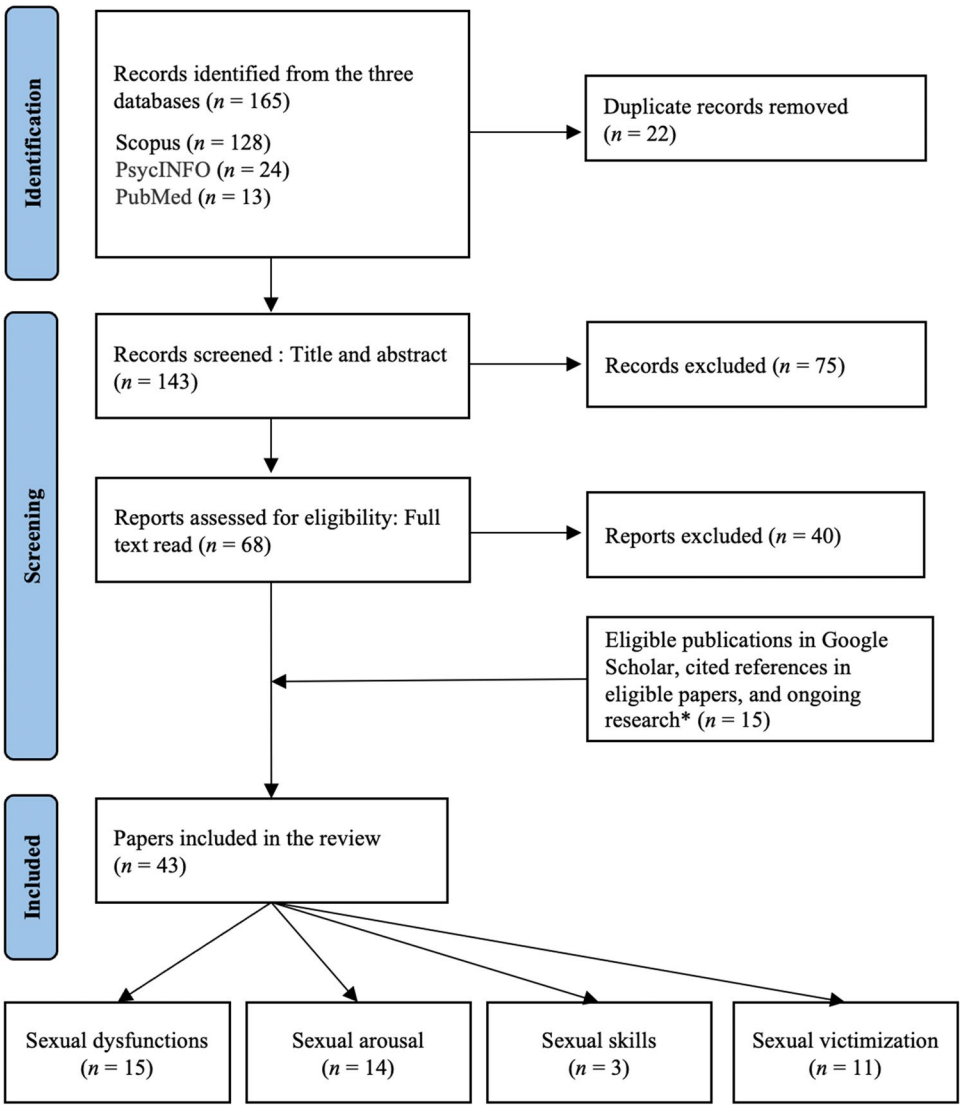

Fig. 1 Flow diagram detailing the inclusion and exclusion process for the review

and UK ($n = 1$). Among empirical studies, the population of interest were mostly nonclinical samples (45%; $n = 12$), followed by individuals with SD/sexual difficulties (19%; $n = 6$), victims of sexual assault (16%; $n = 4$), child molesters (10%; $n = 3$), and other populations (i.e., individuals with a dissociative disorder, with intellectual and developmental disabilities, as well as men who have sexually assaulted women; 10%; $n = 3$).

Overall, the number of papers increased from only three between 1993 and 2003 to approximately three per year between 2013 and 2023. The included publications reveal that VR-related technologies have been investigated in diverse contexts associated with SD, including (1) to explore, assess, or treat sexual dysfunctions ($n = 15$); (2) to investigate or assess subjective and/or genital sexual responsiveness ($n = 14$); (3) to explore or reduce post-traumatic symptoms among victims of sexual abuse ($n = 11$); and (4) to measure or improve sexual skills ($n = 3$). See Table 1 for details on each study's aims, sample characteristics, procedure, and main outcomes.

Sexual Dysfunctions

Eight empirical papers explored the relevance of VR to elicit (and potentially alleviate) symptoms of sexual difficulties. In their studies, Optale et al. [20–23] assessed the efficacy of a 12-session VR-assisted psychodynamic therapy for erectile disorder and premature ejaculation. The VR simulation included a pathway through a forest and 30-s film clips depicting various 2D scenarios symbolizing developmental stages of male sexual identity. Grounded in a psychodynamic conceptualization of SD etiology, this VR simulation aimed to regress participants to their infancy, uncovering underlying unconscious issues related to erectile disorder and premature ejaculation symptomatology. Among participants who partook in the VR-assisted psychodynamic therapy,

Table 1 Characteristics of included papers

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Abbey et al. [60]	Sexual assault perpetration proclivity assessment	87 heterosexual men	Four dating simulations[a] of 10 min each with an interactive female character Measures: number of refusals during the simulation, sexual assault history, stereotypes that rationalize forced sex, sexual dominance, alcohol consumption	Received number of refusals was associated with sexual assault history, stereotypes about forced sex, sexual dominance, and the number of drinks given to the female character throughout the simulation
Aleksandrovich and Gomes [41]	Sexual arousal	140 adults (women [$n=69$]; men [$n=64$]; nonbinary [6]; or transgender [$n=1$])	Three VE (safe space, abstract intimacy, and orgy) in the solo [$n=52$] or couple [$n=88$] experience over a 25-min session. Included audiovisual, tactile, and olfactory stimuli Measures: qualitative assessment of sexual arousal	Simulation increased sexual arousal for both groups by the end of the experiment. Audiovisual stimuli were rated as more arousing than other types of stimuli
Binter et al. [46**]	Paraphilic sexual preference profiling	Child sex offenders and nondeviant men	3D animations of six age categories depicting girls and women exhibiting consenting and nonconsenting behavior Measures: PPG, SC, ECG, fMRI	
Brown and Brotto [29**]	Treatment of vaginismus	Individuals with vaginismus and controls	VRET treatment in a single two-hour session. Mixed methods design Measures: emotional responses to VR videos, immersion, impressions on the treatment. Qualitative interviews probing how VRET can be combined with psychoeducational material to optimize treatment uptake	Preliminary results show significant differences in immersion, anxiety, and distress among those with vaginismus compared to controls. No significant difference in endpoints whether first- or third-person point of view. Clinical participants emphasized the importance of integrating VRET with psychoeducational information to enhance clinical efficacy
Corno and Bouchard [58*]	VR applications to prevent SAV		Conceptual paper	Future VR-based psychoeducational training could help identify situations linked to SAV and enhance strategies for responding to them
Dekker et al. [35•]	Perceived sexual intimacy in VR	50 heterosexual men	Two 25-min sexual films (in VR or 2D) presented on consecutive days in randomized order Measures: sexual arousal and desire, perceived intimacy	In the VR condition, participants reported higher sexual arousal and desire for the actresses, as well as greater perceived intimacy, compared to the 2D condition

Table 1 (continued)

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Döring et al. [32*]	Sexual interactions in digital contexts		Conceptual paper	Identification of three types of sexual interactions involving technology (*through*, via, and *with*) and corresponding opportunities/risks for sexual health
Dubé et al. [33*]	Erobotics in sex-related research		Conceptual paper	Erobotics can overcome ethical and methodological challenges in sex research and increase ecological validity of sexological studies
Elsey et al. [36]	Sexual arousal	95 heterosexual men ($n=48$) and women ($n=47$)	Two 10-min sexual films (in VR or 2D; randomized) from both a third and first-person perspective Measures: sexual arousal, presence	Men exhibited higher arousal when exposed to VR pornography compared to women. Both groups reported greater arousal in first-person conditions, regardless of the medium, compared to third-person perspectives. VR generated a stronger sense of presence than 2D. The ratings of presence were positively associated with sexual arousal
Fromberger et al. [37]	Sexual arousal and interest	45 men (gynephilic [$n=25$] or androphilic [$n=20$])	Twenty adult characters (10 women, 10 men) presented in three conditions (computer screen, static character in VR, mobile character in VR; randomized order) Measures: sexual attractiveness, realness, presence, viewing time	Levels of sexual attractiveness, realness, and presence were higher in VR conditions (static and mobile) compared to the computer screen condition. The mobile VR condition provided the best discriminant validity of sexual preferences and led to greater viewing times. Participants looked longer at characters that matched their sexual preferences
Fusaro et al. [42•]	Embodiment in VR	Study 1: 74 heterosexual men and women Study 2: 42 participants (lesbian women [$n=21$] and gay men [$n=21$])	Two blocks (touched by male or female character) in counterbalanced order. Blocks included 20×3-s touches on different parts of the avatar's body (e.g., genitals) Measures: SC, HR, embodiment, vicarious touch, erogeneity	Study 1: differences in vicarious touch sensation, erogeneity, and appropriateness based on sexual preferences and gender were found. Participants who were touched on intimate areas by avatars of the opposite sex experienced higher erogeneity Study 2: all participants rated caresses on their embodied avatar's intimate parts as most erogenous, particularly from the gender they are attracted to. SC was the highest when genital touches were delivered by female characters

Table 1 (continued)

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Jouriles et al. [52]	Realism of role play for sexual coercion-resistance skills	62 female college students	10-min stimulation[b] of sexual coercion including four stages (getting acquainted, beginning of sexual advances, escalation of advances, and anger). Random assignation to either the RP ($n=31$) or VRP ($n=31$) conditions Measures: perceived realism, negative affect, observed negative affect, and HR	VRP was perceived as more realistic than the RP. Individuals in the VRP condition reported more negative affect after the role plays, and more verbal negative affect were observed in VRP condition compared to RP. No HR differences were found between the conditions
Jouriles et al. [53]	Validation of a VE to assess responses to sexual threat	48 women	Simulation described in Jouriles et al. (2009)[b]. Random assignation to RP ($n=23$) or VRP ($n=25$) Measures: self-reported and observed negative affect, level of immersion and assertiveness, recent sexual victimization	The VRP condition generated greater negative affect (self-reported and observed) and level of immersion compared to the RP condition. Assertive refusals in the VRP were higher for women with prior history of sexual victimization but not in the RP condition
Lafortune et al. [31*]	Applications of VR in sex therapy		Conceptual paper	Despite the limited focus on SD in VR-based treatments, VR shows great potential to assist exposure-based strategies, cognitive restructuring, and mindfulness techniques in sex therapy
Lafortune et al. [25••]	Validation of a VE for SA	16 low-SA and 23 high-SA individuals (women [$n=24$]; men [$n=7$]; nonbinary [$n=8$])	15-min VR simulation including six erotic scenarios of increasing intensity (e.g., flirting, nudity, masturbation, and orgasm) Measures: anxiety, disgust, SC, HR, cardiac output, and eye fixation time	Anxiety and disgust scores significantly increased throughout the scenarios in both groups, although the high-SA group reported significantly more anxiety and disgust than the low-SA group. No group differences were found for physiological data and gaze behaviors
Lafortune et al. [26••]	Assessment of SA	27 SA and 28 non-SA controls (women [$n=34$]; men [$n=17$]; nonbinary [$n=4$])	18-min simulation[c] comprising two 4-min VR-Behavior Avoidance Test (sexual or nonsexual stimuli; counterbalanced) Measures: anxiety, disgust, SC, HR, movement time, genital touch duration, eye fixation time, sexual avoidance	The SA group reported higher anxiety and disgust during the sexual stimuli condition compared to the non-SA group. No group differences were found for physiological data, movement time, duration of touch, and fixation time. Condition effects were found for SC, HR, and touch duration. Sexual avoidance levels were negatively associated with touch duration

Table 1 (continued)

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Lafortune et al. [27]	Sexual disgust and sexual functioning	70 adults (women [$n=41$]; men [$n=24$]; nonbinary [n=5])	Secondary analyses on a larger sample[c] Measures: sexual functioning (i.e., low sexual interest/arousal, sexual pain, erection/lubrication difficulties, orgasmic difficulties), disgust, sexual arousal	Low sexual interest/arousal and higher sexual pain were both predictors of disgust toward sexual stimuli. Lower sexual functioning was not related to sexual arousal rating in the VR sexual condition
Lafortune et al. [30**]	Treatment for SA	36 individuals (with [$n=18$] or without SA [$n=18$])	Four VRET protocols (i.e., selected depending on the reported sexual orientation and the participant's gender), each comprising 15 sexual scenarios that progressively depict sexual behaviors of increasing intensity (e.g., flirting, nudity, genital touch, oral sex, and penetration) Measures: anxiety, disgust, sexual arousal, catastrophizing, sexual presence	
Loranger and Bouchard [49]	Validation of a VE for SAV	30 women (with [$n=15$] or without SAV history [$n=15$])	Two 5-min simulations (counterbalanced order): one involving an assault and one that does not lead to an assault Measures: anxiety, positive and negative affect, HR	The sexual assault condition led to greater anxiety and negative affect compared to the control condition. The SAV group did not respond more intensely than control participants. No differences in HR were found
Loucks et al. [50]	Treatment of MST-related PTSD	15 individuals with MST (women [$n=11$]; men [$n=4$])	Six to 12 90-min VRET sessions using idiosyncratic audiovisual elements from participants' experiences[d]. Number of sessions based on level of improvement Post-test and follow up at 3 months Measures: PTSD, depression, HR, SC, acoustic startle	Reduction of PTSD and depressive symptoms in the post-test and difference maintained at follow up. Reduction of HR in post-test, but no difference for SC and startle
Marschall-Lévesque et al. [43]	Paraphilic sexual preference profiling	30 men (child molesters [$n=15$] and nonmolesters [$n=15$])	A 150-min session including eight 90-s vignettes in audio, visual, and audiovisual (VR) formats. Vignettes depicted scenes with consenting and nonconsenting adults or children and neutral stimuli (counterbalanced order) Measures: PPG, perceived age of virtual characters	The three modalities were efficient in discriminating between the two groups based on their sexual arousal responses to the adult and child stimuli, but VR and visual modality had better discriminant validity. Child molesters showed enhanced arousal to child stimuli and nonmolesters showed greater arousal to adult stimuli

Table 1 (continued)

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Massa et al. [34*]	Human companion-robot interaction		Conceptual paper	Proposition of a theoretical framework to understand human-companion robot interactions and their potential associations with collusive dynamics, paraphilic fixation, and user infantilization
Milani et al. [38•]	Sexual arousal	38 women	Erotic (5-min) and neutral (2-min) videos presented in four modalities (2D, VR, first person, and third person; counterbalanced order) Measures: general and sexual presence, sexual desire and arousal	General and sexual presence scores as well as sexual arousal were higher during VR videos than 2D modalities. No difference was found for sexual desire. Sexual presence was higher in the first-person videos
Optale et al. [20]	Treatment of ED	70 heterosexual men (psychological ED [$n=20$], combined factors [$n=30$], controls with psychological ED [$n=10$] or combined factors [$n=10$])	Twelve 60-min sessions over 25 weeks combining VR ($10\times$ 15-min VR simulations) and psychodynamic psychotherapy or psychotherapy alone (controls)[e]. The simulation included a VR pathway through a forest and 30-s film clips depicting different 2D scenarios symbolizing developmental stages of male sexual identity Measure: sexual activity report	Resolution or improvement of sexual activity (i.e., improvement in the principal pathology, return of adequate erection during sexual activity) for the experimental group was 82 to 84% and 29 to 50% for controls
Optale et al. [21]	Treatment of ED and PE	66 heterosexual males (psychological ED [$n=20$] or combined factors ED [$n=30$], or PE [$n=16$])	Twelve 60-min sessions over 25 weeks combining VR and psychotherapy. Simulation described in Optale et al. (1997)[e] Measure: sexual activity report	Resolution or improvement of sexual activity was 82 to 84% for ED and 73% for PE
Optale et al. [22]	Treatment of ED and PE	160 heterosexual men (psychological ED [$n=50$], combined factors ED [$n=60$] or PE [$n=50$])	Stimulation described in Optale et al. (1997). 1-year follow-up[e] Measure: sexual activity sex report	Resolution or improvement of sexual activity was from 47 (combined factors ED) to 76% (psychological ED) for ED groups and 54% in the PE group in the 1-year follow-up

Table 1 (continued)

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Optale et al. [23]	Treatment of ED and PE	Study 1: 30 heterosexual males with psychological ED ($n=5$) or combined factors ED ($n=5$) and PE ($n=5$); controls with psychological ED ($n=5$), combined factors ($n=5$), or PE ($n=5$) Study 2: 160 heterosexual males with psychological ED ($n=50$), combined factors ED ($n=60$), or PE ($n=50$)	Study 1: 12 sessions (or 15 if a sexual partner was involved) over 25 weeks including six × 15-min VR simulations or control condition with, using simulation described in Optale et al. (1997)[e] Measure: sexual activity report Study 2: same as study 1 with no control condition	Study 1: resolution or improvement of sexual activity ranged between 40 (combined ED) and 80% (psychological ED and PE) and was 71% for the control group Study 2: results correspond to Optale et al. (2003) responses following the intervention and show a resolution or improvement of sexual activity of 45% (combined factors ED) to 76% (psychological ED) for ED groups and 56% for the PE group
Platt [54]	Assessment of risk perception in sexual coercion situations	62 female college students	Simulations described in Jouriles et al. (2009)[b] and vignette risk assessment (i.e., latency of the detection of risk during a description of a sexually coercive interaction) Measures: risk detection latency (vignette and VRP), observed negative affect during VRP, and prior sexual victimization experiences	Risk detection latency during vignette was related to recent sexual victimization. Observed negative affect increased over the course of the role play. Responses to VRP did not predict recent sexual victimization better than responses to the vignette
Pegram et al. [61]	Profiles of SAP with sober versus drunk women	87 men (sexual assault with drinking women [$n=19$]; sexual assault that involved sober women [$n=25$]; non-SAP [$n=42$])	Simulation described in Abbey et al. (2018)[a] Measures: alcohol consumed, alcohol given to the female character, perception of the intoxication of the character, number of refusals from the character	SAP with drinking women gave themselves and the female character significantly more alcohol to drink and perceived her as more disinhibited than the other groups. The number of refusals did not differ from one group to another
Renaud et al. [40]	Assessment of sexual preferences	8 men (homosexual [$n=4$]; heterosexual [$n=4$]) and 5 women (homosexual [$n=1$]; heterosexual [$n=4$])	Two VR stimuli (i.e., a gray sphere and a naked female virtual character) in two modes of exploration (locomotion or no locomotion) Measure: eye tracking	Different patterns of exploration according to gender and sexual orientation were found. Men displayed a greater focus on erogenous zones and more exploration. Heterosexual individuals focused more on facial features than homosexuals. No difference in gaze behaviors during the control condition was found
Renaud et al. [44]	Paraphilic sexual preference profiling	42 men (child molesters [$n=13$]; nondeviant adults [$n=29$])	A 90-min session including five randomized VR stimuli (neutral, man, boy, woman, girl) Measures: PPG, eye tracking	Distinct sexual arousal profiles based on sexual preferences. Child molesters displayed greater genital arousal and fixation time to children characters compared to controls

Table 1 (continued)

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Říha et al. [47**]	Paraphilic sexual preference profiling and treatment	70 males (pedophilic preference [$n=15$]; child sex offender [$n=15$]; controls [$n=40$])	162 stimuli including 80 avatars of varying age and gender, each exhibiting consenting or coercive proceptive behavior, as well as two adult avatars engaging in genital interactions (anal and vaginal penetration) Measures: ECG, SC, PPG, eye tracking, pupillometry, respiratory rate	
Rizzo and Schilling [59*]	VR as a clinical tool for PTSD		Conceptual paper	Seven benefits and challenges are discussed regarding the use of VR to prevent, assess, and treat PTSD and break down barriers to care
Rowe et al. [57]	Training program to prevent SAV	83 female students (randomly assigned to the experimental [$n=47$] or control condition [$n=36$])	Experimental group: a 90-min group session including a training in assertive resistance skills and practice in VRP (i.e., where an actor simulated verbal sexual coercion of increasing intensity). Control group: waiting list Measures: sexual and nonsexual violence victimization and psychological distress	The experimental group reported less sexual victimization compared to controls. Girls with higher levels of prior victimization reported reduced psychological victimization and psychological distress in the 3-month follow-up compared to controls
Schmidt [62]	Validation of a sex education program for individuals with intellectual and developmental disabilities	Individual with intellectual and developmental disabilities ($n=4$)	5-week community program including a 20-min learning-focused VR serious game that focused on fostering positive attitudes related to healthy sexual relationships Measures: qualitative assessment of usability and appreciation of the VE	Among participants, 75% found the virtual reality script agreeable, usable, useful, and desirable
Schippers et al. [48**]	Sexual arousal	50 adult males	Four blocks of the following sequence: 80-s neutral clip; 60-s VR clip in counterbalanced order (disgust, aggression, fear, endearment); 10-s neutral film; 60-s sexual clip; 10-s neutral clip; return to baseline Measure: HR, PPG and subjective sexual arousal, unusual and deviant sexual interests, sexual activity	

Table 1 (continued)

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Simon and Greitemeyer [39]	Sexual arousal	60 heterosexual men	Two videos (neutral [3-min] and sexually explicit [6-min]) presented in two levels of immersion (desktop and VR) in counterbalanced order Measure: sexual arousal, presence and sexual presence, SC	Sexual video in the VR condition yielded greater sexual arousal, presence, sexual presence, and SC compared to the desktop condition
Spagnolli et al. [24]	Validation of a VE for the assessment of ED	Four heterosexual men randomly assigned to contextualized [$n=2$] or noncontextualized [$n=2$] condition	A simulation including 13 scenarios depicting objects and characters symbolizing sexuality Measures: qualitative assessment of VE usability, comprehension of the symbols presented and their incentive, and relationship between user and guide	Participants found the simulation pleasant and the guidance through the simulation helpful. Understanding of the symbolic value of the stimuli was modest in noncontextualized participants
Tavabi et al. [55]	Assessment of PTSD	15 individuals with MST (female [$n=11$]; male [$n=4$])	Secondary analyses[d] using multimodal machine learning to detect PTSD symptoms based on response patterns during VR treatment Measures: performance in the verbal, visual, and vocal modalities	Vocal modality better detected PTSD symptoms than the other conditions, and visual modality had a higher recall on PTSD patients. Multimodal machine learning seems to be a valuable tool to assess PTSD during virtual simulations
Trottier et al. [45]	Paraphilic sexual preference profiling	64 males (children sex offenders [$n=22$]; nonoffenders [$n=42$])	A 2-h session including (1) eleven 2-min audio scenarios depicting sexual interactions with characters (child or adult) engaging in consensual or nonconsensual sex and a neutral scenario, (2) a 5-min erotic film, and (3) five VR scenarios of 90 s (woman, girl, boy, man, neutral; randomized order) Measure: PPG	VR modality generated greater genital arousal for sex offenders compared to audio stimuli. VR allowed for better group classification accuracy and discriminant validity. Profiles of sexual interest were obtained according to the group: sex offenders exhibited greater arousal to children stimuli, while nonoffenders exhibited greater arousal to adult characters
van Meggelen et al. [51]	Validation of a trauma-focused intervention for PTSD using VR components	44 war veterans and survivors of CSA (female [$n=21$]; male [$n=23$])	Randomized controlled trial. Two 12-session programs: VR multimodal memory restructuring self-help program versus nonimmersive program conducted by psychologists. Pre, post, and three-month follow-ups Measures: PTSD, depression, and well-being	Both treatment modalities yielded reduction in PTSD and depression symptoms and improvement in well-being between pre- and post-measurements

Table 1 (continued)

Study	Objectives/focus	Sample	Design and measures	Results/conclusions
Vila and Riva [28**●●]	Treatment for female orgasm disorder	30 women with female orgasm disorder	Development of VR-based protocol incorporating different modules such as psychoeducation, desensitization, simulations with a sexual partner, and self-exploration. The protocol is currently undergoing clinical trials	The authors state that preliminary data suggest that the protocol may be an effective tool for treating female orgasm disorder and other sexual disorders
Weniger et al. [56]	Neural correlates of dissociative disorder and self-referential processes	28 women (with dissociative disorder who experienced childhood abuse [$n = 14$]; matched healthy controls [$n = 14$])	Five trials in a virtual maze (of 5 min maximum) in first-person view during which participants were instructed to find the shortest way to a pot of money in the virtual maze Measures: CSA, fMRI	No group differences in the capacity to learn the virtual maze were found, although women with dissociative disorder presented weaker patterns of activity changes during egocentric learning. Severity of dissociative disorder was associated with a better performance in the virtual maze

AV audiovisual, *CSA* childhood sexual abuse, *DD* dissociative disorder, *ECG* electrocardiography, *ED* erectile disorder, *fMRI* functional magnetic resonance imaging, *HR* heart rate, *MSA* military sexual trauma, PPG penile plethysmography, PE premature ejaculation, *RP* role play, *SA* sexual aversion, *SAP* sexual assault perpetrators, *SAV* sexual assault victimization, *SC* skin conductance, *TAU* treatment as usual, *VE* virtual environment, *VRET* virtual reality exposure therapy, virtual role play.

**Ongoing research.

*Review or conceptual paper.

the studies reported significant symptom improvement for 82–84% of individuals with erectile disorder [20, 21] and 73% with premature ejaculation [21]. Only one study included a control group (i.e., non-VR psychodynamic therapy), where 29–50% of participants with erectile disorder reported total or partial improvement of their condition [20]. Results further showed improvements of sexual activity after the 25-week treatment. Indeed, 45 to 76% of individuals with erectile disorder showed resolution or improvement, as did 56% of individuals with premature ejaculation [22, 23]. Effects were also maintained at 12-month follow-up among 47–76% of participants with erectile disorder and 54% with premature ejaculation [22].

Also, based on a psychodynamic framework, Spagnolli et al. [24] explored whether a VR protocol comprising 13 scenarios depicting objects and characters symbolizing sexuality could assist erectile disorder assessment. Qualitative results suggested good acceptability of the simulation and collaboration between the patient and the experimenter. However, participants reported a modest comprehension of the symbolic value of the VR stimuli, whether they had been explained the goals of the study and had access to the treatment protocol or not.

Further research has been dedicated to the use of VR to elicit sexual aversion disorder manifestations and explore factors associated to low sexual functioning [25••, 26••, 27]. For one, Lafortune et al. [25••] exposed individuals with low and high sexual aversion to 6 erotic/sexual scenarios of increasing intensity. They found that individuals with high sexual aversion exhibited higher levels of anxiety and disgust throughout the scenarios compared to those with low sexual aversion. They also found that the intensity of aversive emotional responses increased in accordance with the graded intensity of the sexual behaviors displayed in the sexual scenarios.

These researchers' subsequent study [26••] investigated the relevance of a *VR Behavior Avoidance Test* in the examination of sexual fear, disgust, and avoidance in individuals with(out) sexual aversion disorder. Individuals with sexual aversion reported higher levels of anxiety and disgust during the sexual stimuli condition compared to healthy controls. Also, greater levels of sexual avoidance were associated with less time spent touching the virtual character's genitals. Using a larger sample, secondary analyses [27] examined the relationships between sex-related disgust, sexual responsiveness, and four indicators of sexual functioning (i.e., sexual interest/arousal, ability to have and maintain an erection/to lubricate, ability to reach orgasm, and pain during sex) during the VR sexual condition. Results showed that, when exposed to virtual sexual cues, low sexual interest/arousal and pain during sex were linked to increased disgust.

Beyond that, three clinical research studies are currently assessing feasibility and effects of VRET protocols for female orgasmic [28••], genito-pelvic pain/penetration [29], and sexual aversion disorders [30]. Precisely, Vila and Riva [28••] are completing a clinical trial aiming to validate a VRET's efficacy among persons with female orgasmic disorder (*Sextreatverse* study). Their pilot data suggested that their protocol is effective in reducing orgasmic disorder symptoms. Similarly, Brown and Brotto [29] have recently completed a proof-of-concept study examining the feasibility, patient satisfaction, and potential effects of a VRET among individuals living with vaginismus compared to healthy controls (i.e., *VIVID* study), exploring the impacts of first versus third-person point of view, partnered versus solo sexual activity, and same sex versus opposite sex partners depicted in the sexual stimuli. Lafortune et al. [30] are undertaking a proof-of-concept study to evaluate the feasibility, adequacy, and clinical impact of four VRET protocols among sexually and gender diverse individuals living with sexual aversion disorder (i.e., *EVAS* study).

Moreover, four theoretical papers addressed VR and sexual functioning (i.e., reviews and conceptual papers) [31–34]. In their review, Lafortune et al. [31] proposed avenues for future VR-based sex therapy, based on the existing literature on VR-assisted treatment for anxiety, eating, and pain-related disorders. In a conceptual review, Döring et al. [32] further differentiated between three types of sexual interaction *through*, *via*, and *with* technology—including VR—and disentangling opportunities and risks related to sexual health (e.g., sexual education, relationship difficulties, sexual compulsion). In parallel, in their conceptual review on erobotics, Dubé et al. [33] suggested that artificial erotic agents (i.e., erobots), including virtual ones, could help overcome some of the ethical and methodological challenges associated with sex research and therapy (e.g., risks of harm, lack of intimate partners, and the control for experimental stimuli and conditions). Lastly, in their conceptual paper, Massa et al. [34] posited a theoretical framework to understand human-companion robot interactions—notably, in virtual or augmented reality—and their potential risks of collusive dynamics, paraphilic fixation, and infantilization among users.

Sexual Responsiveness

Fourteen empirical studies investigated sexual responses to VR erotic/sexual stimuli among individuals without SD. Of these studies, five assessed VR's capacity to elicit sexual arousal among nonclinical samples by comparing sexual responses to erotic stimuli presented in immersive to non-immersive settings (e.g., 2D videos on flat-screen monitor) [35•]. Results consistently showed that immersive conditions generated greater subjective sexual arousal or interest across studies and sense of presence compared to control conditions [35•, 36, 37, 38•, 39]. A study also found that

computer-generated characters were viewed for a longer period and perceived as more attractive when they were presented in VR than on a computer screen [37]. Likewise, Dekker et al. [35•] found that individuals were more willing to interact with the actors in VR compared to actors in 2D videos and felt more connected to them.

One pilot study [40] examined the links between visual exploration and reported gender and sexual orientation (i.e., heterosexual or homosexual) during a VR simulation depicting a naked female character and a control stimulus (i.e., a gray sphere). The researchers found that fixation time on genital areas was higher among men than women. Another study [41] explored sexual arousal when immersed in three VR multisensorial simulations of increasing sexual explicitness with(out) the presence of sexual partners. Results showed increased sexual arousal between the baseline and the end of the simulation, but no differences between conditions (alone or with sexual partners). Participants were also mostly aroused by the audiovisual stimuli, regardless of the condition, yet did rate the olfactory and tactile components as somewhat arousing. Fusaro et al. [42•] further found that being touched while embodying a VR character led to increased sexual arousal, especially when participants were touched on their erogenous zones (i.e., genitals, inner thigh, breast) by a character that matched their sexual orientation. Touch intensity was also positively correlated to the level of embodiment participants experienced.

Complementarily, three studies found that VR may help profile sexual offenders through their genital sexual responses toward underage 3D characters [43–45], as results showed greater arousal responses and visual interest to childish characters among individuals who have sexually abused children compared to nonoffenders.

Three research proposals also addressed sexual responsiveness [46–48]. Two included the use of virtual characters of varying age groups exhibiting either consenting courtship displays or nonconsenting negative displays to help profiling pedophilic individuals based on their genital sexual arousal responses [46, 47]. Another paper proposed to assess whether sexual arousal during VR erotic films can be transferred to VR films depicting aggression/dominance, fear, disgust, or endearment among a nonclinical sample in order to determine if this transferability may be associated to unusual sexual interests [48].

Sexual Victimization

Eleven studies examined the potential of VR to prevent sexual victimization, explore the experience of victims during sexual coercion simulations, or reduce post-traumatic symptoms among victims of sexual abuse. Of those 11 studies, three aimed to validate VR-based treatment protocols for persons with a history of sexual assaults [49–51]. Loranger and Bouchard [49] focused on developing and examining the ability of a VRET protocol comprising eight stages leading up to sexual assault to elicit negative emotional response among individuals who have experienced sexual assault. They showed that sexual assault simulation gradually elicited greater anxiety and negative affect among participants, with no significant differences between victims and non-victims. In their feasibility study, Loucks et al. [50] later assessed the efficacy of a 6- to 12-session VRET program on post-traumatic stress disorder (PTSD) and depressive symptoms among veteran reporting military sexual trauma. The results showed a reduction in PTSD and depressive symptoms immediately after the program and maintenance of improvements at 3-month follow-up. In one randomized-controlled trial among veterans reporting childhood sexual abuse, van Meggelen et al. [51] compared the efficacy of a self-help VR-based 12-session multimodal memory restructuring program to a traditional non-VR 12-session trauma-focused program for PTSD. They found that both treatment methods displayed similar efficacy in reducing depressive and PTSD symptoms.

Beyond that, four studies used VR to develop assessment methods for PTSD and risk perception of sexual coercion [52–55]. In two pilot studies, Jouriles et al. [52, 53] developed a VR role play depicting sexual interactions escalating to hostility and assessed its realism compared to a nonimmersive role play (control condition) [52] and individuals' responses to sexual threat [53]. The virtual role play was perceived as more realistic [52] and immersive [53], as well as elicited greater negative affect compared to the non-VR condition [52, 53]. The simulation was also associated with greater levels of assertive refusals among women reporting prior experience of sexual victimization [53]. One study aimed to develop a behavioral risk assessment measure in sexually coercive situations among women using VR role play [54]. Participants reported an increase in negative emotions (e.g., fear and anger) as the simulation gets more coercive. Using the data of Loucks et al. [50], Tavabi et al. [55] examined whether verbal, visual, and vocal response patterns during VR treatment sessions could help detect PTSD symptoms. Results suggest a good performance of vocal and visual modalities in improving diagnostic accuracy.

In parallel, Weniger et al. [56] examined the brain activity and the performance of individuals reporting dissociative disorders and history of childhood abuse (sexual or physical) while they navigate through a VR maze. No differences were found in learning capacity, attention, and visuospatial functioning between individuals with dissociative disorders and the healthy controls. However, greater dissociative disorder severity was associated with better performance in the virtual maze than the control group. In another study, Rowe et al. [57] developed a 90-min training program for assertive resistance to sexual coercion among female high

school students. Following the training, participants had the opportunity to practice their newly acquired skills in virtual role plays. At a 3-month follow-up, participants who received the training reported experiencing less sexual victimization compared to controls (wait list).

Lastly, two theoretical papers emphasized the relevance of VR for treatment of PTSD among victims of sexual violence [58, 59]. Corno and Bouchard [58] proposed that VR could be used, for instance, to prevent sexual assault thought training, including psychoeducation on beliefs and attitudes about sexual assault or application of learned techniques. Rizzo and Shilling [59] further argued that VRET offers seven main benefits for the treatment of PTSD, including improved treatment accessibility, affordability, and adherence.

Sexual Skills

Three studies utilized virtual environments to examine or enhance sex-related skills and attitudes among two populations: persons who have sexually assaulted women [60, 61] and individuals with intellectual and developmental disabilities [62].

In one study, Abbey et al. [60] assessed sexual assault perpetration proclivity among single men using four 10-min interactive dating simulations featuring a 3D female character. They found that the frequency of refusals by the virtual character was positively linked with previous instances of sexual aggression, sexual dominance, stereotypes that rationalize forced sex, and the number of drinks consumed by partners in sexual situations. Using the same dating simulation [60], Pegram et al. [61] compared the characteristics of men who have sexually assaulted drinking women to those who targeted sober women, as well as nonperpetrator controls. Participants with a history of sexually assaulting women who were drinking gave significantly more alcohol to the virtual woman compared to the sober women and the nonperpetrators. Perpetrators with intoxicated victims also perceived the female character as significantly more disinhibited due to alcohol.

Finally, in a doctoral thesis, Schmidt [62] aimed to validate a 5-week sexual health education program tailored for individuals with intellectual and developmental disabilities, which included a VR serious game. Qualitative assessment of the VR scenarios revealed that participants found the virtual scripts enjoyable, realistic, and engaging.

Discussion

VR is increasingly used in psychology and therapy, with encouraging results for mental health conditions [2]. Yet, less attention has been given to the use of VR to address sexuality-related problems and enhance human sexual health. Hence, this paper reviewed the literature on VR-based research on SD and their related issues. The findings of this scoping review point to promising avenues for the application of VR for SD and highlight the limits of current VR research in this area.

Summary of Current State of Knowledge

The identified VR-based research mostly pertains to sexual dysfunctions, responsiveness, victimization, or skills. This suggests, for instance, that VR may help alleviate symptoms of some SD (e.g., premature ejaculation, erectile disorder, and female orgasmic disorder) [21, 22, 28••], provide a new, more effective and immersive mean of exploring sexual desire, arousal, and preference/orientation-based response patterns [38•, 40, 41, 43, 44], and elicit emotional manifestations (e.g., sexual fears) and behavioral avoidance characteristics of sexological issues, such as sexual aversion and vaginismus [25••, 26••, 29]. It also suggests that VR may help reduce post-traumatic symptoms among survivors of sexual abuse [50, 51] and enhance individuals' ability to negotiate consent and establish boundaries in sexually coercive situations [53, 57]. Lastly, this review points to the possibility of using VR as a way of assessing one's sexual competencies and understanding of sexual contexts [60, 61], as well as a means to deliver sex education in diverse populations (e.g., people with intellectual disabilities) [62].

Sex Therapy Insights and Potentials

These findings have significant implications for the future of sex therapy. For instance, they suggest that virtual sexual environments and scenarios may be used in VRET programs designed to treat conditions such as sexual aversions and pain-related disorders [25••, 28••, 29, 30]. As such, VR may provide therapists with greater control over the stimuli and patient's response and ensure the proper execution of VRET exercises at an appropriate/adapted level of exposure to fear-inducing or anticipated sexual contexts. During VRET, therapists could also monitor patients' real-time emotional and cognitive experiences during simulated erotic or sexual interactions, through verbal questioning, gamification feedback, or command-based interactions. When combined with specific tools (e.g., vaginal inserts), VR could offer the opportunity to supervise tasks in a clinical setting that may be challenging to regulate at home, thereby helping individuals overcome severe phobia and anxiety about penetration.

In addition, the use of virtual characters and environments would allow to (re)create, in therapy settings, safe simulations of sexual behaviors and contexts that would otherwise be unfeasible ethically, impossible due to lack of access to sexual partners in one's life, challenging because of specific

SD symptoms, such as sexual avoidance, failure expectancies, and pain anticipation. The fictional and playful aspects of VR could also create a safe environment free from real-world hazards, facilitating practice and skill development without the risks of sexual assault, pressure, or rejection [26••, 33]. As virtual environments become increasingly interactive and realistic, they will also be able to more closely approximate real-world intimate interactions by incorporating multisensory stimuli replicating a broad range of erotic cues, interactions, and contexts relevant to the etiology and manifestations of SD. This includes expressions of sexual interest, sexual communication, and attempts at sexual intercourse [63, 64]. Accordingly, VR could then help clinicians identify specific triggers or situations that elicit SD symptoms, enabling personalized treatment plans and tailored interventions targeting specific symptoms or mechanisms based on clients' needs and characteristics. In parallel, the growing affordability of VR could make in-home therapy more affordable (alone or with a partner), de facto addressing issues of geolocalization and limited access to specialized clinics or resources. VR-based exercises could also support couples in continuing treatment independently, promoting the maintenance of therapy benefits and relapse prevention.

Together, this could arguably enable more effective, progressive exposure approach and other potential VR-based sexological interventions compared to traditional sex therapy: accessible and controllable virtual environments that safely and ethically elicit authentic emotional, sexual, and behavioral responses akin to real-world experiences related to sexual (dys)functions.

Shortcomings in VR Research on SD

VR applications for SD remain understudied and several issues must still be addressed. For one, some of the prior studies reviewed here were conducted more than 20 years ago, and their conclusions have yet to be replicated using more modern VR systems [21, 22]. Contemporary studies further employ a wide variety of VR systems and procedures, including different equipment, stimuli, exposure methods, interactivity levels, and sensory experiences, with no clear standards or guidelines. Also, in addition to being predominantly feasibility and proof-of-concept studies, they mainly use audiovisual stimuli (with haptic and olfactory cues receiving little attention) and are based on diverse theoretical models with varying levels of operationalization of conceptual frameworks and targeted mechanisms in SD, such as psychodynamic [20, 24] and cognitive-behavioral approaches [28••, 29, 30]. Moreover, to date, little attention has been given to the cognitive, relational, and pathophysiological manifestations of SD in VR, which could be used as a tool to enhance cognitive restructuring, biofeedback, and mindfulness strategies [31]. More studies have also yet to report dose–effect outcomes and compare VR-based treatments—aided by or only using VR—to controlled conditions/groups ongoing non-VR therapy (e.g., in vivo or imaginal exposure). Finally, the samples of previous studies and the stimuli used in experiments lack diversity, often overrepresenting sociodemographic groups, such as Caucasian heterosexual cisgender individuals. Intimate partners are also not consistently included.

Limitations and Strengths of the Review

This scoping review is limited by its search terms, search engines, language (i.e., English publications), and time scope (i.e., the last thirty years of research). It is also limited by how empirical results are reported in publications—that is, rarely with raw and processed data—which constrains their interpretations to what authors made available. That said, this review still consolidates the current knowledge—key empirical findings and theoretical conceptualizations—on the use of virtual VR in SD and related areas, identifies potential avenues for the use of VR in therapy, and highlights shortcomings in present VR applications for clinical sexology. In doing so, it contributes to understanding how VR can improve sex therapy and sexual health, as well as invites further investigations of potential VR therapy targeting SD and their underlying factors.

Conclusion

Future research should replicate previous findings with updated technologies and standardize VR systems, procedures, and means to report them in scientific publications. Such updated methods should gradually incorporate new immersive experiences and technologies (e.g., haptic equipment), and researchers should move toward performing adequately powered studies and randomized controlled trials, as well as comparing VR treatments to standard therapy. They may also want to compare theoretical frameworks in future review articles and empirical studies and leverage VR to explore the causal effects and manifestations of SD (e.g., cognitive, physiological, and relational), as well as dose-effects of VR stimuli in therapy. Finally, given the VR's ability to customize characters and avatars—in terms of gender expression, sexual practices, and physical attributes, for instance—it is crucial that, in partnership with VR stimuli producers, future research further incorporates more options that promote inclusivity and allow us to explore the heterogeneity of treatment response across more diverse samples (e.g., age, gender/sex, ethnicity/cultural background, and sexual orientation). This is essential to provide researchers and therapists with the necessary tools to investigate and help people who struggle with SD and unlock the full potential of VR in sex therapy.

Author contributions D.L. and V.A.L. wrote the main manuscript text (original draft, review, and editing), V.A.L. prepared table 1, and S.D. and L.B. reviewed the manuscript thoroughly.

Declarations

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent All reported studies/experiments with human or animal subjects performed by the authors have been previously published and complied with all applicable ethical standards (including the Helsinki declaration and its amendments, institutional/national research committee standards, and international/national/institutional guidelines).

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