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Virtual reality as a supportive opportunity in treatment patients with anorexia nervosa Review article

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Abstract
Theoretical background: Virtual reality (VR) is a computer-based tool for visualizing interactive three-dimensional environments where the user can experience a feeling of physically present in a non-physical world. The main feature of the technology makes possible using the method in treatments of patients suffering from anorexia nervosa (AN).
Aim: The purpose of the review is summarizing the studies discussing the possibilities of using VR technology in treatment of patients with AN thus showing how VR is being used in treatment of AN all over the world.
Material and Methods: The main medical databases (Ovid Medline, Biological Abstracts, PubMed, PsycINFO, the Cochrane Library, Scopus, and Web of Science) were searched for relevant data. The papers were selected by focusing on key words: virtual reality and anorexia.
Results: Finally, 12 articles were selected. The aims of the studies can be categorized into 3 dimensions, namely a) correcting perceptual body image (7), b) reducing anxiety regarding food and environment (4), and c) the effect of AN on spatial ability (1).
Conclusions: VR technology can be considered as a successful supportive tool in treatment of AN and also in providing more information for educational purpose about the nature of the disease.

Keywords: VR, virtual reality, anorexia nervosa, eating disorder.

1. Introduction

Virtual reality (VR) is one of the most significant inventions of the 20st century. It can be described as a computer-based tool for visualizing interactive three-dimensional environments where the user can experience a feeling of physically present in a non-physical world.

There are three basic types of VR exist, namely the non-immersive, the semi-immersive and the fully immersive ones (Poetker, 2019). Average video games where the system detects the motion of the player and translates it on the screen can be considered as non-immersive VR tools. Semi-immersive experiences can provide partially virtual environment and the experience is created usually by graphical computing and large projector systems. In this case the large screen displays the virtual content providing the experience of being in a different reality. Fully immersive VR simulations give the users the most realistic experience. Usually it is created by VR headsets providing high-resolution content with a wide field of view and with realistic sound. It can be made even more complete by applying kinesthetic tools like VR gloves.

The main feature of the technology makes possible for the user to immerse in an environment that cannot be discovered in another way. There are three main fields where VR is used in healthcare. The first is human simulations which enables doctors, nurses and other medical personnel to interact with others in an interactive environment. They engage in training scenarios in which they have to interact with patients within a 3D environment without actual physical contact with the patients. The second is VR diagnostics enabling doctors to arrive at a diagnosis in conjunction with other methods such as MRI scans without invasive procedures or surgery. The third is VR robotic surgery where surgery is performed by means of a robotic device, controlled by a human surgeon (Virtual Reality Society, 2019). It is increasingly used in medical education, patient care and health decision making (Ammanuel, Brown, Uribe, & Rehani, 2019). The application of VR offers new solutions for old problems including using the method in treatments of patients suffering from different diseases. One of such diseases is anorexia nervosa (AN).

The prevalence of AN is reported as 0.9% among women and 0.3% among men (Hudson, Hiripi, Pope, & Kessler, 2007). Body image disturbance is one of the leading symptoms of AN (Boehm et al., 2016; Roy & Meilleur, 2010; Waller & Hodgson, 1996). Most of the research papers report about the overestimation of body size by the patient (Hagman et al., 2015; Metral & Mailliez, 2018; Overas, Kapstad, Brunborg, Landro, & Ro, 2017; Probst, Vandereycken, Coppenolle, & Pieters, 1998) although there are also some exemptions where patients with AN underestimated their body weight (Molbert et al., 2017). As a consequence, dieting and excessive fear of eating coexist in AN patients (Kissileff et al., 2016). The purpose of the study is comparing the studies discussing the possibilities of using VR technology in treatment of patients with AN thus showing how VR is being used in treatment of AN all over the world.

2. Material and Methods

The search strategy contained a search of the main medical databases (Ovid Medline, Biological Abstracts, PubMed,

PsycINFO, the Cochrane Library, Scopus, and Web of Science). Searching were performed till 6th September 2019 using the terms: "virtual reality" [AND] "anorexia". There were no language restrictions. Only articles containing clinical trials were included. Reviews and systematic reviews were excluded from the research. The primary end point was collecting studies using VR techniques in treating patients with anorexia nervosa. Studies without a clinical population and theoretical articles presenting an application of VR were also excluded. Considering the small number of articles case studies with only one participant were also included into the research. The studies were compared regarding countries, aims, sample sizes, technologies applied, results and conclusions.

3. Results

Figure 1 shows the PRISMA flow diagram summarizing the stages of the review.

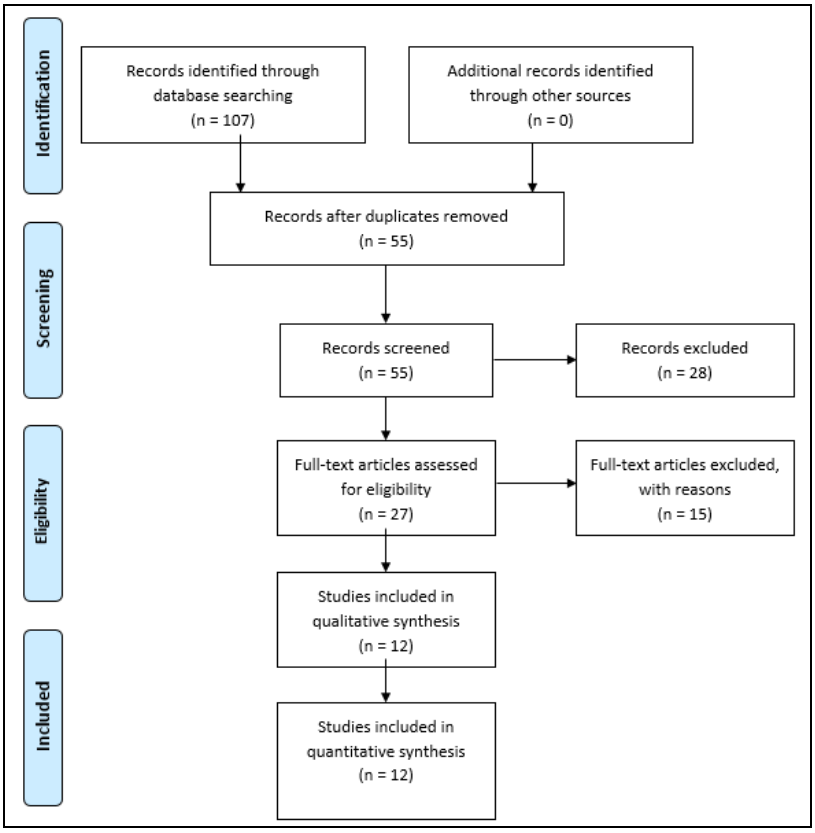

Fig 1: Flow diagram of study selection using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2010)

The initial database searches could identify 107 results, 55 of which were removed as duplicates. By the titles and abstracts another 28 studies were excluded. The remaining 27 articles were examined for full-text review. Another 15 articles were excluded for several reasons: 8 articles referred to clinical trials already published and included in our research, 6 articles didn't include clinical trials and 1 article evaluated healthy participants. The resulting 12 articles were analyzed.

The articles were published between 1997 and 2019. Distribution of studies by country is as follows: Italy (6), Spain (4), The Netherlands (2), UK (2), France (1), Germany (1), Switzerland (1) and Russia (1). All the patients participating in the studies were female patients. The aims of the studies can be categorized into 3 dimensions, namely a) correcting perceptual body image (7), b) reducing anxiety regarding food and environment (4), and c) the effect of AN On spatial ability (1). Three of the articles were focusing on single case studies and nine studies presented the application of VR technology on a larger number of patients. Four studies were focusing on patients with AN and other eating disorders and in eight studies only patients with AN were participating. In 4 studies healthy control groups were also included. The studies emphasize the following advantages of VR applications: realistic, capable of provoking strong emotional reactions, capable of inducing beneficial change in the relationship to food, flexible, capable of inducing drives for change in thinking. The technology applied in all treatments was based on creating a virtual environment where reality experienced by the participants was shaped according to the aim of the experiments.

The detailed description of the results is shown in Table 1.

Table 1: Comparison of studies using virtual reality (VR) in treatment of patients with anorexia nervosa (AN)

Authors	Country	Aim of Study	Sample Size	Technology Used	Result	Conclusion
Riva et al. (1997)	Italy	Investigating if VR based cognitive-behavioral treatment can improve body satisfaction and motivation for change in AN patient.	n = 1 female patient with AN (single case study)	Virtual environment for enhancing to the body experience of the subject.	The subject increased her bodily awareness joined to a reduction in her level of body dissatisfaction and presented a high degree of motivation to change	VR based cognitive-behavioral treatment experiential cognitive treatment could be an elective method for the treatment of anorectic patients. The therapist can be invisible to the patient and thus presents no direct arguments to oppose. VR treatment can cause the participant to feel `present' in the virtual, rather than real, environment.
Gutiérrez-Maldonado et al. (2006)	Spain	Assessing the usefulness of virtual environments representing situations that are emotionally significant to subjects with eating disorders.	n = 30 female patients with AN.	The participants were exposed to six virtual environments: a living-room (neutral situation), a kitchen with highcalorie food, a kitchen with low-calorie food, a restaurant with high-calorie food, a restaurant with low-calorie food, and a swimming-pool. After exposure to each environment the STAI-S (a measurement of state anxiety) and the CDB (a measurement of depression) were administered to all subjects.	Virtual environments in which subjects are obliged to ingest high-calorie food provoke the highest levels of state anxiety and depression.	The results show that VR instruments are particularly useful for simulating everyday situations that may provoke emotional reactions such as anxiety and depression, in patients with eating disorders.
Gorini et al. (2010)	Italy, The Netherlands, Russia	Testing whether virtual stimuli are as effective as real stimuli, and more effective than photographs in the anxiety induction process regarding food. Emotional reactions to real food, virtual reality (VR) food and photographs of food were tested.	n = 10 female AN patients, n = 10 female patients with bulimia and n = 10 female healthy controls.	The participants were randomly exposed to three experimental conditions: real food, photographs of food, and VR while their psychological (Stait Anxiety Inventory (STAI-S) and visual analogue scale for anxiety (VAS-A) and physiological (heart rate, respiration rate, and skin conductance) responses were recorded.	Real food and VR induced a comparable emotional reaction in patients higher than the one elicited by the photographs of food condition. A significant effect was also found in the subjects' degree of presence experienced in the VR condition about their level of perceived anxiety (STAI-S and VAS-A): the higher the sense of presence, the stronger the level of anxiety.	VR is more effective than photographs in eliciting emotional responses similar to those expected in real life situations.
Ferrer-García et al. (2011)	Spain	Examining the influence of several modulating variables on subjective discomfort experienced by patients with eating disorders while exposed to virtual environments.	n = 49 female patients with AN and n = 22 female patients with bulimia nervosa	Participants were exposed to VR environment with variable food and people.	Both variables influenced the level of subjective discomfort during the exposure to virtual environments	A higher sense of presence reflected a more realistic and intense experience of the simulated situation, and consequently, concluded a stronger emotional reaction of participants.
Cardi et. al. (2012)	UK, Italy, Spain,	Reducing the levels of fear and anxiety related to eating.	n = 1 female patient with AN (single case study)	Food items of different caloric contents (e.g. fruit, salad, yoghurt, chicken, lasagna and cake) are stored in a refrigerator or cupboards in a virtual kitchen, which can be explored by using the mouse of the computer. These food items may be used to prepare a meal, which is eaten at a table using plates and cutlery. Each bite is associated with sounds of chewing and swallowing.	At the end of the module, the patient reported lower levels of anxiety, safety behaviors and fears related to food. Both eating disorder symptoms and distress were reduced. Body mass index increased from 15 to 16.8 kg/m2 during the therapy.	The VR exposure therapy was associated with a beneficial change in the relationship to food and was perceived to be helpful by the individual.
Marco et al.	Spain	Investigating the effect of	n = 17 female	Participants were treated by cognitive	Results showed that the patients who	The results reveal the advantage of

(2013)		Cognitive Behavioral Treatment (CBT) for eating disorders with and without a component for body image treatment using VR techniques.	patients with bulimia nervosa, n = 12 female patients with Eating Disorder Not Otherwise Specified), n = female 5 patients with AN.	behavioral therapy with or without body image treatment using VR technology.	received the component for body image treatment improved more than the group without this component.	including a treatment component addressing body image disturbances in the protocol for general treatment of eating disorders.
Keizer et al. (2016)	The Netherlands	Investigating whether a full body illusion affects size of body parts estimation.	n = 30 female patients with AN, and n = 29 controls.	Participants were asked to estimate the size of their body parts by using VR googles and without VR googles.	AN patients decrease the overestimation of their shoulders, abdomen and hips directly after the full body illusion was induced.	Disturbed experience of body size in AN is flexible and can be changed, even for highly emotional body parts.
Cipolletta et. al. (2017)	Italy, UK	1) Verifying whether spatial variables and aspects of construing differentiate patients with AN and healthy controls (HCs) and are related to severity of anorexic symptomatology. 2) Exploring correlations between impairments in spatial abilities and interpersonal construing.	n = 12 female patients with AN and n = 12 female controls	Participants were asked to find a hidden object and memorize its position in the virtual city. After they had discovered the object, they were invited to indicate its position on a real map. Then participants were invited to retrieve the position of the object, which was absent, after entering the virtual city from another starting point.	The AN group compared to healthy controls showed significant impairments in spatial abilities, more unidimensional construing, and more extreme construing of the present self and of the self as seen by others.	VR technology represents an experiential tool able to allow safe exploration of changes in the experience of the body which may improve the processing of spatial reference frames in AN, and facilitate reconstructing of the self and its relationship with others.
Mölbert et al. (2017)	Germany, Switzerland	Disentangling perceptual and attitudinal components of Body image disturbance in AN.	n = 24 female patients with AN and n = 24 female controls	Realistic virtual 3D bodies (avatars) for each participant that were varied through a range of ±20% of the participants' weights. Avatars were presented in a VR mirror scenario.	Women with AN and controls underestimated their weight, with a trend that women with AN underestimated more.	The results contradict the widespread assumption that patients with AN overestimate their body weight due to visual distortions.
Serino et. al. (2017)	Italy	Investigating whether illusionary ownership over a virtual body would result in differences in body representation before and after a multidisciplinary treatment provided in a center of excellence.	n = 23 female patients with AN, no control	A group of female participants suffering from AN could experience a first-person perspective of a virtual body with a skinny belly substituting their own physical body in two experimental conditions (i.e., synchronous vs. asynchronous visual-tactile stimulation).	After the treatment the patients could decrease the body-size distortions in abdomen.	The method can be useful for anorexic patients for specifically improving body representation disturbances.
Fisher et al. (2019)	France	Examining the hypothesis that VR with standardized 3D avatars would improve body image perception and then body image evaluation by adolescents with AN, compared to the paper-based figure rating scales.	n = 31 female patients with AN, no control	VR-based avatar rating scale (C2CARE PSY software).	Participants with AN overestimated own body size regardless of the assessment tool used.	Results of body image disorder evaluation by VR standardized 3D avatars are comparable to those obtained by paper-based figure rating scales. The perceptive component could be better evaluated using biometric-enhanced assessment tools.
Serino et al. (2019)	Italy	Reporting the use of exploitation of a VR-based body swapping within a multidisciplinary treatment of AN.	n = 1 female patient with AN (single case study)	Two types of measures were used to evaluate the patient's response to VR full body illusion: one assessing the accuracy of her body perceptions, the other assessing the level of her embodiment of the avatar created by VR.	The VR illusion successfully worked and the patient showed an improvement in the estimation of her body.	The VR full body illusion was both able to effectively monitor changes of multisensory bodily integration and to act as a driver for these changes.

4. Discussion

The aim of the review was collecting all the articles focusing on the possibilities of applying VR in treatment of patients with AN. The first studies on this field were published at the end of the 20th century (Riva, Bacchetta, Baruffi, Borgomainerio, et al., 1999; Riva, Bacchetta, Baruffi, Defrance, et al., 1999; Riva, Bacchetta, Baruffi, Rinaldi, & Molinari, 1998a, 1998b, 1999; Riva et al., 1997). The authors discovered the possibilities of VR treatments by naming it as an elective method for treating anorectic patients. They were focusing on improvement of body satisfaction and motivation for change in an AN patient. Although it was just a case study of a single patient the results were promising. Later it turned out that VR instruments are particularly useful for anxiety and depression reduction by simulating everyday situations (Gutiérrez-Maldonado, Ferrer-García, Caqueo-Urízar, & Letosa-Porta, 2006). Focusing on emotional reactions it turned out that VR technique is more effective than photographs in eliciting emotional responses (Gorini, Griez, Petrova, & Riva, 2010). VR can produce higher sense of presence and consequently conclude a stronger emotional reaction of patients with AN in situations where they are exposed to different food and people (Ferrer-Garcia & Gutierrez-Maldonado, 2011). The development of the technology made also possible for implementing other types of interventions like reduction the levels of fear and anxiety related to eating (Cardi et al., 2012). The experimental nature of this method is also manifested in the fact that another case study involving just a single patient was published by the authors. VR technology can also be combined with cognitive behavior therapy (CBT) (Marco, Perpina, & Botella, 2013). The results showed that patients who received VR therapy with CBT improved more than patients who received just CBT. In 2016 the rapid evolution of immersive VR technology made possible to create realistic visualization of human bodies making thus possible to use artificially created body illusions in treatment of AN patients. First the researchers were focusing on investigating whether a full body illusion affects the estimation the size of body parts (Keizer, van Elburg, Helms, & Dijkerman, 2016). They concluded that disturbed experience of body size in AN is flexible and can be changed by using VR technology. The wide possibilities created by the immersive feature of such technology expanded the palette of options. It made also possible to investigate the effect of AN on the spatial abilities of AN patients (Cipolletta, Malighetti, Serino, Riva, & Winter, 2017). The AN group compared to healthy controls showed significant impairments in spatial abilities, more unidimensional construing, and more extreme construing of the present self and of the self as seen by others. In the study VR technology represented an experimental tool for safe exploration of body illusion changes and for facilitation reconstruction of the self and its relationship with others. Since AN is more typical in women population and only a substantial minority of men are involved (Striegel-Moore et al., 2009) it was advisable to investigate the interaction between level of immersion and gender (Gutierrez-Maldonado et al., 2017). According to the results VR technology can be used more successfully with men because of a greater proneness to motion sickness in women. From the point of view of AN treatment it can be considered as a disadvantage. The application of VR technology can also reveal some misconceptions regarding the perceptual components of body size in anorexic patients. The results of the study of Mölbert et al (2017) contradicted the widespread assumption that patients with AN overestimate their body weight due to visual distortions. Reduction of body-size distortion is one of the main purposes of applying VR technology. It was proven that the method can be useful for improving body representation disturbances (Serino et al., 2017). Since patients with AN usually overestimate their own body size it should be corrected by tools considered to be objective by the patients. Thus VR technology can substitute the paper-base figure rating scales (Fisher, Abdullah, Charvin, Da Fonseca, & Bat-Pitault, 2019). The VR full body illusion is able to effectively monitor changes of multisensory bodily integration and to act as a driver for such changes. It was also proven by a 1 year follow-up examination (Serino, Polli, & Riva, 2019). Besides all the above-mentioned advantages, VR technology can also be used for teaching and for shifting perspectives. For example, interviews with patients can be recorded by a 3D camera providing opportunities for realistic "meeting" patients for people who never had the opportunity for having such experience. It can also be applied for increasing the knowledge and awareness of new evidence-based approaches in the field of eating disorders (Aya, 2018).

5. Conclusions

VR technology can be considered as a successful supportive tool in treatment of AN and also in providing more information for educational purpose about the nature of the disease. Comparing to the definitely cheaper and simpler methods like using mirrors for reflecting the body image of the patient VR has several advantages. It provides realistic experience for example the patient can change his/her VR body image according to his/her imagination and is able to accept the VR image as it was real. Based on its realistic feature the VR experience can provoke strong emotional reactions and can induce beneficial changes in the relationship to food. It can be flexibly shaped according to the aims of the therapy and by using VR technology change of thinking can be more easily accomplished. Of course, VR therapy cannot be considered as a complete solution for such problems. The key of an effective treatment is a carefully chosen therapeutic process most of the time involving the whole family into the therapy and a part of it can be the use of VR applications (NICE Guideline, 2017). Nevertheless, the price of a VR set and the small number of trained professionals in this field can definitely be mentioned as a limitation of the method.

The method from a certain point of view is similar to the classical Freudian psychoanalysis where the therapist cannot be seen by the patient thus facilitating to free the mind and thinking of the patient. This review of the literature had also some limitations. It excluded studies without clinical trials although they also may contain some hints and guidance regading the possible applications of VR in therapies of patients with AN.

Further studies needed to investigate the opportunities of applying VR in family therapy.

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