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The use of virtual reality for the treatment of anxiety states in pediatric patients diagnosed with anorexia nervosa. A pilot study[1].

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Key words

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Abstract

Eating and nutrition disorders (ED) are complex psychological conditions characterized by a dysfunctional relationship with food and one's body image. Of these, anorexia nervosa appears to be the most severe form, characterized by an intense fear of gaining weight and subsequent extreme food restriction, which can even lead to death. In order to implement treatment by promoting relaxation and subsequent caloric intake, several techniques have been developed and proposed including diaphragmatic breathing techniques. It has been shown how the proposed gradual exposure through virtual reality can be a valuable tool for the treatment of eating disorders. In this study, a relaxation protocol with Virtual Reality (VR) support is proposed for the treatment of pediatric patients with anorexia nervosa. The study was conducted in a long-stay pediatric ward and involved 12 subjects with anorexia nervosa aged 10 to 18 years. The participants were asked to undergo one breathing session per day before dinner for 30 days accompanied by the use of a virtual reality visor. To monitor the progress of symptoms, a battery of tests was administered every 10 days from day one. Several correlations emerged between the constructs investigated by the administered testing; however, from the analysis of the case reports of the 7 participants who completed the research, it is not possible to find an unambiguous result as some reported benefiting from the treatment as opposed to others. Although previous studies prove the effectiveness of diaphragmatic breathing for the treatment of anxious states, the present study found no such effect, noting mixed feedback among participants. It is hypothesized that this result is partly due to the failure to find a large enough sample to perform the necessary statistical analysis. Clinical and research suggestions emerge in this study to further investigate the use of RV in ED. This study is comparable with opinions of authoritative authorities, based on descriptive studies, narrative reviews, clinical experiences or expert committee reports and some experimental studies.

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1. Introductory aspects and hypothesis

In recent decades, the age of onset of anorexia nervosa (AN) disorder has lowered to affect younger and younger individuals (Nicholls, Bryant-Waugh, 2009; Petkova, et al., 2019; Reas, Rø, 2018; Smink, et al., 2012; Van Eeden et al., 2021). Studies show how early intervention can prove critical to patients' prognosis by increasing the chances of complete remission of symptoms (Jagielska, Kacperska, 2017; Resmark, et al., 2019). Early diagnosis and intervention are crucial especially with young patients in order to prevent psychopathology from further impairing their physical development as well (Herpertz-Dahlmann, 2009; Nicholls, Bryant-Waugh, 2009). For this reason, anorexia nervosa is a disorder that is increasingly being treated in pediatric settings.

Anorexia nervosa disorder is characterized by a psychological framework including excessive perfectionism, anxiety, and depression (Dahlenburg, et al., 2019; Herzog, et al., 1992; Marucci, et al., 2018; Steinglass et al., 2010). Since the literature has shown that treatment of pre-meal anxiety is positively associated with increased caloric intake during meals (Lloyd, et al., 2021; Steinglass, et al., 2010), the present study aims to propose a relaxation protocol in order to enhance the therapeutic treatment of young pediatric patients with AN.

Such a relaxation protocol is intended as an adjunct to an already structured inpatient treatment protocol including intake by a multidisciplinary team consisting of medical monitoring and treatment, nutrition education, psychological and dietary interviews with a gradually increasing calorie intake diet plan, neuropsychiatric interventions, and family support. Numerous relaxation techniques are reported in the literature as valid, employed even in cases of poor psychopharmacological outcomes (Stubenrauch, 2011).

Based on the results obtained from research using different breathing techniques as a treatment for anxiety states (Jerath, et al., 2012; Kjellgren, et al., 2007; Manzoni, et al., 2008; Nemati, 2013), the present study chose to propose a diaphragmatic breathing protocol based on the resonance frequency identified by Vaschillo (Vaschillo, et al., 2002). This resonance frequency is identified in a breathing pattern consisting of 6 breaths per minute (4 seconds of inhalation and 6 seconds of exhalation, without pauses), which seems to be one of the most effective in improving cardiac variability and thus reducing stress (Bae, et al., 2021; You, et al., 2022).

Therefore, it is hypothesized that by following such a breathing pattern, patients are able to modulate their cardiac variability and thus induce a state of relaxation.

In addition, it is hypothesized that such a state of relaxation achieved before meals may promote patients' compliance with treatment by increasing the proportion of food ingested during meals and facilitating remission of the condition.

Since the literature reports how the use of virtual reality is a valuable aid in the treatment of eating disorders (Clus, et al., 2018) it was decided to accompany the breathing sessions with the use of a visor in order to create an immersive environment.

In this regard, a crucial study for the development of the present research design was the one conducted by Blum and colleagues in 2019. That study investigated the benefits of administering immersive virtual reality in a biofeedback protocol on heart rate variability (HRV-BF) based on slow paced breathing. When comparing the HRV-BF based on virtual reality with a standard implementation, what emerged was that the protocol with virtual reality increased the effectiveness of relaxation to a greater extent, reducing mind-wandering and promoting concentration. The study conducted by Blum and colleagues demonstrated how the use of VR is able to promote sustained attention by immersing the patient in a comfortable environment.

This was achieved by proposing subjects to view natural environments. Indeed, it has been shown that natural environments are among the most relaxing environments as even brief exposure to nature reduces stress and restores productivity (Berto, 2014; Bowler, et al., 2010; Kaplan, 1995; Ohly, et al., 2016).

Research on the use of simulated environments for relaxation and stress reduction has demonstrated the positive effect of exposure to natural environments including virtual ones (Andersen, et al., 2017; De Kort, et al., 2006; White, et al., 2018).

Numerous studies have demonstrated the effectiveness of exposure to virtual natural environments (Anderson, et al., 2017; Annerstedt, et al., 2013; Gromala, et al., 2015; Serrano, et al., 2016; Villani, Riva, 2012) as the user is confronted with immersive stimuli capable of inducing a sense of presence, i.e. the feeling of actually being inside the virtual environment (Cummings, Bailenson, 2016; Sanchez-Vives, Slater, 2005).

Thus, Blum's study shows how in a Biofeedback protocol, virtual natural environments can reduce mind wandering in the form of intrusive or distracting thoughts. This occurs from the moment the subject's attention is drawn to the immersive virtual environment. Consequently, by providing a salient stimulus, the virtual natural environment promotes an experiential focus on the present moment (Blum, et al., 2019).

Based on these studies, the present research hypothesises that exposing patients to virtual natural landscapes through the use of a visor can increase their ability to concentrate by reducing intrusive thoughts.

This would favour the execution of the breathing exercises by increasing the ability to follow the proposed breathing pattern. Consequently, a greater impact on cardiac variability and a consequent reduction in pre-meal anxiety is hypothesised.

2. Partecipants

The sample analysed consisted of 12 female subjects with anorexia nervosa diagnosed according to DSM-5 criteria, admitted to the long-stay paediatrics ward of the SS. Giovanni e Paolo Hospital in Venice. The patients ranged in age from 10 to 18 years with a mean age of 14.67 years and Standard Deviation of 2.229.

Most of the participants were of Italian nationality (91.67%), while only one participant was of Romanian nationality (8.33%).

With regard to the occupation of the participants, the entire sample was made up of female students. At the time of the research, the majority were attending secondary school (66.68%) while a smaller proportion were attending lower secondary school (33.32%).

3. Materials

The protocol comprised the viewing of a scenario via a virtual reality device, together with the performance of breathing exercises and the administration of a battery of 7 self-report questionnaires: 1) Eating Attitude Test (Garner, Olmsted, Bohr, Garfinkel, 1982) to investigate symptoms and concerns characteristic of eating disorders; 2) The Inventory of Parent and Peer Attachment (Armsden, Greenberg, 1989) to investigate adolescents' attachment to parents and peers; 3) Generalised Anxiety Disorder Assessment (Spitzer, Kroenke, Williams, Löwe, 2006) to investigate the anxiety dimension; 4) Patient Health Questionnaire (Spitzer, Kroenke, Williams, 1999) to investigate the depressive dimension; 5) WHOQOL-Short (De Girolamo, et al. , 2000) to investigate the quality of life; 6) Strenghts and Difficulties Questionnaire (Goodman, 1997; Di Riso, et al., 2010) to assess behavioural and emotional difficulties in developmental age, in particular hyperactivity, conduct disorders, emotional problems, peer relations, pro-social behaviour; 7) Body Appreciation Scale-2 (Tylka, Wood-Barcalow, 2015) to investigate acceptance, positive opinions and respect towards one's own body.

In addition, patients were asked to fill out a likert scale with a score from 1 to 7 in which they were asked to indicate the pleasantness and difficulty of the breathing exercise.

In order to enable the immersive virtual reality experience, a stand-alone device was used. The hardware part of this device was provided by Pico Interactive, Inc, specifically the device 'Pico G2 4K' was used (Learn devices - PICO Developer. (n.d.), https://developer.picoxr.com/).

4. Delivered treatment

Data collection was carried out over the course of 13 months. At the time of admission, the personal and medical data of each patient were collected in a medical record, recording age, weight, height, B.M.I., blood pressure, blood tests and previous medical history.

The patients were asked to perform one diaphragmatic breathing session per day with the aid of a virtual reality visor, which scanned the breathing rhythm with cycles of 6 slow, deep breaths per minute consisting of 4 seconds of inhalation and 6 seconds of exhalation. Inside the visor they were able to choose, by moving their eye saccades over the icons on the display, which of the four proposed natural scenarios to use to accompany their relaxation.

The proposed scenarios were: a Caribbean beach, a stream flowing in the mountains, the horizon line merging between sky and sea, and finally the scenario of a night lake with stars reflected on the surface of the water.

In addition, the patients had the choice of being accompanied in the experience by relaxing music or only by the sounds of nature, being able to choose a different scenario from among those proposed from day to day, taking care, however, not to interrupt the exercise once it had begun.

Each session lasted 20 minutes and was offered 30 minutes before dinner time for 30 days. At the end of each breathing session, participants could go to the common room to eat dinner.

During the 30 days, the progress of the research was monitored through the administration of tests.

A battery of self-report tests including PHQ-9, GAD-7, IPPA, SDQ, EAT-26, BAS and WHOQOL-Short Version was administered on day 1 (T0) and day 30 (T3) of treatment in order to investigate whether the treatment had brought about changes in anxiety and depressive symptoms, attachment dimensions, daily difficulties experien-

ced, typical anorexia nervosa symptoms and quality of life. Furthermore, as it was expected that the values for anxiety, depression and perceived quality of life could fluctuate more within 30 days than eating symptoms and attachment, it was decided to administer PHQ-9, GAD-7 and WHOQOL-short also on the 10th (T1) and 20th (T2) day of treatment.

At the end of the 1st, 10th, 20th and 30th breathing sessions, the patients were asked to fill in two short 1- to 7-point likert scales indicating the level of difficulty and pleasantness of breathing.

5. Statistical analysis

Since of the initial sample of 12 subjects, only 7 completed the study, the data available to make a comparison between T0 and T3 were insufficient. It was therefore decided to carry out an analysis of the sample at T0 in order to provide a detailed description of the initial sample. The data were analysed with the statistical software SPSS (Statistical Package for Social Science). Descriptive statistics were first calculated and then a bivariate correlational analysis was carried out using Spearman's Rho index.

Tab 1 shows the descriptive statistics for the variables under investigation. While tabs 2, 3, 4 report a bivariate correlational analysis using Spearman's Rho index between the different constructs investigated (tabs 2, 3, 4).

Table 1. Descriptive statistics of the variables under study.

Constructs	N	Mean	Median	Standard deviation	Min.	Max.
EAT-26	12	44.25	49.00	15.978	1	59
SDQ prosocial	12	8.08	8.50	1.782	6	10
SDQ emotional	12	6.58	6.50	1.621	3	9
SDQ behavioural	12	2.33	2.00	1.923	0	6
SDQ hyper	12	3.58	4.00	2.466	0	7
SDQ peer	12	3.25	3.50	1.712	0	6
SDQ tot. Difficulties	12	15.75	16.50	5.691	3	23
SDQ tot impact	12	2.17	2.00	2.082	0	6
PHQ-9	12	13.92	14.00	5.534	3	22
GAD-7	12	12.67	12.50	4.438	3	21
BAS-2	12	20.00	16.00	10.153	12	45
WHOQL general	12	5.75	6.00	1.215	4	9
WHOQL psy	12	34.33	31.00	21.877	6	81
WHOQL phisical	12	61.67	59.50	17.660	38	88
WHOQL social	12	53.58	50.00	24.916	0	100
WHOQL enviromental	12	77.17	78.00	12.342	50	94
IPPA tot mother	12	100.92	99.50	14.563	71	121
IPPA tot father	11	87.82	100.00	26.118	39	117
IPPA tot peer	12	85.08	88.50	16.914	56	105
Breathing difficulties	12	3.67	4.00	1.231	1	5
Breathing pleasantness	12	5.3333	5.5000	1.77525	2	7

Table 2. Correlations found among the administered tests.

Constructs	EAT-26	SDQ Emotional	SDQ Behavioral	SDQ Hyper	SDQ Peer	SDQ Tot. Diff.
PHQ-9	.559	.508	.394	**.619***	**.634***	**.709****
GAD-7	.527	**.621***	**.620***	.435	.317	**.668***
BAS-2	**-.837***	**-.608***	-.151	-.112	-.572	-.401
WHOQOL psy	**-.630***	-.528	**-.633***	**-.757****	-.416	**-.862****
WHOQOL social	**-.696***	-.422	-.221	**-,613***	-.554	-.565
WHOQOL enviromental	**-.592***	-.249	**-.698***	-.381	-.305	**-,648***
IPPA tot father	**-.814****	-.502	-.497	-.253	-.392	-.429
IPPA tot peer	**-.577***	-.228	-.329	-.318	**-.592***	-.419

* The correlation is significant at p < .05 - ** The correlation is significant at p < .01

Table 3. Correlations found among the administered tests.

Constructs	WHOQOL phisical	IPPA tot. peer	Breathing difficulties
PHQ-9	**-.774****	-.518	**.619***
WHOQOL social	.493	**.701***	**-.701***
WHOQOL enviromental	**.598***	.569	-.242
IPPA tot mother	**.683***	-	-.531
IPPA tot father	**.799****	-	-.350
IPPA tot peer	.461	-	**-.726****

* The correlation is significant at p < .05 - ** The correlation is significant at p < .01

Table 4. Correlations found among the administered tests.

Constructs	SDQ impact	PHQ-9	GAD-7	BAS-2	WHOQOL general	WHOQOL psy
EAT-26	.535	.559	.527	**-.837****	**-.655***	**-.696***
SDQ tot impact	-	.455	.429	**-.643***	-.090	-.455
GAD-7	.429	**.685***	-	-.355	-.340	**-632***
WHOQOL general	-.090	**-.587***	-.340	.435	-	.531
WHOQOL psy	-.455	**-.829****	**-.632***	.444	.531	-
WHOQOL phisical	-.226	**-.774****	**-.727***	.272	.501	**.603***
WHOQOL social	**-.593***	**-.800****	-.463	**.694***	.380	**.784****
WHOQOL enviromental	**-.580***	-.529	**-.639***	.311	.244	**.735****
IPPA tot father	-.517	**-.760****	**-.778****	**.795****	.494	**.650***
IPPA tot peer	**-.680***	-.518	-.343	.542	.181	**.701***

* The correlation is significant at p < .05 - ** The correlation is significant at p < .01

6. Results

The results from the detailed analysis of the sample at T0 would confirm the clinical picture of Anorexia Nervosa according to the DSM-5 criteria (APA, 2013).

At T0, in fact, all participants presented severe symptomatology inherent to eating thoughts and behaviour, with the EAT-26 score clearly above the cut-off score (mean score obtained 44.25 with cut-off of 20).

With regard to depressive symptoms, the average score found in the sample suggests mild Major Depression, while anxiety is rated as moderate.

Interesting considerations can be made by analysing the correlations that emerged from the different constructs.

As the psychopathological symptoms inherent in anorexia increase, the patients' appreciation of their own bodies decreases.

Furthermore, dysfunctional thoughts and behaviour in relation to food were found to be correlated with a poorer quality of life in all aspects as well as with a poorer quality of attachment to the father and peers. A worse attachment to peers would also be associated with greater difficulties in relating to peers, as well as a worse quality of social life.

Anxiety and depression are also correlated with lower quality of life and numerous difficulties expressed through the subscales of the SDQ. These difficulties are also associated with a lower quality of life.

Each type of difficulty is associated with a worsening in the different domains of life measured by the WHOQOL, whereas higher scores in psychological quality of life are positively correlated with quality of life in the other domains.

A better psychological quality of life is also associated with better attachment to the father and peers.

Interestingly, higher attachment to the father figure is also associated with lower anxiety and depression scores and higher body appreciation. Higher body appreciation is also associated with a better quality of social life.

6.1 Case report

Since, as previously reported, the data available to make a comparison between T0 and T3 proved to be insufficient, it was decided to proceed with a special case analysis of the patients who completed the study.

Below are the weight and BMI values reported by the patients at the time of hospitalization and at the end of the 30-day treatment period (Tab 5).

The quantitative dimension of the proposed symptomatology and experience was investigated through the administration of the tests, while the patients' qualitative opinions on the proposed research design were collected in order to investigate its qualitative aspects. When asked by the experimenters, patients 1, 2 and 11 did not report that they experienced an improvement as a result of the proposed protocol, but rather, reported that after an initial pleasantness, they experienced an exacerbation of their anxious state as the task was seen as repetitive.

Subjects 5, 8, 10 and 12, on the other hand, reported a positive effect, to the extent that patients 5 and 10 asked to be allowed to continue the breathing exercises after the trial had ended.

Below is the table of the scores obtained by the seven patients who completed the 30-day course of the research design by completing all the questionnaires at times T0 and T3.

Below are the tables of the scores of the seven participants at times T0, T1, T2 and T3 for each test (Tabs 6, 7, 8).

Table 5. Summary table with the values reported by the patients at T0 and T3. BMI percentile calculated with LMS Parameters used by WHO and CDC

Pz	Age	Height	Weight T0	BMI T0 kg/m²	BMI percentile T0	Weight T3	BMI T3 kg/m²	BMI percentile T3
1	18	1.86 m	65.3 kg	18.9	9.9	65.8 kg	19	11.1
2	14	1.65 m	42.7 kg	15.7	3.1	43.5 kg	16	4.9
5	16	1.69 m	41.5 kg	14.5	0.1	43.2 kg	15.1	0.1
8	13	1.535 m	31.3 kg	13.3	0.1	33.1 kg	14.1	0.3
10	15	1.62 m	40.1 kg	15.2	0.5	40.8 kg	15.5	0.9
11	17	1.62 m	44.0 kg	16.8	1.2	44.8 kg	17.1	2
12	14	1.55 m	33.7 kg	14	0.1	35.2 kg	14.7	0.3

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Table 6. Scores obtained by the seven patients on all questionnaires administered at T0 and T3

Constructs	Pz 1		Pz 2		Pz 5		Pz 8		Pz 10		Pz 11		Pz 12	
	T0	T3	T0	T3	T0	T3	T0	T3	T0	T3	T0	T3	T0	T3
EAT-26	54	60	54	57	35	28	44	39	51	51	57	60	51	53
SDQ prosocial	10	10	8	7	7	8	6	8	10	9	6	5	10	10
SDQ emotional diff	8	8	6	5	6	5	7	5	9	9	8	9	6	9
SDQ behavioral problems	0	2	4	3	4	2	2	2	2	2	6	8	0	2
SDQ Hyperactivity	5	7	0	0	6	3	3	3	4	3	5	6	0	2
SDQ peer	5	6	2	5	6	5	4	4	3	4	4	5	5	8
SDQ tot. difficulties	18	23	12	13	22	15	16	14	18	18	23	28	11	21
BAS-2	12	11	14	14	19	23	17	28	16	15	13	12	13	11
IPPA tot. Mother	88	86	93	96	90	110	120	126	108	98	97	87	98	88
IPPA tot. Father	-	-	48	38	103	116	100	113	79	87	71	71	88	81
IPPA tot. Peer	70	76	78	88	57	79	100	107	90	88	97	78	84	68
Breathing difficulties	4	6	4	6	5	6	1	1	4	2	3	3	5	5
Breathing pleasantness	1	6	3	6	1	2	1	1	6	1	4	5	1	2
PHQ-9	14	19	12	10	19	18	11	9	20	18	19	16	15	16
GAD-7	12	15	14	12	13	14	15	8	17	14	14	14	11	13
Whoqol general	6	7	6	7	6	6	6	9	5	7	4	6	5	5
Whoqol psy	25	19	31	38	19	31	56	69	19	25	6	13	50	19
Whoqol phisical	81	44	44	56	44	44	63	50	38	50	56	63	56	38
Whoqol social	31	44	50	56	50	50	81	81	50	56	50	44	50	44
Whoqol enviromental	75	69	69	75	69	56	81	88	75	75	69	63	94	94

Table 7. Scores of the seven participants at times T0, T1, T2 and T3 for PHQ-9 and GAD-7 tests and Breathing difficulties pleasantness likert scales

Pz	Time	PHQ-9	GAD 7	Breathing difficulties	Breathing pleasantness
1	T0	14	12	4	1
	T1	12	12	3	6
	T2	14	15	5	6
	T3	19	15	6	6
2	T0	12	14	4	3
	T1	19	14	7	7
	T2	10	11	6	7
	T3	10	12	6	6
5	T0	19	13	5	1
	T1	14	14	6	2
	T2	17	10	6	3
	T3	18	14	6	2
8	T0	11	15	1	1
	T1	10	11	1	1
	T2	13	18	1	1
	T3	9	8	1	1
10	T0	20	17	4	6
	T1	20	13	3	2
	T2	14	13	3	2
	T3	18	14	2	1
11	T0	19	14	3	4
	T1	15	19	4	4
	T2	16	13	4	5
	T3	16	14	3	5
12	T0	15	11	5	1
	T1	16	13	2	1
	T2	17	10	4	2
	T3	16	13	5	2

7. Discussion

Starting from an analysis of the literature, the aim of the present research was to propose a diaphragmatic breathing protocol in order to obtain a relaxing effect that could alleviate the anxious pre-meal symptoms presented by young paediatric patients suffering from AN. Each patient admitted to the long-stay hospital ward was offered a 30-day treatment comprising one 20-minute diaphragmatic breathing session per day, half an hour before dinner time. These sessions were accompanied by the use of virtual reality viewers with the aim of placing the patients in an immersive environment to promote concentration and relaxation. In addition, this study aimed to monitor the progress of the exercises and symptomatology by administering questionnaires every 10 days. In doing so, it was originally hoped to be able to detect variations between the scores given at different times of administration of the test.

As dimensions such as attachment, appreciation towards one's own body, eating disorder-related symptoms and difficulties experienced in different areas of daily life are less susceptible to change in the short term, the corresponding questionnaires were administered on the first and 30th day of treatment, while dimensions such as

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Table 8. Scores of the seven participants at times T0, T1, T2 and T3 for Whoqol test

Pz	Time	Whoqol general	Whoqol psy	Whoqol phisical	Whoqol social	Whoqol enviromental
1	T0	6	25	81	31	75
	T1	7	25	63	56	75
	T2	8	25	50	56	88
	T3	7	19	56	56	75
2	T0	6	31	44	50	69
	T1	5	25	44	56	69
	T2	6	44	44	56	75
	T3	7	38	56	56	75
5	T0	6	19	44	50	69
	T1	5	44	44	44	75
	T2	5	31	44	56	50
	T3	6	31	44	50	56
8	T0	6	56	63	81	81
	T1	7	38	63	75	81
	T2	8	69	69	75	100
	T3	9	69	50	81	88
10	T0	5	19	38	50	75
	T1	7	19	44	75	88
	T2	5	19	44	56	81
	T3	7	25	50	56	75
11	T0	4	6	56	50	69
	T1	6	25	63	50	63
	T2	6	19	63	44	69
	T3	6	13	63	44	63
12	T0	5	50	56	50	94
	T1	5	19	31	50	94
	T2	5	31	38	56	94
	T3	5	19	38	44	94

anxiety, depression, quality of life and the difficulty and pleasantness of breathing proposed were investigated every 10 days from the time when they were assumed to be most susceptible to change.

However, due to early discharges, of the initial 12 participants in the study only 7 remained in hospital long enough to complete the 30-day protocol and to be able to fill out the relevant test.

As the initial sample was already small, it was not possible to correlate the test results at T0, T1, T2 and T3 as the remaining participants would not have constituted a statistically significant sample.

It was therefore decided to carry out the correlational analyses only with the data collected from the administration of the test on the first day of treatment.

What emerged was a description of the initial sample consistent with the psychopathological picture of anorexia nervosa, characterised by a severe symptomatology inherent in eating thoughts and behaviour, a mild form of Major Depression and moderate anxiety. Analysis of the remaining constructs reveals that they are consistent with each other, and several correlations were found, confirming the diagnosis and the validity of the tests administered.

We therefore proceeded with an analysis of the data reported by only the seven patients who completed the treatment. Starting with the medical records, the vital parameters were assessed, the tests administered at T0, T1, T2 and T3 were evaluated and any qualitative comments made by the patients were taken into account.

Furthermore, although not inherent to the present study, it is interesting to note that almost all patients date the onset of their eating disorder symptoms to the period corresponding to the Covid-19 pandemic.

However, it was not possible to identify an unambiguous course of treatment either with regard to the symptomatology of the pathology or with regard to the appreciation of the administration of VR breathing exercises.

The test scores administered every 10 days vary for all patients and it is not possible to detect a linear trend either overall or for each patient over the 30-day period.

Similarly, with reference to the experience proposed in this research, based on both the quantitative findings reported by the tests and the qualitative findings reported by the patients to the examiner, it is not possible to detect an unambiguous opinion or effect.

In fact, showing poor compliance with the treatment, subjects 1, 2 and 11 report that they did not enjoy the required task, but rather experienced it as a source of discomfort.

On the contrary, subjects 5, 8, 10 and 12 reported that they enjoyed the breathing exercises and the administration of virtual reality as they proved to be relaxing and enjoyable, so much so that they requested to continue the treatment even after the research had ended.

It is necessary, however, to take into consideration several aspects that may have influenced the variables examined.

Firstly, it can be seen from the medical records that the patients underwent numerous changes in drug therapy during the 30-day period. It is plausible that changes in the types and dosages of anxiolytics, antidepressants and antipsychotics influenced the course of the symptoms reported by the testis.

The application of the naso-gastric tube in the cases of patients 5 and 12 is also presumed to have affected their psychological framework by causing a further mood deflection.

In conclusion, 57% of the analysed sample reported a pleasant and relaxing effect as a result of the treatment proposed by the following research, while the remaining 43% stated the opposite. However, as the sample studied was too small and almost split in half, it is not possible to deduce clear and unambiguous results that confirm or deny the initial hypotheses.

8. Criticality of the study

To complete the analysis of the outcome of the present study, it is necessary to point out the various critical aspects of the research design reported here, as they may have contributed to the failure to identify clear results and may provide clinical suggestions.

In the first instance, it is necessary to point out the small number of participants who took part in the study. This was due to the limited number of admissions allowed by the hospital at which the sampling was carried out. It is hoped that this pilot study can be continued for a longer period and extended to other healthcare facilities in order to have a statistically significant sample.

The small number of in-patients meant that there was no way of finding subjects for a control group, i.e. a group of patients with anorexia nervosa who were subjected to the standard treatment provided by the hospital ward in the absence of relaxation exercises.

Furthermore, the long duration of the research often clashed with the therapeutic demands of the ward and the patients. This meant that, although the collection was carried out in a long-stay ward, of the 12 participants who initially took part, only 7 completed the project, as the remaining patients were discharged before the 30th day was reached. It should also be noted that some participants found the VR environment repetitive, which may have influenced their engagement, willingness to continue the treatment, and relaxation response.

In addition, again due to ward requirements, it was reported that patients occasionally missed breathing sessions due to medical and psychological visits or personal leave. This resulted in the administrations losing the desired constancy. Consistency was not present in the timing of the test administration as this could be done compatibly with the commitments of the healthcare personnel and the patients. The test batteries were therefore administered at different times within the day; this could constitute an uncontrolled variable within the research since administering tests at different times of day can introduce potential biases.

Lastly, it is essential to point out that any results obtained cannot be understood as resulting from the administration of the research design alone, since the relaxation and exposure therapy took place concomitantly with the treatment prescribed by the ward guidelines.

It is therefore not possible to observe an isolated result, but it should be noted that what emerged from this study is a mixture of medical-psychological treatments and therefore the interpretation of the results cannot be separated from the hospital treatment. In this regard, it is important to consider

that changes in pharmacological therapy and the use of nasogastric tubes likely influenced the psychological states of the participants, thereby confounding the results.

It is also important to note that the present study does not assess whether the effects of the intervention persist beyond the 30-day period.

9. Conclusions

The aim of this research was to propose a diaphragmatic breathing protocol within a virtual immersive environment in order to enhance the therapeutic treatment of young paediatric patients suffering from Anorexia Nervosa by alleviating their anxiety symptoms.

The results obtained were only able to provide an initial description of the sample consistent with a picture of anorexia nervosa.

Due to the excessive number of drop-outs, as it was not possible to carry out a re-test comparison between the scores obtained at the end of treatment and the baseline scores, a detailed analysis of each individual clinical case of the patients who completed the study was necessary. Even from this analysis, it was not possible to confirm the hypothesis that a clear improvement in pre-treatment anxiety symptoms was expected, as no trend, either positive or negative, could be identified from the analysis of the results.

It must be kept in mind that the present study shows some limitations that may have influenced the results obtained.

Firstly, since this is a relaxation protocol added to an already structured hospital protocol (comprising medical, neuropsychological, individual/group psychological and nutritional aspects), all the results obtained at the different measurement times are to be understood as resulting from the integration of the different forms of therapy.

It is therefore not possible to observe the results from the research design alone as proposed here due to the lack of a control group due to the difficulty in finding participants.

The results obtained could therefore be due to individual preferences and abilities, changes in the pharmacological treatment plan, difficulties encountered by the patients within the ward.

It is also possible that the resistance to treatment and the obsessiveness typical of the psychopathological picture of anorexia nervosa constituted a maintenance factor that the present research was unable to modify.

The data provided by this pilot study are not statistically significant but could be used in order to structure future research drawing on this study by taking into consideration its limitations and making modifications in order to reduce them.

In the light of what is reported in the literature, it is indeed plausible that the present research has the right theoretical assumptions but has not obtained the desired results due to the lack of control on several variables. It would therefore be advisable for future research to involve a greater number of patients, in order to obtain both a statistically significant sample and a control group to which the test could be administered in the absence of respiratory treatment with VR.

In addition, more control over the activities carried out on the ward would be necessary, by scheduling the timetable of the test administration and defining a common start date from the first day of admission.

Furthermore, since in some cases one of the limitations presented by the patients was the repetitiveness of the immersive scenarios, it would be desirable to increase the number of scenarios to choose from at each administration in order to provide greater variability.

In conclusion, in spite of the lack of results obtained, it is believed that this could be a pilot study from which projects could be developed that do not replace therapy but could be an eventual support to ward and hospital treatment.

In our opinion (and comparing ourselves with the literature: Covri, Righetti, Nizzoli, 2004; Righetti 2004) this experience - moreover - gives rise to some useful suggestions in the clinic and hospital treatment of AD: 1) the importance of a wide-ranging multifactorial therapeutic proposal even in a hospital setting (often relegated only to treatment in Residential Therapeutic Communities) which includes individual/group psychological interventions, medical, neuropsychiatric, imaginative, body, dietary, internist, etc.; 2) considering the hospital environment - often 'cold' and unwelcoming - as the first relational environment where one can begin to change and therefore; 3) also making available environments and rooms favourable to this change; 4) considering the hospital environment - which is often 'cold' and unwelcoming - as the first relational environment where change can begin and thus; 5) providing environments and rooms conducive to this change; 6) the importance of using new therapeutic aids in tune with the 'modernity' of our patients, who are increasingly involved in their daily lives by RV, the Internet, social media, etc.

With the hope that RV can increasingly play a leading role in the research and clinic of other psychopathological forms.

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