ESCOLA
SUPERIOR
DE SAÚDE
POLITÉCNICO
DO PORTO

P.PORTO

M

MESTRADO
TERAPIA OCUPACIONAL – REABILITAÇÃO E SAÚDE MENTAL

Contact with blue spaces using virtual reality technology: effect on the mental health of older adults

Ana Rute Marques Correia

09/**2024**

P.PORTO

ESCOLA SUPERIOR DE SAÚDE

Contact with blue spaces using virtual reality technology: effect on the mental health of older adults

Autor

Ana Rute Marques Correia

Orientadores

Professor Doutor Tiago Coelho, LabRP/CIR, E2S, Politécnico do Porto

Professor Doutor Nuno Rocha, TBIO/RISE-HEALTH, E2S, Politécnico do Porto

Dissertação apresentada para cumprimento dos requisitos necessários à obtenção do grau de Mestre em **Terapia Ocupacional** – Área de Especialização em **Reabilitação e Saúde Mental** pela Escola Superior de Saúde do Instituto Politécnico do Porto.

Menção de apoio financeiro

Dissertação realizada com o apoio da Fundação para Ciência e Tecnologia (FCT) através da R&D Units funding (CIR: UIDB/05210/2020).

Acknowledgements

Writing this dissertation has been a challenging, rewarding and enriching journey, which only became possible thanks to the support and collaboration of various people and institutions. I would like to express my sincere gratitude to everyone who has contributed in some way to the realisation of this work.

Firstly, I would like to express my deepest gratitude to Professor Tiago Coelho, my supervisor, whose guidance, patience and vast knowledge were indispensable to the development of this dissertation.

I would also like to thank everyone who contributed, directly or indirectly, to the realisation of this work, whether through fieldwork, enlightening conversations, valuable suggestions, or simply by being there in moments of uncertainty. To all of you, thank you very much.

A special thank you to my work colleagues, friends and family, who have always believed in me and supported me unconditionally. Your love, support and understanding, as well as your conversations, moments of relaxation and words of encouragement, have been fundamental pillars in keeping my spirits up during the most difficult times and overcoming the challenges along the way.

Resumo

Este ensaio clínico randomizado avaliou o impacto de um programa de cinco sessões de exposição virtual imersiva a espaços azuis nos níveis de ansiedade, depressão e bem-estar em 55 pessoas com 60 anos ou mais, sem défices cognitivos, auditivos ou visuais significativos, recrutadas por conveniência. Os efeitos foram comparados com um programa de exposições virtual imersiva a espaços urbanos e não imersiva a espaços azuis. A avaliação decorreu antes e após a intervenção usando a Escala de Depressão Geriátrica 15, o Generalized Anxiety Disorder-7, o Warwick-Edinburgh Mental Well-being Scale.

Os resultados revelaram que todas as intervenções impactaram positivamente o bem-estar e reduziram os sintomas de depressão e ansiedade (p-value < 0.001). Porém, os participantes expostos imersivamente aos espaços azuis avaliaram de forma mais positiva a experiência relativamente à melhoria do estado geral, sensação de calma e relaxamento comparativamente aos expostos imersivamente aos espaços urbanos (p-value < 0.05). Além disso, os participantes expostos de forma não imersiva aos espaços azuis relataram menos desconforto ou efeitos colaterais que os participantes expostos imersivamente aos espaços urbanos (p-value < 0.05).

Embora a amostra não seja grande o suficiente para generalizar os resultados, o estudo sugere que a tecnologia pode ajudar a facilitar o acesso dos adultos mais velhos a esses ambientes, especialmente para aqueles com limitações físicas. Mais pesquisas são necessárias.

Palavras-chave: Pessoas idosas; envelhecimento; saúde mental; realidade virtual; espaços azuis.

Abstract

This randomized clinical trial evaluated the impact of a five-session virtual immersive blue space exposure program on anxiety, depression and well-being levels in 55 people aged 60 years or older without significant cognitive, auditory or visual deficits, recruited for convenience. The effects were compared with a virtual immersive program of exposure to urban spaces and non-immersive to blue spaces. The assessment was performed before and after the intervention using the 15 Geriatric Depression Scale, the Generalized Anxiety Disorder-7, the Warwick-Edinburgh Mental Well-being Scale.

The results revealed that all interventions had a positive impact on well-being and reduced symptoms of depression and anxiety (p-value < 0.001). However, the participants exposed to blue spaces were more positive in their experience regarding the improvement of the general state, sense of calm and relaxation compared to those exposed to urban spaces (p-value < 0.05). In addition, participants exposed to blue spaces in a non-immersive way reported less discomfort or side effects than participants exposed to urban spaces in an immersive way (p-value < 0.05).

Although the sample is not large enough to generalize the results, the study suggests that technology can help facilitate access by older adults to these environments, especially for those with physical limitations. More research is needed.

Keywords: Elderly people; aging; mental health; virtual reality; blue spaces.

Index

1. Introduction

The world's population is ageing rapidly. Due to the increase in average life expectancy and the decrease in fertility levels, there has been an exponential increase in the number of older people, greater than in the other age groups.[1–5] In 2020, one billion people in the world were 60 years old or older and these numbers are tending to increase.[6]

Ageing is a natural, progressive and inevitable process in human life. As individuals age, they face physiological, morphological, biochemical, psychological, social and family changes that influence their quality of life and well-being.[1–3,7] However, the way in which ageing occurs varies and depends on factors such as lifestyle, physical and psychological illnesses, socio-economic and environmental conditions. Thus, although most older people are in good health, as they get older they are at greater risk of suffering from illnesses and disabilities at various levels.[1–4,6,8] In addition to problems related to physical and cognitive condition, the prevalence of conditions affecting mental health in ageing populations is significant.[6] It should be noted that around 14% of adults aged 60 and over live with a mental illness, the most common of which are depression and anxiety. This is a predictor of disability, as it directly impacts multiple aspects of daily functioning (from the ability to maintain social roles to greater use of health services).[4,6,9,10]

For ageing to be a positive experience, it must be accompanied by continuous opportunities to participate in the different domains of life, according to the person's needs, preferences and abilities, enabling people to realise their potential for lifelong physical, social and mental well-being.[1,2,11] In addition, the well-being of older people depends on and is enhanced by variation, balance and choice among a repertoire of occupations that provide structure, value and meaning in daily life.[12] To this end, the different determinants of ageing must be taken into account, including transversal factors (such as culture or gender), factors related to health and social service systems, behavioural factors (such as smoking, diet, physical activity or oral health), personal factors (such as biology, genetics or psychological factors) or factors related to the environment (such as accessibility or safety).[1,2,4,13–16]

In particular, age-appropriate environments can mean the difference between independence and dependence for older people.[1,11,15] For example, older people who live in risky environments with multiple barriers tend to go out less often, are more prone to isolation, depression and mobility problems, and are more likely to become dependent.[1,9,10]

Analysing urban spaces, although they offer robust social networks, employment opportunities and access to facilities and services that can promote health, they also have characteristics that can contribute to a higher prevalence of chronic diseases and negatively affect mental health.[17] Examples of this are the increase in traffic, noise and air pollution; the overload on sewage

systems; the pressure on already overloaded urban infrastructure (housing, transport and health); as well as the increase in socio-economic disparities and problems such as poverty and crime.[17] That said, it is understandable that there is a need to develop a public health response to ageing and to provide safe, adapted and encouraging environments that allow people to do what is important to them, despite the loss of capacity, because these incentives or barriers in the environment can affect health opportunities, decisions and behaviours.[14]

In this vein, scientific evidence has shown an association between mental health and exposure to natural environments.[7,9,10,18–23] In general, the studies conclude that proximity to these spaces is associated with benefits at different levels and has stood out as a particularly positive experience compared to closed environments,[10] especially if these spaces are safe and easy to access.[9,10] In the case of limited access, evidence seems to demonstrate that even using the virtual environments for exposure to natural spaces immediate reduces the depressive and anxious symptomatology.[10,24–27]

This relationship can be explained by the Attention Restoration Theory or the Stress Reduction Theory.[23,28] The first theory suggests that exposure to natural environments can help restore the capacity for directed attention and reduce mental fatigue,[23] since these spaces offer visual and cognitive relief from the demands of urban life, enabling the recovery of cognitive processes related to attention.[23,28] The second theory explores the idea that exposure to natural spaces can lower cortisol levels and other physiological indicators of stress, due to factors such as detachment from everyday stress, experience in these expansive spaces and contexts, involvement in intrinsically motivated activities and the experience of different soft stimuli.[28]

In detail, green and blue spaces can confer environmental benefits (such as reducing air pollution or cooling), social and community benefits (such as social interactions), physical benefits (such as physical activity) and psychological benefits (such as stress recovery), cultural and spiritual benefits (such as creative or cultural benefits).[7,9,10,21,22,29,30] Thus, natural environments have become an increasingly important part of global public health and urban planning policies, but the health potential of blue spaces in particular has received less attention than green spaces.[7,17,31] This may be due to the fact that scientific evidence tends to generalise the results and classify blue spaces as a form of green space, or even the difficulties in finding green spaces without the presence of blue spaces.[7,9]

Blue spaces refer to outdoor environments that feature water prominently and that are accessible, whether close or distant / virtual (maintaining the possibility of seeing, hearing or otherwise perceiving the water).[17,22,32] Examples of these spaces include coastal margins, natural or channelled rivers, lakes, ponds, artificial retention basins, fountains.[21,22,32]

Although the scientific evidence for blue spaces is limited, it increasingly provides associations between health promotion and exposure to safe, clean and attractive blue spaces, due to the availability of the different mechanisms mentioned above. These benefits, due to the sight and sound, cover physical aspects (such as water sports), mental aspects (these spaces are associated with a state of calm and relaxation) and social aspects (they facilitate meetings and interactions), as well as helping with sleep quality.[7,9,17,22,31–33]

To better understand the specific effects and mechanisms of blue spaces on human health and to maximize the benefits and guide urban planning and public health policies, it is necessary to deepen research in this area, regarding the impact of different forms of contact. This is particularly important for populations with limited access to the outdoors (due to environmental or mobility constraints), opening up possibilities in improving health, accessibility and inclusion.[24,34]

Considering the rapid advances in technology, low-cost virtual reality (VR) interventions could be considered because VR equipment is becoming increasingly accessible, user-friendly, and adaptable for home or therapeutic use, offering customizable environments that can be tailored to specific needs.[27,34] Perhaps for this reason, VR has proved relatively effective as a tool in different contexts and with different applications for health promotion, particularly in mental health.[25,27,35–38]

Thus, VR has significant potential to improve the quality of life for older adults by providing immersive experiences that allow them to explore the world and try new activities from home.[39] While studies show VR doesn't fully replicate real-life experiences, it still provides notable mental health benefits and physiological and cognitive responses similar to real immersion.[25,40] VR offers an immersive experience in 360º that engages the senses more than flat-screen videos (2D).[24,40] The more immersive the experience, the more realistic and engaging it feels, enhancing the psychological benefits of virtual nature. Key elements that contribute to this sense of presence include the quality of visuals and sound, interactivity and the details of the natural environments.[40]

This provides an additional motivation for further clear and robust studies on the impact of virtual environments on mental health, particularly regarding virtual exposure to blue spaces and its effects on well-being, depression, and anxiety in the elderly people, as many current studies lack clarity on VR interventions. So that are necessary more clear and robust investigations for the implementation of this tool as a therapeutic tool.

This study analyses how a virtual immersive program of blue spaces affects the well-being, depression and anxiety symptoms in elderly individuals, compared to immersive exposure to

urban spaces and non-immersive exposure to blue spaces. It assumes that (A) blue spaces have a more positive impact than urban spaces, and (B) immersive exposure to blue spaces, due to the greater sense of presence, leads to a better experience. Based on this, the hypothesis is that a five-session immersive experience in blue spaces will improve well-being and reduce depression and anxiety more than non-immersive exposure to blue spaces or immersive exposure to urban environments. Additionally, the study also assessing participant satisfaction and perceived impact.

2. Methods

2.1. Research design and participants

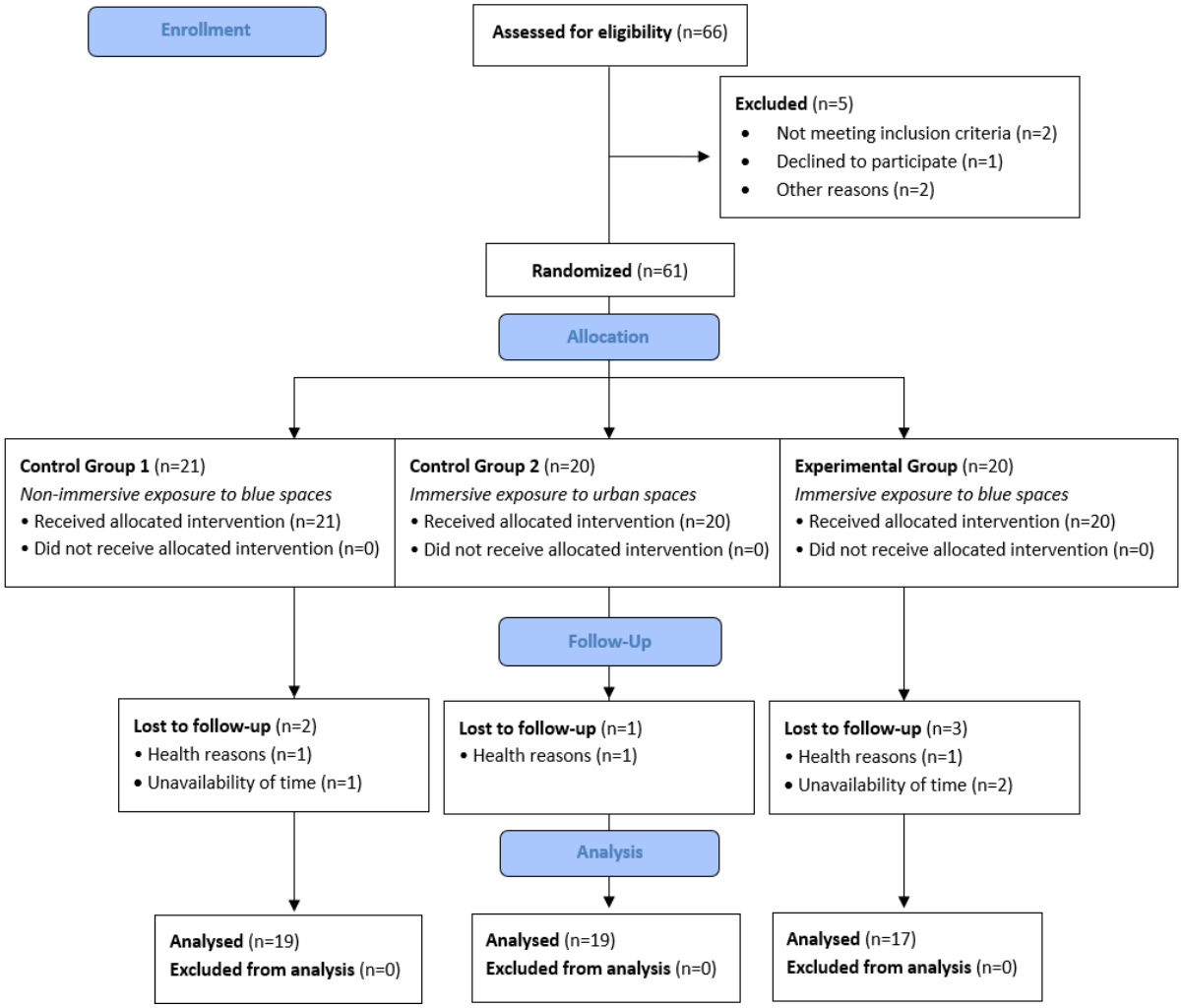
A quantitative randomised controlled trial was carried out, using a non-probabilistic convenience sample of older adults living in Portugal and France. The study received approval from the Ethics Committee of School of Health of the Polytechnic of Porto (code CE0054E).

Participants, aged 60 and older, without severe cognitive, hearing and visual impairments, were recruited from health and/or social service institutions and were subjected to a 5-week intervention. Quantitative data were collected before and after the intervention. After selection, participants signed an Informed Consent Form that detailed the study's objectives and ensured data anonymity and confidentiality, following the Declaration of Helsinki.[41]

Individuals were randomly distributed to the three intervention groups: experimental group, with immersive exposure to blue spaces (IBS group); control group 1, with immersive exposure to urban spaces (IUS group); and control group 2, with non-immersive exposure to blue spaces (NIBS group).

As described in Figure 1, of the 66 individuals who volunteered to participate, five were excluded due to refusal, failure to meet study criteria, or health reasons. Therefore, 61 participants were included, though six dropped out during the intervention for health or availability reasons, leaving 55 who completed the intervention.

Figure 1. Diagram of the allocation of participants



2.2. Measures

In this study, an evaluation was carried out before and after the intervention (approximately 15–20 minutes) as well as a subjective assessment after each session (approximately 5 minutes). The data was collected by two occupational therapist researchers, adequately prepared and following the same protocol. Several measures were used, in Portuguese or French, according to the preference of the participant.

A questionnaire was used to assess sociodemographic and clinical indicators, and exposure to blue spaces; the Montréal Cognitive Assessment (MoCA)[42–44] was used to assess cognitive skills and check compliance with the pre-established criteria; the Geriatric Depression Scale – Short Version (GDS-15)[45,46] to assess the presence of depressive symptoms; the Generalised

Anxiety Disorder – 7 item scale (GAD-7)[47,48] to assess the presence of anxiety symptoms; and the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS)[49,50] to assess general mental wellbeing. Participants were also required to rate their experience after each intervention session using a scale including several topics addressing overall satisfaction and perceived impact related with the session.

The sociodemographic, clinical and blue space exposure questionnaire was developed by the researchers to obtain, the sociodemographic, clinical and blue space exposure data. Sociodemographic questions collect data such as age, gender, marital status and educational level; clinical data relate to the presence or absence of a diagnosis of mental illness; and exposure to blue spaces was analysed using the questions "*Do you usually have contact with blue spaces?*", "*If so, what type of blue space* you usually visit*?*". Proximity to blue spaces was measured through the questions "*Average time taken to travel to the nearest blue space?*". Regarding the frequency of exposure, questions such as "*How often do you visit these spaces?*"

The MoCA is a sensitive tool for detecting cognitive impairment.[42,43] It assesses several mental functions, namely short-term memory, executive functions, visuospatial ability, language, attention, concentration and working memory, and temporal and spatial orientation.[42,43] The sum of all the items gives the final score, and the lower the result, the more severe the cognitive impairment. A score of less than 10 indicates severe cognitive impairment.[42,43] This instrument is validated for the Portuguese and French population, presenting an internal consistency of α=0.92[44] and α= 0.83,[42] respectively.

The GDS-15 is an assessment tool used for the diagnosis and evaluation of depression in elderly people.[46,51] It is a shorter version designed to be quicker and reduce fatigue while maintaining good diagnostic accuracy.[46,52,53] It consists of 15 questions with "Yes" or "No" answers, scored 1 or 0 points. In questions 1, 5, 7, 11, and 13, the scoring is inverted. The total score indicates the person's depression risk, with a higher score meaning a higher risk.[46,52,53] This instrument is validated for the Portuguese and French populations, presenting an internal consistency of α=0.83[53] and α=0.66[46], respectively.

The GAD-7 is a scale used to assess anxiety symptoms over the past two weeks, commonly applied to general anxiety. It consists of 7 items rated on a Likert scale from 0 to 3, where 0 is "Never" and 3 is "Almost every day." The final score varies from 0 to 21, in which high scores indicate higher severity of anxiety symptoms.[47,48,54] This instrument is validated for the Portuguese and French population, presenting an internal consistency of α=0.88[48] and α=0.898[47], respectively.

The WEMWBS was developed to measure well-being in two theoretical dimensions: hedonic well-being (happiness and life satisfaction) and eudemonistic well-being (positive psychological functioning, satisfying relationships with others, personal realisation and acceptance).[55] This 14-item scale has five response options ("never" to "always") scored from 1 to 5. The total score reflects overall well-being, with higher scores indicating greater well-being. All items are positively framed, making the concept easier to understand.[55,56] This instrument is validated for the Portuguese and French population, presenting an internal consistency of α=0.91[57] and α>0.84[50], respectively.

The subjective assessment scale was developed by the researchers to obtain the person's subjective assessment of their experience after each intervention session. It includes 12 items rated on a Likert scale from 0 to 10, where 1 means "totally disagree", 5 means "neither agree nor disagree", and 10 means "totally agree". For the evaluation of feelings before exposure, questions such as "*I was worried about the possibility of side effects before the intervention*" were asked. As for the evaluation of the session, questions were asked such as "*I felt comfortable during the intervention*", "*I feel there were side effects or discomfort associated with the intervention*". Regarding the moments after the exposure, questions such as "*I feel that there have been perceptible improvements in my general state after this intervention*", "*I feel calmer / happier / more relaxed / confident after the intervention*". The general analysis of the session is made through questions such as "*In general, I am satisfied with this experience*" and "*I would like the intervention to be different*".

2.3. Procedures

In the first phase, extensive research was carried out on the subject in order to acquire the knowledge needed to develop the project. After approval from the Ethics Committee, requests for collaboration were sent via e-mail to several institutions working in the area of health or social services. Those that agreed to collaborate helped to identify and disseminate the study to any volunteer participants. All the individuals were contacted, but not all were accepted into the study. Once the participants were selected, the intervention was carried out over the months of June and August 2024.

It consisted of five individual sessions preferably over five weeks, each lasting about 15 minutes. Each session involved watching high-quality 10-minute videos featuring the sights and sounds of blue spaces (such as beaches and rivers) or urban spaces (such as streets and monuments), but without interaction. The videos should be preferably of good quality, clarity, absence of movement, cuts or background music. The intervention used Meta-Quest2 VR glasses or the

researcher's laptop as a tool. The NIBS group used a computer to view 2D videos of blue spaces, while the IBS group wore Meta-Quest2 VR glasses to experience 360º videos of blue spaces. The IUS group also used the VR glasses to view 360º videos of urban spaces.

Preferably, participants sat in quiet, safe, and noiseless places during the sessions and were encouraged to verbalize what they were seeing.

At the end of the intervention, the data collected by the researchers was integrated into a single database in the Microsoft Office Excel programme (Office 365 version) and then exported to the IBM Statistical Package for the Social Sciences (SPSS) software version 29, in which the variables were coded and the statistical analysis of this study was conducted.

2.4. Statistical Analyses

For the statistical analysis, a significance level of 0.05 was considered for all statistical tests.

In the first instance, descriptive statistics were used to characterise the sample, based on means and proportions.

The groups were compared for several indicators using ANOVA or non-parametric equivalent when there were no assumptions of normality and homogeneity of variances and sphericity, and the chi-square or fisher tests for the case of categorical variables.

The evaluation of the outcomes before and after intervention was then compared for each group, using the T-test for paired samples.

Finally, the presence of a significant interaction between intervention and result of evaluation at different times was evaluated through mixed ANOVA.

In terms of achieving the study's objective, the relationship between the average score obtained in the evaluation of the participants' perception of the sessions and the type of exposure to blue spaces was investigated.

3. Results

Table 1 shows the sociodemographic and participants' mental health characteristics, as well as the variables related to exposure to blue spaces of the sample (n=55) before the intervention, distributed among the three study groups.

It is possible to verify that the sample was made up of participants aged between 60 and 98 years, with an average age of 78.27 years. The sample was predominantly female (81.8%) and only nine participants were married or in a civil partnership (16.4%). The education level (number of years completed) was in average 6.49 years.

Regarding the participants' mental health characteristics, 34 participants had no mental illness diagnosis, while 21 had at least one. The IBS and IUS groups had a similar number of diagnosed participants, whereas the IUS group had fewer.

Regarding the MoCA values, in general, participants presented similar values, although the values for the NIBS group indicated a slightly lower cognitive performance (16.58) compared to the other groups (17.65 for the IBS group and 18.26 for the IUS).

Concerning the variables related to exposure to blue spaces, of the 55 participants, 29 have contact with blue spaces. Most of these participants (36.4%) take 30 to 60 minutes to reach a blue space, with the sea/coast being the preferred location for 40% of them. The majority (32.7%) visit these spaces less than once a month.

It was found that there were no statistically significant differences between the groups, given that a p-value > 0.05.

Table 1. Sociodemographic and participants' mental health characteristics, and variables related to exposure to blue spaces of the sample (n=55) before the intervention

Variables	Characteristics of the sample before the intervention n (%)				p-value
	Total sample (n=55)	IBS Group (n=17)	IUS Group (n=19)	NIBS Group (n=19)	
Sociodemographic characteristics					
Age (years)					
Mean ± SD	78.27 ± 10.25	79.88 ± 12.05	76.42 ± 9.55	78.68 ± 9.41	0.594*
Min-Max	60-98	60-98	60-90	60-94	
Sex					
Male	10 (18,2)	1 (5,9)	4 (21,1)	5 (26.3)	0.304**
Female	45 (81.8)	16 (94.1)	15 (78.9)	14 (73.7)	

Marital status					
Single or Widowed or Divorced / Separated	46 (83.6)	15 (88.2)	15 (78.9)	16 (84.2)	0.900**
Married or Cohabiting	9 (16.4)	2 (11.8)	4 (21.10)	3 (15.8)	
Education level					
Mean ± SD	6.49 ± 4.63	6.06 ± 4.52	6.95 ± 5.16	6.42 ± 4.38	0.850*
Min-Max	0-15	0-14	0-15	0-13	
Characteristics related to Mental Health					
Diagnosis of mental illness					
Depressive disorder	3 (5.45)	3 (17.6)	0	0	0.180 *
Generalised anxiety disorder	3 (5.45)	1 (5.9)	1 (5.3)	1 (5.3)	
Depressive and anxiety disorder	15 (27.27)	5 (29.4)	7 (36.8)	3 (15.8)	
No diagnosis	34 (61.81)	8 (47.1)	11 (57.9)	15 (78.9)	
MoCA Score (0-30)					
Mean ± SD	17.49 ± 5.79	17.65 ± 5.97	18.26 ± 6.52	16.58 ± 4.97	0.671*
Min-Max	10-29	10-28	10-29	11-29	
Exposure to blue spaces					
Do you have usual contact with blue spaces? (n=55)					
Yes	29 (52.7)	8 (47.1)	11 (57.9)	10 (52.6)	0.809***
No	26 (47.3)	9 (52.9)	8 (42.1)	9 (47.4)	
How long does it take to get to the nearest blue space? (n=29)					
< 30 minutes	9 (16.4)	1 (5.9)	5 (26.3)	3 (15.8)	0.323**
30 - 60 minutes	20 (36.4)	7 (41.2)	6 (31.6)	7 (36.8)	
Type of blue space you usually visit? (n=29)					
Only Sea/Coast	22 (40)	6 (35.3)	9 (47.4)	7 (36.8)	0.867**
Sea/Coast/River/Lakes	7 (12.07)	2 (11.8)	2 (10.5)	3 (15.8)	
How often do you visit blue spaces? (n=29)					
Once a month or +	11 (20)	1 (5.9)	6 (31.6)	4 (21.1)	0.175**
< Once a month	18 (32.7)	7 (41.2)	5 (26.3)	6 (31.6)	

* ANOVA test
** Fisher test
*** Chi-squared test

Table 2 shows the intervention's effects in different groups, verified through the test results after the intervention. There was a notable reduction in GDS-15 and GAD-7 scores across all groups, with the most significant change in the immersive groups. Additionally, well-being, measured by the WEMWBS, increased in all groups following the intervention. The T-test revealed significant differences in all groups before and after the intervention (p-value < 0.05), except for the NIBS group, where no significant change was observed in anxiety levels.

Table 2. Comparison of GDS-15, GAD-7 and WEMWBS scores between groups and evaluation moments (n=55)

Variables		Intervention's effects n (%)				
		Total sample (n=55)	IBS Group (n=17)	IUS Group (n=19)	NIBS Group (n=19)	p-value*
GDS-15 Score (0-15)						
Initial	Mean ± SD	6.35 ± 3.73	6.18 ± 3.49	6.00 ± 3.71	6.84 ± 4.09	0.772
	Min-Max	0-14	1-13	0-12	0-14	
Final	Mean ± SD	5.11+3.04	4.76+2.71	5.05+3.47	5.47+2.97	0.785
	Min-Max	0-12	1-11	0-12	0-12	
p-value **			.008	.046	.015	
GAD-7 Score (0-21)						
Initial	Mean ± SD	7.60 ± 5.23	8.47 ± 5.79	7.89 ± 5.70	6.43 ± 4.23	0.523
	Min-Max	0-20	0-19	0-20	1-18	
Final	Mean ± SD	4.82+3.79	5.18+4.23	4.32+3.58	5.00+3.73	0.774
	Min-Max	0-15	0-14	0-10	1-15	
p-value **			.008	.008	.124	
WEMWBS Score (14-70)						
Initial	Mean ± SD	44.38 ± 7.89	46.76 ± 7.85	42.42 ± 8.24	44.21 ± 7.39	0.259
	Min-Max	28-59	32-57	28-56	31-59	
Final	Mean ± SD	47.60+6.46	49.82+6.11	46.32+6.91	46.89+6.12	0.227
	Min-Max	33-60	37-60	33-58	37-60	
p-value **			.016	.010	.019	

* ANOVA test

** T-test

Table 3 shows the inferential statistics of the mixed ANOVA for the three variables (GDS-15, GAD-7, WEMWBS) across the groups (IBS, IUS, NIBS) over time (initial and final moments). There were no significant differences between groups, nor any significant interaction between groups and time (p-value > 0.05). However, all groups showed a significant reduction in the GDS-15 and GAD-7 scores, and an increase in WEMWBS score over time, (p-value < 0.001), suggesting the intervention was effective across all groups.

Table 3. Mixed ANOVA inferential statistics

Inferential statistics of the mixed ANOVA		
Variables	**F-value**	**p-value**
GDS-15		
Between subjects (Group)	.249	.780
Within subjects (Initial-Final Moments)	20.434	<.001
Interaction Within subjects (Initial-Final Moments * Group)	.295	.746
GAD-7		
Between subjects (Group)	.328	.722
Within subjects (Initial-Final Moments)	20.018	<.001
Interaction Within subjects (Initial-Final Moments * Group)	1.082	.346
WEMWBS		
Between subjects (Group)	1.609	.210
Within subjects (Initial-Final Moments)	21.921	<.001
Interaction Within subjects (Initial-Final Moments * Group)	.282	.756

Table 4 concerns the comparison of the participants' assessment of their experiences and perceived impacts across the different groups, presenting the average responses to questions regarding their overall perception of the intervention. There were no significant differences between groups, except for the questions 3, 4, 5 and 7 (p-value < 0.05). The question 3 relate to the side effects or discomfort associated with the intervention. The others relate to improvements in general condition, a sense of calm and relaxation after the session.

Table 4. Comparison of the participants' assessment of the experience and perceived impact between groups

Comparison of the participants' assessment (Mean ± SD) n (%)				
Variables	**IBS Group (n=17)**	**IUS Group (n=19)**	**NIBS Group (n=19)**	**p-value**
1. I was worried about the possibility of side effects before the intervention.	1.482±.7316	1.874±1.7916	1.221±.4467	.104*
2. I felt comfortable during the intervention.	9.412±.8230	8.653±1.3496	9.400±.4853	.077*
3. I feel that there were side effects or discomfort associated with the intervention.	1.482±.7316	1.916±.8441	1.221±.5159	.005*
4. I feel that there have been noticeable improvements in my general condition after	6.624±1.5197	4.937±1.9631	5.632±1.3503	.012**

	this intervention.				
5.	I feel calmer after the intervention.	7.141±1.5520	5.379±2.8007	6.442±1.2729	.036**
6.	I feel happier after the intervention.	6.518±.9951	5.547±2.0985	6.168±1.2334	.165**
7.	I feel more relaxed after the intervention.	7.235±1.6796	5.495±2.8405	6.526±1.2369	.044**
8.	I feel more confident after the intervention.	6.024±1.1745	4.874±1.5989	5.211±1.7042	.078**
9.	Overall, I'm satisfied with the experience.	8.965±.8923	8.389±1.1303	8.726±.9757	.236**
10.	I wish the intervention had been different.	2.012±.6688	2.274±1.0795	1.716±.9317	.182**
11.	I'm motivated to continue the intervention.	9.435±.7558	8.958±1.2554	9.242±.7618	.364*
12.	I would recommend this intervention.	9.341±.5185	8.800±.9638	9.274±.6539	.122*

* Kruskal–Wallis test

** ANOVA test

To better understand the relationships between the groups in terms of subjective evaluations, the Bonferroni Post-Hoc test was used, the results of which are presented in Table 5. There were significant differences between the IBS and IUS groups in terms of improvements in general condition, sense of calm and relaxation (p-value < 0.05). There were also differences between the IUS and NIBS groups in terms of side effects or discomfort (p-value < 0.05).

Table 5. Pairwise comparison of the evaluation of the experience and the impact perceived by the participants, for the questions 3, 4, 5 and 7.

Pairwise comparison of the evaluation of the experience			
Variables	**Groups**		**p-value**
Side effects or discomfort associated with the intervention	**IBS Group**	**IUS Group**	,219
	IBS Group	**NIBS Group**	,825
	IUS Group	**NIBS Group**	,012
Improvements in general condition after the intervention	**IBS Group**	**IUS Group**	,010
	IBS Group	**NIBS Group**	,225
	IUS Group	**NIBS Group**	,589
Calmer after the intervention	**IBS Group**	**IUS Group**	,033
	IBS Group	**NIBS Group**	,903
	IUS Group	**NIBS Group**	,324
More relaxed after the intervention	**IBS Group**	**IUS Group**	,042
	IBS Group	**NIBS Group**	,913
	IUS Group	**NIBS Group**	,379

4. Discussion

In the present study, exposure to blue spaces using immersive VR technology had a positive effect on well-being, depressive and anxiety symptoms of older adults, in similarity to exposure to urban spaces using the same technology and exposure non-immersive to blue spaces using a computer monitor. Although preliminary results suggest that the immersive approaches resulted in better outcomes than the non-immersive intervention, in a deeper analysis there were no significant interactions between type of intervention and differences between assessments. Even so, people exposed to the blue spaces (especially immersively) seem to evaluate the experience more positively, especially with regard to improvements in their general condition, a sense of calm and relaxation than people exposed to urban spaces. In addition, people exposed to urban spaces seem to report greater discomfort or side effects than people exposed to blue spaces in a non-immersive way. This seems to indicate that exposure to blue spaces, in general, is evaluated more positively than urban spaces.

The overall positive effect of different types of intervention on well-being, depressive and anxiety symptoms may result from the fact that the structure of the intervention is similar, and in which participants were able to discuss their environmental memories (urban or blue) with a therapist, allowing the elderly to relive significant experiences or places, corresponding to a reminiscing therapy approach.[58] Another aspect to consider is that participants could discover new places or revisit familiar ones virtually, which might motivate them and offer a refreshing break from their usual routine. In this sense, the sessions could be viewed as an enjoyable form of leisure, providing entertainment tailored to individual preferences, while also helping to reduce feelings of loneliness. [58] In addition, for some participants, the time of the sessions was one of the few times in the week when they enjoyed a different experience or discussed with someone. This may also be related to the positive results of the study.

This findings suggests that the benefits of the intervention may go beyond the specific type of exposure, emphasizing the importance of involving older adults in therapeutic activities that focus on well-being and the individual characteristics (such as personal preferences, state of health or socio-cultural context) of the people who frequent them,[59] regardless of the environment. It's also crucial for implementing technology-based mental health interventions, ensuring they are safe, stimulating, intuitive and easy to use, considering participants' limitations,[60] even for older people with cognitive problems, helping to improve their quality of life and emotional state.[61]

In addition, blue spaces do not seem to have been significantly more beneficial than urban ones, perhaps because most of the benefits can result from direct contact with these spaces, although

there are some records of benefits with VR. On the other hand, one of the elements that contribute to the feeling of presence is interactivity, which can amplify the psychological benefits of exposure.[62] Therefore, for future studies, it would be pertinent to check whether the effects of this study would be amplified if exposure to blue spaces is interactive.

It should be noted that the majority of participants who have contact with blue spaces do so for a relatively long period of time, but infrequently. The low frequency may, among other factors, be linked to the difficulty of access, since most participants need between 30 and 60 minutes to get to a blue space. These aspects reinforce the importance of ease of access for people's participation in activities because the frequency and duration dedicated to social and family relationships seem to be of great importance and contribute strongly to a sense of belonging and well-being, especially if this time is spent in natural spaces, whose sensory factors (such as images, sounds, smells) also seem to contribute to stress reduction and improvements in mood.[59,63–65] This leads us to another pertinent result is the fact that the majority of participants favour the sea/coast over the river/lake. This also may be related to factors such as sensitivity to sound and the calming effect of water, which are important to some people.[59]

In this study, no statistically significant differences were found between the groups in the variables relating to sociodemographic data, characteristics relating to the mental health of the participants and data on exposure to blue spaces. This suggests that these factors did not have an adverse impact on the results, reinforcing the robustness and validity of the study's conclusions. Another significant strength is its originality, addressing an area little explored in national and international literature, with a scarcity of studies mentioning contact with blue spaces and the relationship with mental health. In addition, the results can enrich knowledge on the subject and contribute new information that can open up paths for future research. It should also be emphasised that this study is innovative, as it uses high technology applied to the elderly population. In addition, this study compares different types of exposure, includes older people and people from different contexts.

On the other hand, in this study there was no control group without intervention to compare the results with the interventions performed. In addition, it can be said that the number of sessions (five) carried out so far does not seem to be sufficient to ascertain the total effectiveness of the intervention. A significant limitation of this study is the sample size, possibly due to the lack of responses from institutions and the short time to carry out the study. Thus, this sample may not be large enough to generalise the results to a wider population. Larger samples could provide more statistical power and allow for better generalisation of the results. Another limitation concerns data collection due to the lack of blinding of the evaluator to the intervention, and

considering that the evaluations were self-reporting, the participants may have given the answers that would be expected by the researchers, which can introduce bias into the results. Another weak point there is no record of what types of intervention had people. These limitations should be considered when interpreting the results of the study and emphasise the need for more robust and comprehensive future research to validate the findings.

5. Conclusion

In conclusion, the findings demonstrate that exposure to blue spaces through virtual reality technology positively impacted the well-being of older adults, as well as their symptoms of depression and anxiety. This effect was consistent across all interventions. While initial results indicate that immersive approaches led to better outcomes than non-immersive interventions, subsequent analyses did not identify significant interactions between the type of intervention and the evaluation differences.

Nevertheless, the subjective experience of participants exposed immersively to the blue spaces seemed to be more positive, indicating improvements in their general condition, calm and relaxation. Furthermore, people exposed to blue spaces in a non-immersive way appear to report less discomfort or side effects.

The findings suggest that virtual environments can serve as valuable tools for promoting mental health, highlighting the potential of virtual interventions as therapeutic options for older adults. This emphasizes the necessity for further studies to investigate the mechanisms behind these improvements and to optimize various exposure types for this demographic. Additionally, the role of immersion and interactivity as factors that can enhance psychological benefits suggests promising avenues for future research. Immersion and interactivity are elements that can amplify the psychological benefits of exposure, which suggests directions for future research.

References

1. World Health Organization. Active Ageing: A Policy Framework. 2005; Available From: Https://Www.Who.Int/Ageing/Publications/Active_Ageing/En/

2. Tavares RE, Jesus MCPD, Machado DR, Braga VAS, Tocantins FR, Merighi MAB. Healthy Aging From The Perspective Of The Elderly: An Integrative Review. Rev Bras Geriatr Gerontol. 2017;20(6):878–89.

3. Lee J, Kim HJ. Normal Aging Induces Changes In The Brain And Neurodegeneration Progress: Review Of The Structural, Biochemical, Metabolic, Cellular, And Molecular Changes. Front Aging Neurosci. 2022;14:931536.

4. E. Bloom D, Mcgee P, Seike A, Boersch-Supan A. Population Aging: Facts, Challenges, And Responses. Program On The Global Demography Of Aging. 2011;(71).

5. Rudnicka E, Napierała P, Podfigurna A, Męczekalski B, Smolarczyk R, Grymowicz M. The World Health Organization : Approach To Healthy Ageing. Maturitas. 2020;139:6–11.

6. World Health Organization. Mental Health Of Older Adults [Internet]. 2023. Available From: Https://Www.Who.Int/News-Room/Fact-Sheets/Detail/Mental-Health-Of-Older-Adults

7. Wang L, Md Sani N. The Impact Of Outdoor Blue Spaces On The Health Of The Elderly: A Systematic Review. Health & Place. 2024;85:103168.

8. Zhang W, Qu J, Liu GH, Belmonte JCI. The Ageing Epigenome And Its Rejuvenation. Nat Rev Mol Cell Biol. 2020;21(3):137–50.

9. White MP, Elliott LR, Gascon M, Roberts B, Fleming LE. Blue Space, Health And Well-Being: A Narrative Overview And Synthesis Of Potential Benefits. Environmental Research. 2020;191:110169.

10. Jarosz E. Direct Exposure To Green And Blue Spaces Is Associated With Greater Mental Wellbeing In Older Adults. Journal Of Aging And Environment. 2023;37(4):460–77.

11. Wahl, H. W., & Tesch-Römer, C. Environmental Gerontology: Making Meaningful Places In Old Age. Springer Publishing Company. 2012;

12. Jessen-Winge C, Petersen MN, Morville AL. The Influence Of Occupation On Wellbeing, As Experienced By The Elderly: A Systematic Review. JBI Database Of Systematic Reviews And Implementation Reports. 2018 May;16(5):1174–89.

13. Serviço Nacional Saude. ENEAS – Estratégia Nacional Para O Envelhecimento Ativo E Saudável [Internet]. Available From: Https://Www.Sns.Gov.Pt/Wp-Content/Uploads/2017/07/ENEAS.Pdf

14. World Health Organization. Ageing And Health [Internet]. 2022. Available From: Https://Www.Who.Int/News-Room/Fact-Sheets/Detail/Ageing-And-Health

15. Van Den Berg, A. E., Maas, J., Verheij, R. A., & Groenewegen, P. P. Green Space As A Buffer Between Stressful Life Events And Health. Social Science & Medicine. 2010;70(8):1203–10.

16. Buckingham S, Tu G, Elliott L, Poole R, Walker T, Bland E, Et Al. Digital Competence And Psychological Wellbeing In A Social Housing Community: A Repeated Survey Study. BMC Public Health. 2023;23(1):2002.

17. Smith N, Georgiou M, King AC, Tieges Z, Webb S, Chastin S. Urban Blue Spaces And Human Health: A Systematic Review And Meta-Analysis Of Quantitative Studies. Cities. 2021;119:103413.

18. Van Den Bosch M, Ode Sang Å. Urban Natural Environments As Nature-Based Solutions For Improved Public Health – A Systematic Review Of Reviews. Environmental Research. 2017;158:373–84.

19. Markevych I, Schoierer J, Hartig T, Chudnovsky A, Hystad P, Dzhambov AM, Et Al. Exploring Pathways Linking Greenspace To Health: Theoretical And Methodological Guidance. Environmental Research. 2017;158:301–17.

20. Twohig-Bennett C, Jones A. The Health Benefits Of The Great Outdoors: A Systematic Review And Meta-Analysis Of Greenspace Exposure And Health Outcomes. Environmental Research. 2018;166:628–37.

21. World Health Organization. Assessing The Value Of Urban Green And Blue Spaces For Health And Well-Being [Internet]. 2023. Available From: Https://Www.Who.Int/Europe/Publications/I/Item/WHO-EURO-2023-7508-47275-69347

22. World Health Organization. Green And Blue Spaces And Mental Health: New Evidence And Perspectives For Action [Internet]. 2021. Available From: Https://Iris.Who.Int/Bitstream/Handle/10665/342931/9789289055666-Eng.Pdf?Sequence=1

23. Ohly H, White MP, Wheeler BW, Bethel A, Ukoumunne OC, Nikolaou V, Et Al. Attention Restoration Theory: A Systematic Review Of The Attention Restoration Potential Of Exposure To Natural Environments. Journal Of Toxicology And Environmental Health, Part B. 2016;19(7):305–43.

24. Reece R, Bornioli A, Bray I, Newbutt N, Satenstein D, Alford C. Exposure To Green, Blue And Historic Environments And Mental Well-Being: A Comparison Between Virtual Reality Head-Mounted Display And Flat Screen Exposure. IJERPH. 2022;19(15):9457.

25. Sun Y, Li F, He T, Meng Y, Yin J, Yim IS, Et Al. Physiological And Affective Responses To Green Space Virtual Reality Among Pregnant Women. Environmental Research. 2023 ; 216:114499.

26. Riva G, Serino S. Virtual Reality In The Assessment, Understanding And Treatment Of Mental Health Disorders. JCM. 2020 ;9(11):3434.

27. Baghaei N, Chitale V, Hlasnik A, Stemmet L, Liang HN, Porter R. Virtual Reality For Supporting The Treatment Of Depression And Anxiety: Scoping Review. JMIR Ment Health. 2021;8(9):E29681.

28. Sullivan WC. Attention Restoration And Stress Reduction: Two Mechanisms Underlying The Health Benefits Of Exposure To Green Spaces.

29. Power MC, Adar SD, Yanosky JD, Weuve J. Exposure To Air Pollution As A Potential Contributor To Cognitive Function, Cognitive Decline, Brain Imaging, And Dementia: A Systematic Review Of Epidemiologic Research. Neurotoxicology. 2016; 56:235–53.

30. Portegijs E, Keskinen KE, Eronen J, Saajanaho M, Rantakokko M, Rantanen T. Older Adults' Physical Activity And The Relevance Of Distances To Neighborhood Destinations And Barriers To Outdoor Mobility. Front Public Health. 2020;8:335.

31. Zhang H, Nijhuis S, Newton C. Freshwater Blue Space Design And Human Health: A Comprehensive Research Mapping Based On Scientometric Analysis. Environmental Impact Assessment Review. 2022;97:106859.

32. Grellier J, White MP, Albin M, Bell S, Elliott LR, Gascón M, Et Al. Bluehealth: A Study Programme Protocol For Mapping And Quantifying The Potential Benefits To Public Health And Well-Being From Europe's Blue Spaces. BMJ Open. 2017;7(6):E016188.

33. Georgiou M, Morison G, Smith N, Tieges Z, Chastin S. Mechanisms Of Impact Of Blue Spaces On Human Health: A Systematic Literature Review And Meta-Analysis. IJERPH. 2021; 18(5):2486.

34. Li H, Zhang X, Wang H, Yang Z, Liu H, Cao Y, Et Al. Access To Nature Via Virtual Reality: A Mini-Review. Front Psychol. 2021;12:725288.

35. Usmani SS, Sharath M, Mehendale M. Future Of Mental Health In The Metaverse. Gen Psych. 2022;35(4):E100825.

36. Blanco D, Roberts RM, Gannoni A, Cook S. Assessment And Treatment Of Mental Health Conditions In Children And Adolescents: A Systematic Scoping Review Of How Virtual Reality Environments Have Been Used. Clin Child Psychol Psychiatry. 2023; 13591045231204082.

37. Emmelkamp PMG, Meyerbröker K. Virtual Reality Therapy In Mental Health. Annu Rev Clin Psychol. 2021;17(1):495–519.

38. Kim S, Kim E. The Use Of Virtual Reality In Psychiatry: A Review. J Korean Acad Child Adolesc Psychiatry. 2020;31(1):26–32.

39. Lee LN, Kim MJ, Hwang WJ. Potential Of Augmented Reality And Virtual Reality Technologies To Promote Wellbeing In Older Adults. Applied Sciences. 2019;9(17):3556.

40. Browning MHEM, Mimnaugh KJ, Van Riper CJ, Laurent HK, Lavalle SM. Can Simulated Nature Support Mental Health? Comparing Short, Single-Doses Of 360-Degree Nature Videos In Virtual Reality With The Outdoors. Front Psychol. 2020;10:2667.

41. World Medical Association. World Medical Association Declaration Of Helsinki: Ethical Principles For Medical Research Involving Human Subjects. JAMA. 2013;310:2191–4.

42. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, Et Al. The Montreal Cognitive Assessment, Moca: A Brief Screening Tool For Mild Cognitive Impairment. J American Geriatrics Society. 2005;53(4):695–9.

43. Moca Test Inc. Moca Cognition [Internet]. 2023. Available From: Https://Mocacognition.Com/Paper/

44. Freitas S, De Coimbra U. Estudos De Adaptação Do Montreal Cognitive Assessment (Moca) Para A População Portuguesa. 2010;

45. Apóstolo J. Escala Geriátrica De Depressão (GDS-15). 2011;

46. Clément J, Nassif R, Léger J, Marchan F. Development And Contribution To The Validation Of A Brief French Version Of The Yesavage Geriatric Depression Scale. Encephale. 1997;23(2)(1997):91–9.

47. Micoulaud-Franchi JA, Lagarde S, Barkate G, Dufournet B, Besancon C, Bartolomei F, Et Al. Rapid Detection Of Generalized Anxiety Disorder And Major Depression In Epilepsy: Validation Of The GAD-7 As A Complementary Tool To The NDDI-E In A French Sample. Epilepsy & Behavior. 2016;57:211–6.

48. Sousa TV, Viveiros V, Chai MV, Vicente FL, Jesus G, Carnot MJ, Et Al. Reliability And Validity Of The Portuguese Version Of The Generalized Anxiety Disorder (GAD-7) Scale. Health Qual Life Outcomes. 2015;13(1):50.

49. Figueiredo S, Trigueiro MJ, Marques A, Almeida, R, Coelho T, Sousa S, Et Al. Tradução, Adaptação E Contributo Para A Validação Da Escala Warwick-Edinburgh Mental Well-Being Scale Para A População Portuguesa. Repositório Científico Do Instituto Politécnico Do Porto. 2022;4(2):26–38.

50. Trousselard M, Steiler D, Dutheil F, Claverie D, Canini F, Fenouillet F, Et Al. Validation Of The Warwick-Edinburgh Mental Well-Being Scale (WEMWBS) In French Psychiatric And General Populations. Psychiatry Research. 2016;245:282–90.

51. Shin C, Park MH, Lee SH, Ko YH, Kim YK, Han KM, Et Al. Usefulness Of The 15-Item Geriatric Depression Scale (GDS-15) For Classifying Minor And Major Depressive Disorders Among Community-Dwelling Elders. J Affect Disord. 2019;259:370–5.

52. Park SH, Kwak MJ. Performance Of The Geriatric Depression Scale-15 With Older Adults Aged Over 65 Years: An Updated Review 2000-2019. Clinical Gerontologist. 2021;44:83–96.

53. Apóstolo JLA, Loureiro LM De J, Dos Reis IAC, Da Silva IALL, Cardoso DFB, Sfetcu R. Contribution To The Adaptation Of The Geriatric Depression Scale-15 Into Portuguese. Revista De Enfermagem Referencia. 2014;4(3):65–73.

54. Spitzer RL, Kroenke K, Williams JBW, Löwe B. A Brief Measure For Assessing Generalized Anxiety Disorder: The GAD-7. Arch Intern Med. 2006;166(10):1092.

55. Tennant R, Hiller L, Fishwick R, Platt S, Joseph S, Weich S, Et Al. The Warwick-Edinburgh Mental Well-Being Scale (WEMWBS): Development And UK Validation. Health Qual Life Outcomes. 2007;5(1):63.

56. University Of Warwick. Warwick Medical School [Internet]. 2021. Available From: Https://Warwick.Ac.Uk/Fac/Sci/Med/Research/Platform/Wemwbs

57. Figueiredo S, Trigueiro MJ, Simões-Silva V, Coelho T, Simões De Almeida R, Portugal P, Et Al. Translation, Adaptation, And Contribution To The Validation Of The Warwick–Edinburgh Mental Well-Being Scale For The Portuguese Population. Revsalus [Internet]. 2022;4(2). Available From: Https://Revsalus.Com/Index.Php/Revsalus/Article/View/192

58. Lin CS, Jeng MY, Yeh TM. The Elderly Perceived Meanings And Values Of Virtual Reality Leisure Activities: A Means-End Chain Approach. IJERPH. 2018;15(4):663.

59. Aghabozorgi K, Jagt AVD, Bell S, Smith H. How University Blue And Green Space Affect Students' Mental Health: A Scoping Review. Urban Forestry & Urban Greening. 2024;97:128394.

60. Appel L, Appel E, Bogler O, Wiseman M, Cohen L, Ein N, Et Al. Older Adults With Cognitive And/Or Physical Impairments Can Benefit From Immersive Virtual Reality Experiences: A Feasibility Study. Front Med. 2020;6:329.

61. Matsangidou M, Solomou T, Frangoudes F, Ioannou K, Theofanous P, Papayianni E, Et Al. Affective Out-World Experience Via Virtual Reality For Older Adults Living With Mild Cognitive Impairments Or Mild Dementia. IJERPH. 2023;20(4):2919.

62. Diemer J, Alpers GW, Peperkorn HM, Shiban Y, MÃ¼Hlberger A. The Impact Of Perception And Presence On Emotional Reactions: A Review Of Research In Virtual Reality. Front Psychol [Internet]. 2015; 6. Available From: Http://Journal.Frontiersin.Org/Article/10.3389/Fpsyg.2015.00026/Abstract

63. Britton E, Kindermann G, Domegan C, Carlin C. Blue Care: A Systematic Review Of Blue Space Interventions For Health And Wellbeing. Health Promotion International. 2020;35(1):50–69.

64. Boffi M, Pola LG, Fermani E, Senes G, Inghilleri P, Piga BEA, Et Al. Visual Post-Occupancy Evaluation Of A Restorative Garden Using Virtual Reality Photography: Restoration, Emotions, And Behavior In Older And Younger People. Front Psychol. 2022;13:927688.

65. Aliyas Z. Physical, Mental, And Physiological Health Benefits Of Green And Blue Outdoor Spaces Among Elderly People. International Journal Of Environmental Health Research. 2021;31(6):703–14.