Evaluating VR and AR Mirror Exposure for Anorexia Nervosa Therapy in Adolescents: A Method Proposal for Understanding Stakeholder Perspectives

Marie Luisa Fiedler *†
marie.fiedler@uni-wuerzburg.de
Arne Bürger‡
Sabrina Mittermeier ‡
Mario Botsch§
Marc Erich Latoschik †
Carolin Wienrich *

Figure 1: The figure shows the augmented reality mirror exposure (left) and the virtual reality mirror exposure (right) from an observer's perspective over the user's shoulder.

Abstract

Body image distortions in anorexia nervosa pose significant therapeutic challenges, requiring innovative interventions. Virtual Reality (VR) and Augmented Reality (AR) technologies offer promising solutions, yet stakeholder preferences, from therapists and patients, remain unexplored. This methodological proposal outlines focus groups to compare VR and AR mirror exposures using personalized and body-weight-modifiable avatars in anorexia nervosa therapy. Therapists will evaluate therapeutic potential, risks, and practicality, while adolescent patients will assess comfort, stress responses, and usability. The findings aim to advance the user-centered integration of VR and AR into anorexia nervosa therapy, addressing critical treatment gaps.

*PIIS Group, University of Würzburg, Germany
†HCI Group, University of Würzburg, Germany
‡KJPPP Group, University Hospital of Würzburg, Germany
§CG Group, TU Dortmund University, Germany

Index Terms: Augmented reality, virtual reality, anorexia nervosa, mirror exposure, body image, user-centered approach

1 Introduction

Anorexia nervosa is a severe eating disorder characterized by distorted body image and the fear of weight gain. These distortions persist even after weight restoration, posing a significant challenge for effective treatment. The disorder peaks between the ages of 14 and 16 and mainly affects girls (ratio 30:1) [10, 16]. One conventional approach is cognitive-behavioral therapy (CBT), which is a central treatment for anorexia nervosa. CBT focuses on addressing maladaptive thoughts related to body image and self-worth through techniques such as cognitive restructuring and behavioral experiments [6]. Integrated into CBT, mirror exposure helps patients confront their reflection in a structured setting to reduce negative emotions and promote body acceptance [18]. Exercises include neutral body observation to challenge distorted perceptions. Despite the availability of these traditional therapies, the rising prevalence, high relapse rates, and limited effectiveness of conventional approaches in improving the patient's body image highlight the need for innovative treatment approaches.

Building on these traditional approaches, emerging technologies such as virtual reality (VR) and Augmented Reality (AR) offer innovative ways to address body image distortions [11, 21, 28]. VR enables immersive virtual mirror exposure in entirely virtual environments, allowing real-time modifications of body representations to challenge distorted perceptions [4, 11, 12, 19, 27]. By overlaying virtual elements onto the real world, AR extends this approach by also maintaining the patient's connection to familiar surroundings and supporting direct interaction with therapists [8, 9]. While these technologies offer unique advantages, no studies have yet explored the suitability of AR for therapeutic contexts. Additionally, we know only two clinical studies involving adolescents [24, 25]. Considering that the peak incidence of anorexia nervosa occurs between the ages of 14 and 16, focusing on younger patient populations presents a promising avenue for future research. Moreover, the involvement of stakeholders in developing VR and AR mirror exposure systems, consistent with user-centered design principles, remains limited. This lack of stakeholder input represents a significant barrier to optimizing these technologies for clinical practice, particularly regarding their efficacy and practical challenges such as cost, training requirements, and spatial considerations.

To address these research gaps, we propose a method proposal using a user-centered approach for the first time in this field involving two focus groups of stakeholders: therapists and adolescents with anorexia nervosa. They will evaluate the suitability of VR and AR mirror exposure therapy and provide feedback for iterative development. The study aims to gather preliminary insights into VR and AR mirror exposure preferences, perceived advantages and disadvantages, practical considerations, and therapeutic potential while also developing scenarios for integrating these technologies into routine therapy. By prioritizing end-user perspectives, this work takes a crucial step toward advancing tailored, effective interventions for body image distortion in anorexia nervosa in alignment with user-centered design principles.

2 Related Work

Extensive research on VR mirror exposures explores their effects on both healthy participants and individuals with anorexia nervosa [20]. However, in the field of AR mirror exposures, we found only four studies conducted with healthy participants [23, 35, 36, 37] exploring the effects of AR on body weight perception of avatars in general. In the following, we will briefly discuss the existing work in the field of VR exposure therapy with individuals diagnosed with anorexia nervosa.

In prior work, VR exposure therapy has been utilized to treat body image distortions through exposure to body shape and weight stimuli, replicating interventions such as mirror or video exposure. Through visuomotor or visuotactile synchrony, aligning the avatar and user movements or touches, the users experience the avatar as their virtual body, developing a sense of embodiment. As defined by Kilteni et al. [17], the sense of embodiment encompasses virtual body ownership, perceived agency, and self-location, forming the subjective sense of owning, controlling, and being inside a virtual body. Keizer et al. [13] demonstrated that embodying healthy-weight avatars using synchronous visuotactile stimulation reduced the overestimation of specific body parts in adult anorexia nervosa patients, highlighting the potential of VR to address body image distortions. Similarly, Serino et al. [32] found in their case study with one anorexia nervosa patient that embodying a healthy-weight avatar using synchronous visuotactile stimulation induced temporary but significant changes in perceived body size and integration during three sessions over one year. Porras-Garcia et al. [24, 25, 26] conducted three studies, each consisting of five sessions: one with an adult patient and two with adolescent anorexia nervosa patients, progressively increasing the avatar's body weight during the sessions. This approach, paired with synchronous visuotactile stimulation, reduced fear of weight gain, drive for thinness, body-related anxiety, and dissatisfaction, with improvements partially maintained after follow-ups. Behrens et al. [3] exposed adult anorexia nervosa patients and individuals with high weight concerns to roughly individualized avatars (accurate height, skin tone, and sex) incorporating visuomotor and visuotactile stimulation to establish a sense of embodiment. Participants underwent four exposure sessions where the avatar's body weight was adjusted from session to session. Although a trend toward reduced fear of weight gain emerged, the results suggested that more sessions may be required for lasting effects. In particular, the use of individualized avatars could also have contributed to further strengthening the sense of embodiment, as previous non-clinical studies have already shown [7, 31, 33].

Together, these studies highlight the effectiveness of VR in altering body-related experiences in anorexia nervosa patients. While promising, the long-term efficacy and ideal protocols for VR exposure therapy remain areas for further investigation. Moreover, no studies have evaluated the effectiveness of AR in altering body-related experiences in patients with anorexia nervosa. Previous research has demonstrated that AR can facilitate the development of a sense of embodiment towards virtual bodies [9, 23, 35, 36]. Moreover, Clinical studies assessing the applicability of existing findings to the most affected demographic, adolescents, are notably rare [24, 25]. Additionally, the perspectives of key stakeholders on the suitability of VR and AR in therapy and their involvement in the development of VR and AR mirror exposure systems aligned with user-centered design principles remain insufficiently explored.

3 Methodological Proposal

To investigate the suitability of VR and AR mirror exposures in adolescent anorexia nervosa therapy, we propose a focus group study designed to gather qualitative and quantitative feedback from therapists and patients. This study aims to identify the therapeutic potential of these technologies and provide insight into their integration into clinical practice.

3.1 Study Concept

We identified different components essential for an intervention using AR and VR technology to support the therapeutic process of adolescent anorexia nervosa patients while ensuring its feasibility and applicability in clinical practice. The following components form the foundation of our system:

- **Type of mirror exposure (AR- or VR-based)**: Previous clinical studies have demonstrated that VR mirror exposures effectively induce and modulate body-related experiences in patients with anorexia nervosa. Although no clinical studies have yet investigated the use of AR in this context, existing evidence suggests that AR technologies hold significant potential for similar applications [23, 35, 36, 37].
- **Participants embody the avatars**: Prior work has demonstrated that embodying avatars and the resulting sense of embodiment influences the self-concept of patients, thereby supporting the correction of distorted body weight estimation and improving self-perception [3, 13, 26, 24].
- **Integration of photorealistic, personalized avatars**: Empirical findings suggest that avatars closely resembling the user's appearance enhance their sense of embodiment [3, 7, 31, 33]. This may further support the correction of distorted body weight estimation and self-perception. Consequently, personalized avatars that closely replicate patients' physical appearance could improve the intervention's therapeutic outcomes.

- **Body Weight Modifiable Avatars**: Integrating body weight modifiable avatars aims to gradually normalize patients' perception of their body weight in a safe and controlled environment. Previous clinical studies have shown that such avatars can assist patients in approaching a healthier body weight while simultaneously reducing their fear of weight gain [3, 24, 26].
- **Practical Considerations**: Practical barriers such as cost, training requirements, and space constraints must be addressed to ensure the clinical applicability and feasibility of the intervention.

We have developed an AR and VR mirror exposure system based on these elements. The concept includes using embodied personalized photorealistic body-weight-modifiable avatars and interactive exposure tasks within the AR and VR mirror exposure systems. These systems enable participants to explore and adjust virtual body representations in AR and VR environments. In designing our systems, we emphasized (1) efficacy by drawing on and implementing findings from previous literature and (2) clinical applicability by selecting cost-efficient hardware with minimal space requirements. This approach aims to ensure seamless integration into routine clinical practice and develop and test a solution ready for future clinical application.

The systems will be evaluated and refined in collaboration with stakeholders during a focus group study. The study will involve two focus groups of stakeholders. The first comprises therapists who specialize in the treatment of anorexia nervosa with experience in therapeutic interventions. The second focus group involves adolescents with a clinical diagnosis of anorexia nervosa, including both inpatient and outpatient participants. During the study, participants will extensively test both systems to gather insights into their therapeutic potential, practical implementation, and user experiences. Data collection encompasses physiological measurements, self-reports, and moderated discussions, capturing emotional responses, engagement, and practical considerations, such as cost, training, and space constraints within a clinical setting. We will conduct the focus groups separately for patients and therapists to ensure targeted discussions and unbiased feedback. Each group will independently experience the AR and VR mirror exposures and then discuss their observations within their respective groups.

3.2 System Description

3.2.1 VR and AR Mirror Exposure System

We developed the AR and VR mirror exposure system using Unity 2022.3.57f1 LTS, with the RealityStack I/O framework for integrating the Meta Quest 3[1] head-mounted display (HMD) [14]. Depending on the exposure condition, the Meta Quest 3 supports VR and video see-through AR modes.

In the AR mirror exposure system, a virtual full-body mirror is displayed on a wall 2 m away, showing the participant's personalized avatar from an allocentric perspective (see Fig. 1, left). The total observation distance between the participant and their avatar is 4 m. A 3D model of our laboratory serves as a realistic background for the virtual mirror. Through the passthrough mode of the Meta Quest 3, participants can see their real surroundings and their body from an egocentric perspective.

The VR mirror exposure system places participants in an entirely virtual environment, modeled after our laboratory, to maintain consistency between the AR and VR systems. As in the AR system, a virtual full-body mirror is located on a wall 2 m away, showing the participants from an allocentric perspective (see Fig. 1, right) and giving a total observation distance between the participant and their avatar of 4 m. Participants can view their virtual surroundings and their avatar from an egocentric perspective.

[1] https://www.meta.com/quest/quest-3/

3.2.2 Avatar Generation

The personalized avatars for each participant were created using the method of Achenbach et al. [1]. The hardware setup at the University of Würzburg includes 92 DSLR cameras mounted on a circular rig and a workstation. This setup simultaneously captures multiple photos of the participant to automatically generate a personalized 3D model with a photorealistic texture, which is imported into Unity via a custom FBX-based runtime importer. Detailed process descriptions and images illustrating the resemblance of the personalized avatars to the participants are provided by Bartl et al. [2].

3.2.3 Avatar Animation

To achieve visuomotor coupling of the participant's movements and the avatar, we employed the Meta Movement SDK (v71) in combination with RealityStack CP [22]. Using the Meta Quest 3 sensors and cameras, it captures upper-body movements (head, hands, and torso). It integrates these data with AI-powered generative algorithms to approximate natural lower-body movements.

3.2.4 Avatar Body Weight Modification

We implemented a statistical model for realistic avatar body weight modification, adapted from previous work [5]. Using anthropometric data from the European CAESAR database [29], the model dynamically adjusts body weight for males and females during runtime, ensuring realistic changes in body shape. Participants can interactively adjust avatar body weight using a gesture-based method adapted from Döllinger et al. [5]. Weight changes are controlled by pressing the controller triggers and moving them closer together or farther apart, with the rate determined by the movement speed and distance. Adjustments are limited to ±35 % of the participant's actual weight to ensure realistic and comfortable body shapes.

3.3 Procedure of the Patient Focus Group

The overall procedure for the patient focus group is illustrated in Fig. 2. Each focus group consists of approximately four patients. A therapist is always present during the entire process to intervene in unexpected stressful situations or emotional reactions. After briefly introducing the purpose and procedures, the patients undergo the personalized avatar generation process. For accurate scans, they will wear tight-fitting, non-monochromatic clothing, remove accessories, and have their body height measured. The scanning process, including photo capture and avatar generation, takes around 30 min. The patients will then complete a short questionnaire capturing demographic information, their current bodily well-being concerning perceived simulator sickness [15], and previous experience with similar technologies.

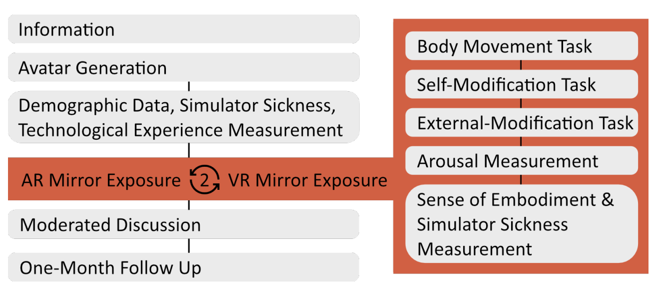

Figure 2: The figure outlines the procedure of the patients' focus group, detailing the AR and VR mirror exposure on the right.

AR and VR Mirror Exposure. Patients test the VR and AR mirror exposures in a counterbalanced order. The patients test the applications in parallel, allowing them to engage in the discussion afterward together. Before the first exposure, the patients are instructed on using the HMD and controllers. The HMD displays a live camera feed of the real lab (AR exposure) or a virtual reconstruction of the lab (VR exposure), with the virtual mirror initially hidden. The HMD is then blacked out to introduce the virtual mirror, which becomes visible. Patients are given time to orient themselves in the displayed environment. After orientation, patients perform five 20-second body movement tasks, adapted from previous research [34, 35], to promote visuomotor coupling with their personalized avatars. Then, two exposure scenarios follow. After familiarizing themselves with the virtual body weight modification, the patients do a self-modification task. They should adjust their avatar's body weight, setting it to the maximum they find comfortable. This task is repeated three times after resetting the avatar's body weight to the participant's actual body weight. Second, the patients are completing an external-modification task. The experimenter continuously increases the avatar's body weight until the participant signals to stop. The avatar's body weight is then reset to the participant's actual body weight, and the task is repeated three times. These tasks should explore patient responses to body weight increases and identify stress thresholds associated with different body weight levels. After each exposure, patients are interviewed about their experiences, complete the questionnaire about their current bodily well-being again, and rate their perceived sense of embodiment [7, 30]. Then, they are given self-selected break times before the following exposure starts.

Measures During Exposure. To address the difficulties that anorexia nervosa patients may have in verbalizing emotions, we assess their state of arousal using physiological and self-report measures. Heart rate variability and skin conductance are tracked before, during, and after exposure. Additionally, patients rate their arousal levels verbally on a visual analog scale (0–100) before, during, and after exposure, following Behrens et al. [3].

Moderated Discussion. Following the exposures, patients participate in semi-structured moderated discussions covering:

- Comfort and engagement with both exposure systems
- Exposure system preference
- Perceived (dis-)advantages of both exposure systems
- Ideas for new therapy scenarios using these technologies that they believe could be helpful during their therapy
- Impact on therapy outcome and personal acceptance

Follow-Up Session. We will contact the patients one month later to reflect on their experiences, exploring which memories persist and whether they are perceived positively or negatively.

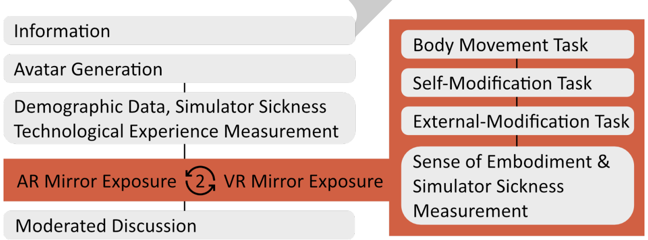

Figure 3: The figure outlines the procedure of the therapists' focus group, detailing the AR and VR mirror exposure on the right.

3.4 Procedure of the Therapist Focus Group

The overall procedure for the therapist focus group is illustrated in Fig. 3. As patients, the therapists will also undergo the avatar generation process and complete a short questionnaire capturing demographic information, current bodily well-being [15], and previous experience with similar technologies after a brief introduction to the purpose and procedures.

Then, the focus group consists of two main phases. In the first phase, the therapists will test out and freely explore both VR and AR mirror exposure systems, including the body movement task, self-modification task, the external-modification task, and the post-exposure measurements (current bodily well-being [15], perceived sense of embodiment [7, 30]), as described above. In the second phase, moderated discussions will be held for therapists. These discussions will follow a semi-structured format and will address:

- Perceived therapeutic potential of both exposure systems for addressing body image distortions in anorexia nervosa
- Perceived (dis-)advantages of both exposure systems
- Potential risks associated with their implementation
- Evaluation of the effectiveness of the current possibilities
- Brainstorming of possible scenarios for therapeutic application
- Practical considerations and barriers (space, costs, training requirements) for integration into daily practice

4 Expected Contribution

The focus group study outlined in this methodological proposal aims to provide a foundational understanding of how therapists and adolescent patients perceive the suitability of VR and AR mirror exposure to treat distortions of body image in adolescent patients with anorexia nervosa. By analyzing quantitative measures of stress and engagement alongside qualitative feedback from group discussions, the study will explore therapy scenarios, advantages, disadvantages, preferences, and differences or alignments between patient and therapist perspectives for both technologies. The findings are expected to offer preliminary insights into which system, VR or AR, is better suited for body image distortion therapy in anorexia nervosa. In addition, this study examines practical barriers to implementing VR and AR technologies in therapy, including cost, therapist training, and space requirements. Considering these factors is essential to ensure that the proposed systems are not only effective but also accessible and practical for integration into routine clinical practice.

Overall, by prioritizing end-user perspectives, this method proposal takes a crucial step toward addressing the specific needs of key stakeholders and guiding the development of tailored, effective VR and AR applications in clinical practice.

Acknowledgments

This research has been funded by the German Federal Ministry of Labor and Social Affairs in the project AIL AT WORK (DKI.00.00030.21) and by the Bavarian State Ministry For Digital Affairs in the project XR Hub (A5-3822-2-16).

References

[1] J. Achenbach, T. Waltemate, M. E. Latoschik, and M. Botsch. Fast generation of realistic virtual humans. In *Proc. VRST*, pp. 1–10. ACM, 2017. doi: 10.1145/3139131.3139154 3

[2] A. Bartl, S. Wenninger, E. Wolf, M. Botsch, and M. E. Latoschik. Affordable but not cheap: A case study of the effects of two 3D-reconstruction methods of virtual humans. *Frontiers in Virtual Reality*, 2, 2021. doi: 10.3389/frvir.2021.694617 3

[3] S. Behrens, J. Tesch, P. Sun, S. Starke, M. Black, H. Schneider, J. Pruccoli, S. Zipfel, and K. Giel. Virtual reality exposure to a healthy weight body is a promising adjunct treatment for anorexia nervosa. *Psychotherapy and psychosomatics*, 92:1–10, 05 2023. doi: 10.1159/000530932 2, 3, 4

[4] N. Döllinger, C. Wienrich, E. Wolf, and M. E. Latoschik. ViTraS – Virtual reality therapy by stimulation of modulated body image – project outline. In *Proc. MuC*, pp. 1–6. Gesellschaft für Informatik e.V., Bonn, 2019. doi: 10.18420/muc2019-ws-633 2

[5] N. Döllinger, E. Wolf, D. Mal, S. Wenninger, M. Botsch, M. E. Latoschik, and C. Wienrich. Resize me! Exploring the user experience of embodied realistic modulatable avatars for body image intervention in virtual reality. *Frontiers in Virtual Reality*, 3, 2022. doi: 10.3389/frvir.2022.935449 3

[6] C. Farrell, R. Shafran, and M. Lee. Empirically evaluated treatments for body image disturbance: a review. *European Eating Disorders Review*, 14(5):289–300, 2006. doi: 10.1002/erv.693 1

[7] M. L. Fiedler, E. Wolf, N. Döllinger, M. Botsch, M. E. Latoschik, and C. Wienrich. Embodiment and personalization for self-identification with virtual humans. In *Proc. VR (VRW)*, pp. 799–800. IEEE, 2023. doi: 10.1109/VRW58643.2023.00242 2, 4

[8] M. L. Fiedler, E. Wolf, C. Wienrich, and M. E. Latoschik. Holographic augmented reality mirrors for daily self-reflection on the own body image. In *CHI 2023 WS28 Integrating Individual and Social Contexts into Self-Reflection Technologies Workshop*, pp. 1–4, 2023. 2

[9] A. Genay, A. Lécuyer, and M. Hachet. Being an avatar "for real": A survey on virtual embodiment in augmented reality. *IEEE Transactions on Visualization and Computer Graphics*, 28(12):1–17, 2021. doi: 10.1109/TVCG.2021.3099290 2

[10] F. Hammerle, M. Huss, V. Ernst, and A. Bürger. Thinking dimensional: Prevalence of DSM-5 early adolescent full syndrome, partial and subthreshold eating disorders in a cross-sectional survey in german schools. *BMJ Open*, 6(5), 2016. doi: 10.1136/bmjopen-2015-010843 1

[11] M. Horne, A. Hill, T. Murrells, H. Ugail, D. Irving, R. Chinnadorai, and M. Hardy. Using avatars in weight management settings: A systematic review. *Internet Interventions*, 19:100295, 2020. doi: 10.1016/j.invent.2019.100295 2

[12] G. M. Hudson, Y. Lu, X. Zhang, J. Hahn, J. E. Zabal, F. Latif, and J. Philbeck. The development of a BMI-guided shape morphing technique and the effects of an individualized figure rating scale on self-perception of body size. *European Journal of Investigation in Health, Psychology and Education*, 10(2):579–594, 2020. doi: 10.3390/ejihpe10020043 2

[13] A. Keizer, A. van Elburg, R. Helms, and H. C. Dijkerman. A virtual reality full body illusion improves body image disturbance in anorexia nervosa. *PLOS ONE*, 11(10), 2016. doi: 10.1371/journal.pone.0163921 2

[14] F. Kern and M. E. Latoschik. Reality stack i/o: A versatile and modular framework for simplifying and unifying xr applications and research. In *2023 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct)*, pp. 74–76, 2023. doi: 10.1109/ISMAR-Adjunct60411.2023.00023 3

[15] B. Keshavarz and H. Hecht. Validating an efficient method to quantify motion sickness. *Human Factors*, 53(4):415–426, 2011. doi: 10.1177/0018720811403736 3, 4

[16] A. Keski-Rahkonen, H. W. Hoek, E. S. Susser, M. S. Linna, E. Sihvola, A. Raevuori, C. M. Bulik, J. Kaprio, and A. Rissanen. Epidemiology and course of anorexia nervosa in the community. *American Journal of Psychiatry*, 164(8):1259–1265, 2007. PMID: 17671290. doi: 10.1176/appi.ajp.2007.06081388 1

[17] K. Kilteni, R. Groten, and M. Slater. The sense of embodiment in virtual reality. *Presence: Teleoperators & Virtual Environments*, 21(4):373–387, 2012. doi: 10.1162/PRES_a_00124 2

[18] T. Legenbauer and S. Vocks. *Interventionen zur Veränderung des Körperbildes*, pp. 231–252. Springer Berlin Heidelberg, Berlin, Heidelberg, 2014. doi: 10.1007/978-3-642-20385-5_13 1

[19] N. Maalin, S. Mohamed, R. S. Kramer, P. L. Cornelissen, D. Martin, and M. J. Tovée. Beyond BMI for self-estimates of body size and shape: A new method for developing stimuli correctly calibrated for body composition. *Behavior Research Methods*, 53:1–14, 2020. doi: 10.3758/s13428-020-01494-1 2

[20] M. Magrini, O. Curzio, M. Tampucci, G. Donzelli, L. Cori, M. C. Imiotti, S. Maestro, and D. Moroni. Anorexia nervosa, body image perception and virtual reality therapeutic applications: State of the art and operational proposal. *International Journal of Environmental Research and Public Health*, 19(5), 2022. doi: 10.3390/ijerph19052533 2

[21] M. Matamala-Gomez, A. Maselli, C. Malighetti, O. Realdon, F. Mantovani, and G. Riva. Virtual body ownership illusions for mental health: A narrative review. *Journal of Clinical Medicine*, 10(1):139, 2021. doi: 10.3390/jcm10010139 2

[22] C. Merz, J. Tschanter, F. Kern, J.-L. Lugrin, C. Wienrich, and M. E. Latoschik. Pipelining processors for decomposing character animation. In *Proceedings of the 30th ACM Symposium on Virtual Reality Software and Technology*, VRST '24. Association for Computing Machinery, New York, NY, USA, 2024. doi: 10.1145/3641825.3689533 3

[23] C. Nimcharoen, S. Zollmann, J. Collins, and H. Regenbrecht. Is that me? – Embodiment and body perception with an augmented reality mirror. In *Proc. ISMAR (Adjunct)*, pp. 158–163. IEEE, New York, NY, USA, 2018. doi: 10.1109/ISMAR-Adjunct.2018.00057 2

[24] B. Porras-Garcia, M. Ferrer-García, E. Serrano, M. Roig, P. Soto-Usera, L. Olivares, N. Figueras-Puigderajols, and J. Gutiérrez-Maldonado. *Virtual Reality Body Exposure Therapy for Anorexia Nervosa. A Single Case Study*, pp. 108–115. Springer International Publishing, 2020. doi: 10.1007/978-3-030-50729-9_15 2, 3

[25] B. Porras-Garcia, E. Serrano-Troncoso, M. Carulla-Roig, P. Soto-Usera, M. Ferrer-Garcia, L. Fenandez-Del Castillo Olivares, N. Fugueras-Puigderrajols, I. D. Santos-Carrasco, B. Borszewski, M. Diaz-Marsa, and J. Gutierrez-Maldonado. Targeting the fear of gaining weight and body-related concerns in anorexia nervosa. preliminary findings from a virtual reality randomized clinical trial. In *Annual Review of Cybertherapy & Telemedicine*, pp. 223–227, 2020. 2

[26] B. Porras-Garcia, E. Serrano-Troncoso, M. Carulla-Roig, P. Soto-Usera, M. Ferrer-Garcia, N. Figueras-Puigderrajols, L. Yilmaz, Y. Onur Sen, N. Shojaeian, and J. Gutiérrez-Maldonado. Virtual reality body exposure therapy for anorexia nervosa. a case report with follow-up results. *Frontiers in Psychology*, 11, 2020. doi: 10.3389/fpsyg.2020.00956 2, 3

[27] G. Riva, J. Gutiérrez-Maldonado, A. Dakanalis, and M. Ferrer-García. Virtual reality in the assessment and treatment of weight-related disorders. In *Virtual reality for psychological and neurocognitive interventions*, pp. 163–193. Springer, 2019. doi: 10.1007/978-1-4939-9482-3_7 2

[28] G. Riva, C. Malighetti, and S. Serino. Virtual reality in the treatment of eating disorders. *Clinical Psychology & Psychotherapy*, 28(3):477–488, 2021. doi: 10.1002/cpp.2622 2

[29] K. M. Robinette, S. Blackwell, H. Daanen, M. Boehmer, and S. Fleming. Civilian american and european surface anthropometry resource (CEASAR). Technical report, Sytronics, 2002. doi: 10.21236/ada406704 3

[30] D. Roth and M. E. Latoschik. Construction of the virtual embodiment questionnaire (VEQ). *IEEE Transactions on Visualization and Computer Graphics*, 26(12):3546–3556, 2020. doi: 10.1109/TVCG.2020.3023603 4

[31] A. Salagean, E. Crellin, M. Parsons, D. Cosker, and D. Stanton Fraser. Meeting your virtual twin: Effects of photorealism and personalization on embodiment, self-identification and perception of self-avatars in virtual reality. In *Proc. CHI*. ACM, 2023. doi: 10.1145/3544548.3581182 2

[32] S. Serino, N. Polli, and G. Riva. From avatars to body swapping: The use of virtual reality for assessing and treating body-size distortion in individuals with anorexia. *Journal of Clinical Psychology*, 75(2):313–322, 2019. doi: 10.1002/jclp.22724 2

[33] A. Thaler, I. V. Piryankova, J. K. Stefanucci, S. Pujades, S. de la Rosa, S. Streuber, J. Romero, M. J. Black, and B. J. Mohler. Visual perception and evaluation of photo-realistic self-avatars from 3D body scans in males and females. *Frontiers in ICT*, 5, 2018. doi: 10.3389/fict.

2018.00018 2

[34] T. Waltemate, D. Gall, D. Roth, M. Botsch, and M. E. Latoschik. The impact of avatar personalization and immersion on virtual body ownership, presence, and emotional response. *IEEE Transactions on Visualization and Computer Graphics*, 24(4):1643–1652, 2018. doi: 10.1109/TVCG.2018.2794629 4

[35] E. Wolf, N. Döllinger, D. Mal, C. Wienrich, M. Botsch, and M. E. Latoschik. Body weight perception of females using photorealistic avatars in virtual and augmented reality. In *Proc. ISMAR*, pp. 583–594. IEEE, 2020. doi: 10.1109/ISMAR50242.2020.00071 2, 4

[36] E. Wolf, M. L. Fiedler, N. Döllinger, C. Wienrich, and M. E. Latoschik. Exploring presence, avatar embodiment, and body perception with a holographic augmented reality mirror. In *Proc. VR*, pp. 350–359. IEEE, 2022. doi: 10.1109/VR51125.2022.00054 2

[37] E. Wolf, D. Mal, V. Frohnapfel, N. Döllinger, S. Wenninger, M. Botsch, M. E. Latoschik, and C. Wienrich. Plausibility and perception of personalized virtual humans between virtual and augmented reality. In *Proc. ISMAR*, pp. 489–498. IEEE, 2022. doi: 10.1109/ISMAR55827.2022.00065 2