Long-term effects of imaginal retraining in overweight and obesity: A controlled study

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Keywords: imaginal retraining, overweight, obesity, approach bias, self-help, craving

Abstract

Background

Imaginal retraining (IR) is a self-help technique that targets automatic approach tendencies toward appetitive stimuli. In a randomized controlled trial (RCT; N=384), IR reduced craving for high-calorie foods after a six-week intervention period (small effect). The aim of the present study was to evaluate long-term effects of IR in this sample.

Methods

One year after baseline, participants from the initial RCT were recontacted. A visual analogue scale measuring craving, the Food Cravings Questionnaire-Trait-reduced (FCQ-T-r), the Three-Factor Eating Questionnaire, the Beck Depression Inventory, quality of life, and subjective appraisal of the intervention were assessed online. Participants were classified as users or nonusers based on self-reported usage of IR over the previous year.

Results

Linear-mixed models showed no significant interaction effects of time and group for any outcome (trend level effects were found for two subscales of the FCQ-T-r). Higher usage of IR was associated with greater symptom reduction. Although overall subjective appraisal of the intervention was comparably good to the initial study, usage of IR and completion rate were unsatisfactory.

Limitations

Main limitations of the present study include the nonrandomized group allocation and the low completion rate.

Conclusions

This study did not find evidence for the long-term efficacy of IR. Only upon high usage of IR, improvement was found. However, low completion rate and usage of the intervention may have resulted in a Type-II error. Future studies may consider low-intensity professional guidance to increase adherence and assess the long-term effects of IR in RCTs.

1. Introduction

Prevalence rates for overweight (body mass index (BMI) ≥ 25 < 30 kg/m²) and obesity (BMI ≥ 30 kg/m²) have been rising exponentially since the 1980s (The GBD 2015 Obesity Collaborators, 2017). In 2015, almost 40% of the world's population was overweight or obese (Chooi et al., 2019). Prevalence rates are especially high for women and for people living in Western regions, particularly in Europe and the USA (Chooi et al., 2019). Nevertheless, prevalence rates in developing countries are rising as well (The GBD 2015 Obesity Collaborators, 2017). Overweight and obesity are associated with an increased risk of various diseases such as cardiovascular diseases, chronic respiratory diseases, diabetes mellitus, and cancer (Peters et al., 2019; Upadhyay et al., 2018), the four major noncommunicable diseases worldwide (World Health Organization, 2019). In 2015, high BMI was associated with a total of 4 million deaths, representing 7.1% of global deaths (The GBD 2015 Obesity Collaborators, 2017). In addition to the physical consequences, overweight and obese individuals suffer from (self-)stigma, social rejection, and resulting psychopathologies (Puhl & Suh, 2015).

To achieve weight reduction, individuals use a variety of methods, such as dieting (Ruban et al., 2019) or enhanced physical activity (Swift et al., 2018). In some cases, bariatric surgery (Ceriani et al., 2019; Gloy et al., 2013) or pharmacological treatment (Bessesen & Van Gaal, 2018) is recommended. However, long-term maintenance of weight loss remains challenging, and the risk of weight regain is high (Dulloo & Montani, 2015; Ochner et al., 2013; Wing & Phelan, 2005). Research suggests that, besides interventions targeting direct changes in eating behavior, treatment programs aimed at indirectly changing behavior by modifying eating-related cognitions and cognitive biases are important determinants of weight loss maintenance (Varkevisser et al., 2019).

Cognitive biases associated with overweight and obesity often relate to an automatic approach behavior toward appetitive food cues (i.e., approach bias; Kakoschke et al., 2015;

Kemps et al., 2013; Kemps & Tiggemann, 2015). Dual-process models (e.g., Strack & Deutsch, 2004; for a review, see Houlihan, 2018) assume that human behavior results from the interplay of automatic and controlled processes. Automatic processing is mostly implicit, fast, and effortless, whereas controlled processing is conceptualized as explicit, slow, and effortful. According to this model, in overweight and obesity, predominantly automatic processing may facilitate the development of food cravings and impulsive approach tendencies to food cues, whereas predominantly controlled processing may favor more explicit decision-making processes, including the individual's will to (dis)engage from food cues as well as their insight into positive and negative consequences of food consumption. In line with this dual-process conceptualization of eating behavior in overweight and obesity, studies have shown that retraining automatic approach tendencies toward food cues by means of a computerized training program, the so-called approach bias modification (ABM; also referred to as approach avoidance training), reduces approach bias (Ferentzi et al., 2018; Kemps et al., 2013; Schumacher et al., 2016), unhealthy food choices (Kakoschke et al., 2017b), and food consumption (Schumacher et al., 2016).

In ABM, overweight and obese individuals are shown food-related and neutral pictures on a computer screen. By means of a joystick, they are asked to push away food-related pictures and pull neutral pictures toward themselves. Pictures in the push condition become larger and pictures in the pull condition become smaller on the screen. A recent meta-analysis showed that ABM improves approach bias and healthy eating behavior but does not reduce unhealthy eating behavior in overweight and obesity (Yang et al., 2019). Therefore, ABM could be an effective strategy to improve the ratio of healthy compared to unhealthy food consumption. All in all, laboratory studies mostly show favorable effects of ABM on approach bias toward food cues and eating behavior; clinical studies, however, often report mixed or null results (A. Jones et al., 2018; Kakoschke et al., 2017a).

One attempt to translate ABM outside the laboratory is the adaption of the basic principles of ABM to their use in the imagination by means of a self-help technique called imaginal retraining (Moritz et al., 2020; Moritz, Paulus, et al., 2019). In imaginal retraining, individuals are instructed to mentally push away individually appetitive but unhealthy food stimuli and to approach healthy ones (the intervention is described in detail in the methods section). The imaginal variant of ABM does not require a computer device to implement the technique in daily life, which is why we found this approach superior to the use of portable technology options like smartphones. In addition, imaginal retraining is less costly. Moreover, participants are involved in the training because they create their own mental imagery, which may foster treatment motivation and improve treatment outcome. This imaginal variant thus allows for individualization of training stimuli, which is especially important as overweight or obese individuals differ in the unhealthy foods they crave as well as in the ways they consume them. A randomized controlled trial on the efficacy of imaginal retraining in 384 overweight or obese women has previously been conducted (Moritz, Göritz, et al., 2019).. Participants in the intervention group received the manual of the self-help technique after completion of the baseline assessment via e-mail. The manual instructs participants to implement the exercises into their daily routine and exercise at least twice a day for a total of 10 minutes. After completion of the post assessment, participants of the waitlist control group also received access to the intervention manual via a download link on the last page of the survey. Findings showed a significant reduction of craving for high-calorie food in the intervention group compared to a waitlist control group. Moreover, individuals in the intervention group demonstrated greater weight loss at the end of the six-week intervention period, suggesting that imaginal retraining may be a promising novel variant of ABM for overweight or obese individuals. However, to date, no data has been assessed on long-term effects of the technique. The aim of the present study was to evaluate the long-term efficacy of imaginal

retraining in overweight or obese women in a one-year follow-up study of the RCT described above.

2. Methods

2.1 Design and procedure

We conducted a one-year follow-up assessment of an RCT on the efficacy of the self-help technique imaginal retraining in a six-week intervention period compared to a waitlist control group among overweight or obese women (Moritz, Göritz, et al., 2019). Individuals who participated in the initial study, which did not include the assessment of long-term effects, were recontacted via email one year after participation in the baseline assessment of the RCT and invited to participate in another study. The email provided information on the study and the link to the online follow-up survey, which was set up using the software Unipark® (EFS survey, Questback AS).

In the initial RCT, the intervention group was divided into one standard group and one group that received additional instructions on using electronic reminders to conduct the intervention on a regular basis. After completion of the post survey of the initial RCT, participants in the control group also received the imaginal retraining self-help manual. In the present one-year follow-up study, participants who of the initial RCT who reported having used the manual at least once in the previous year (users) were compared to those who reported not having used the intervention (nonusers). This categorization is based on studies reporting that a single session of imaginal retraining results in significant reductions of craving for cigarettes and high-calorie foods (Moritz et al., 2021; Wirtz et al., 2021). Similar effects were found for computer-based retraining and cognitive bias modification trainings after only a few training sessions (Luehring-Jones et al., 2017; Machulska et al., 2016; Wiers et al., 2011; Wittekind et al., 2015). However, this post-hoc group allocation did not allow participants to be sampled independently and randomly in the one-year follow-up study. For

their participation in the follow-up study, participants were rewarded with a self-help manual on relaxation techniques.

The local ethics committee for psychologists at the University Medical Center Hamburg-Eppendorf (Germany) approved both the initial RCT (LPEK-0030) and the follow-up study (LPEK-0104), both of which were conducted in accordance with the Declaration of Helsinki. Moreover, both studies were preregistered (DRKS00017220, DRKS00021044) in the German Clinical Trials Register.

2.2 Participants

The 384 individuals in the initial RCT were eligible for participation in the one-year follow-up survey. Primary initial inclusion criteria were age between 18 and 75 years, a BMI > 25 kg/m² (calculated based on self-reported weight and height), and no history of anorexia or bulimia nervosa. Additional information on inclusion criteria and recruitment strategies is in the initial study (Moritz, Göritz, et al., 2019).

2.3 Intervention

Like ABM, imaginal retraining consists of two parts: one in which appetitive stimuli are to be avoided and one in which neutral stimuli are to be approached. In imaginal retraining, these operations are transferred to the imagination, thus obviating the need for a computer. The avoidance sequence starts with the imagination of the participant's favorite high-calorie food and their preferred way of consuming it, followed by a negative mood induction (i.e., exhaling, bending forward with rounded shoulders, and evoking negative thoughts) to establish aversive associations with the appetitive stimuli. Next, participants are told to push away the high-calorie food in their imagination as well as with an actual arm movement. In the approach sequence, healthy foods are imagined, followed by a positive mood induction (i.e., standing up straight and evoking positive thoughts). Next, participants are instructed to move the healthy food toward their mouth and consume it while looking

slightly upwards. Again, this movement should be carried out in their imagination accompanied by actual body movements. A more detailed description of the self-help technique, including illustrations of the two sequences, can be found in the initial study (Moritz, Göritz, et al., 2019).

2.4 Outcomes

2.4.1 Primary Outcome

A visual analogue scale for craving (VAS) assessed participants' craving for high-calorie foods during the previous week. Three items (strength of craving in non-eating phases, strongest craving, and frequency of craving) were answered on a scale ranging from 0 (not at all/never) to 100 (very strong/always). The mean score of the three VAS items served as the primary outcome, with higher scores indicating greater craving. This VAS has been used in previous studies on imaginal retraining (Moritz et al., 2020; Moritz, Göritz, et al., 2019; Moritz, Paulus, et al., 2019). Internal consistency in the present study was Cronbach's $\alpha = .85$.

2.4.2 Secondary Outcomes

The Food Cravings Questionnaire-Trait-reduced (FCQ-T-r; Meule, Hermann, et al., 2014) is a 15-item reduced version of the Food Cravings Questionnaire-Trait (Cepeda-Benito et al., 2000) that assesses food craving on five subscales: "lack of control over eating" (five items), "thoughts or preoccupation with food" (five items), "intentions to consume food" (two items), "emotions prior to or during craving for food" (two items), and "triggers for food craving" (one item). As proposed by Hormes and Meule, we used a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*) with total scores ranging from 15 to 75 (Hormes & Meule, 2016). In previous studies, the FCQ-T-r showed high internal consistency (Cronbach's $\alpha = .94$) and was correlated with other food craving questionnaires, restrictive eating, symptoms of eating disorder, and impulsivity (Hormes & Meule, 2016). Test-retest-reliability of the questionnaire was good (Meule, Teran, et al., 2014). Internal consistency of the total

measure (Cronbach's α = .95) as well as the subscales (Cronbach's α = .79 – .92) was good to excellent in the current study.

The Three-Factor Eating Questionnaire (Fragebogen zum Essverhalten, FEV; Pudel & Westenhöfer, 1989), the German version of the commonly used English Three-Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985), is a self-report scale with three subscales: "cognitive restraint" (21 items), "disinhibition" (16 items), and "hunger" (14 items). The first subscale assesses cognitive control over eating behavior, with high scores reflecting restrictive eating patterns aimed at weight reduction and low scores representing spontaneous eating behavior regulated by internal signals of autonomic appetite and satiety regulation. According to Pudel and Westenhöfer (1989), cognitive restraint is associated with lower food intake and is a facilitating factor in successful weight reduction but at the same time has been found to be a risk factor for the development of eating disorders and is correlated with ravenous appetite, stress-related eating, and craving. Therefore, neither a high nor a low value is considered beneficial. The second subscale assesses disinhibition of control due to situational factors. High scores indicate high disinhibition of control, which is associated with higher food intake. The third subscale measures subjective feelings of hunger and their impact on eating behavior. High scores indicate intense, disturbing feelings of hunger, which raise motivation to increase food intake. The German version has demonstrated high validity and a Cronbach's α of 0.74–0.87 (Pudel & Westenhöfer, 1989). In the present study, internal consistency for the subscales was Cronbach's α = .78 – .80.

The Beck Depression Inventory II (BDI-II; Beck et al., 1996) is a 21-item self-report measure assessing depressive symptoms. Scores range from 0 to 63 (0–8 no depression, 9–13 minimal, 14–19 mild, 20–28 moderate, 29–63 severe). The German version showed high internal consistency and good test-retest reliability in a previous study (Kühner et al., 2007). In the present study, internal consistency was Cronbach's α = .92.

To assess quality of life, the global item of the World Health Organization Quality of Life (WHOQOL-BREF; The WHOQOL Group, 1998)—"How would you rate your quality of life?"—is answered on a 5-point Likert scale ranging from *very bad* to *very good*.

Treatment satisfaction was assessed Patient Satisfaction Questionnaire (German acronym ZUF-8; Schmidt & Wittmann, 2002) which previously showed good reliability and validity (Kriz et al., 2008; Schmidt et al., 1989).

Subjective appraisal of imaginal retraining was measured using nine times (e.g., suitability for self-help, comprehensibility, applicability to eating behavior) on a 5-point scale (1 *does not apply* at all to 5 *absolutely applies*).

Lastly, participants were asked to indicate whether they experienced any changes in their eating behavior ("How has your eating behaviour changed in the previous 12 months?") or weight ("How has your body weight changed in the previous 12 months?"). Changes in eating behavior could be indicated as follows: (1) I ate a lot less, (2) I ate less, (3) I ate the same amount, (4) I ate more, (5) I ate a lot more. In terms of weight, participants were asked to indicate whether they had gained weight, lost weight or had no change in weight. A numerical indication of the change in weight was optional.

At the baseline assessment of the initial RCT, participants' readiness for change was measured by means of a subset of the German version of the University of Rhode Island Change Assessment Scale (URICA; German version: FEVER) (Hasler et al., 2003). Moreover, participants were asked to rate their treatment expectations on a nine-point scale (1 = *not at all successful* to 9 = *very successful*). Readiness for change and treatment expectations were not assessed in the follow-up survey but were used to compare sample characteristics of users and nonusers. Further information on these measures can be found in the initial RCT (Moritz, Göritz, et al., 2019).

2.5 Statistical methods

We performed linear mixed effects models (LMM) using IBM SPSS 26 ® to analyze changes in outcomes from baseline to one-year follow-up. We used a model with a two-level structure (level 1: individual change in outcomes, level 2: group). Significant baseline differences between users and non-users of the intervention were integrated in the model as fixed covariates. Parameters were estimated using restricted maximum-likelihood estimation (REML). We tested all different covariance structures for repeated measures and random effects in SPSS and identified those with the best model fit using likelihood ratio tests. For each outcome, a model with random intercept and time, group, and time/group interaction as predictors was compared to a model including an additional random slope. We identified the final model for each outcome using likelihood ratio tests. Analyses were conducted for the original group allocation of the RCT (intervention group compared to waitlist control group) as well as the usage-based group allocation (users compared to nonusers).

3. Results

3.1 Completion rate and usage

Out of the 384 women who took part in the initial study, 45.3% (n = 174) completed the one-year follow-up assessment. Approximately half of the participants (55.2%) did not use imaginal retraining in the previous year; 29.2% of these did not read the manual at all. Of the 44.8% who used the technique at least once, about one third (32.1%) performed imaginal retraining at least once a month. On average, users conducted the training exercises on 24.28 days (SD = 48.84) days in the previous year. One half of participants (50.0%, n = 87) of the follow-up study was originally allocated to the waitlist control group of the initial RCT and the other half to the intervention group (50.0%, n = 87; 24.7% received additional electronic reminders).

3.2 Baseline characteristics

Table 1 displays group differences for users compared to nonusers in in the follow-up sample regarding sociodemographic characteristics, eating-related measures, psychological well-being, motivation for change, and treatment expectation assessed at baseline of the initial RCT. Users showed a higher strength of craving and higher scores on the FCQ-T-r subscales lack of control, intentions, and action as well as the total score. Moreover, users showed elevated scores on the URICA scales contemplation and action, mapping a stronger readiness for change compared to nonusers.

3.3 Changes in eating behavior and weight from baseline to follow-up

At the one-year follow-up assessment, 25.9% of participants reported having eaten less, 9.8% reported having eaten more, and 60.9% reported no change in their food consumption in the previous year (2.9% did not provide information). Weight loss in the previous year was reported by 27.6% of the sample (M = 7.33 kg, SD = 14.08), while 35.6% reported weight gain (M = 7.39 kg, SD = 7.71). About one third (36.8%) experienced no weight change. Other measures than imaginal retraining for weight reduction from baseline to follow-up assessment were used by 37.9% of the sample; of these, 39.4% implemented a change of diet, 33.3% started or increased physical activity, 21.2% combined both, and 6.1% used other strategies.

Independent-sample t-tests and chi-square tests did not show any significant differences between users and nonusers in self-reported changes in eating behavior or weight as well as utilization of interventions other than imaginal retraining in the previous year.

3.4 Group differences in symptom change over time for users compared to nonusers

No significant interaction effects of group and time were found for any primary or secondary outcome (see Table 2) indicating no differences in symptom change over time between users and nonusers of imaginal retraining. However, interaction effects at a statistical trend level in favor of the user group were found for the FCQ-T-r subscales lack of control

over eating (B = −0.020, SE = 0.011, t(171.647) = −1.748, p = .082, [−0.042; 0.003]) and thoughts/preoccupation with food (B = −0.023, SE = 0.013, t(199.020) = −1.834, p = .068, [−0.048; 0.002]). Surprisingly, a trend effect in favor of the nonuser group was found for quality of life (B = −0.004, SE = 0.002, t(329,558) = −1.842, p = .066, [−0.008; 0.0003]).

We calculated dosage effects by correlating frequency of use in the previous year with difference scores in all outcomes from baseline to follow-up assessment. For the FCQ-T-r total score (r_s = −.182, p = .017) as well as the subscales lack of control over eating (r_s = −.229, p = .002), thoughts/preoccupation with food (r_s = −.172, p = .023), and intentions to consume food (r_s = −.210, p = .005), significant correlations were found, indicating that higher frequency of usage of the intervention was associated with greater symptom reduction on these measures from baseline to one-year follow-up assessment. Moreover, higher frequency of usage was associated with higher scores on the FEV subscale cognitive restraint at follow-up at trend level (r_s = .148, p = .052), representing more restrictive and controlled eating patterns aimed at weight reduction. For the VAS, no dosage effect was found.

3.5 Group differences in symptom change over time for intervention compared to waitlist control group

The initial intervention and waitlist control group did not differ on baseline demographics, eating scales, psychological well-being and treatment motivation (see supplementary material 1). No significant interaction effects of group and time were found for any primary or secondary outcome (see Table 3) indicating no differences in symptom change over time between the intervention group and the control group of the preceding RCT. Interaction effects at statistical trend level favoring the waitlist control group were found for the FCQ-T-r total score (B = 0.050, SE = 0.030, t(328.653) = 1.689, p = .092, [−0.008; 0.109]) as well as the subscale thoughts/preoccupation with food (B = 0.021, SE = 0.012, t(173.097) = 1.707, p = .090, [−0.003; 0.046]).

3.6 Subjective appraisal and satisfaction with treatment

Participants' endorsement of ZUF-8 items and positive appraisal are displayed in Tables 4 and 5. We comment on these items here if scores from the initial study (Moritz, Göritz, et al., 2019) differed from scores in the follow-up assessment by more than 10%. Endorsement of ZUF-8 items was comparable to the initial study. Regarding subjective appraisal, only 37.2% of participants used the manual on a regular basis in the previous year compared to 55.3% of participants in the imaginal retraining group and 70.5% of participants in the imaginal retraining with reminders group in the initial RCT. Fewer participants reported a subjective reduction in high-calorie food consumption because of the application of the intervention in the follow-up study (60.2%) compared to those who received imaginal retraining with reminders in the initial trial (79.5%). Moreover, in the present study, 94.9% endorsed the statement that imaginal retraining would make more sense if it were used in combination with psychotherapy, which differed from the endorsement of participants in the imaginal retraining group (without reminders) in the initial study (81.6%).

3.7 Group differences between completer and non-completer of the follow-up assessment

As only 45.3% of the sample of the initial RCT participated in the follow-up study, we conducted unpaired two-sampled *t*-tests on baseline and post-intervention variables between completers and non-completers of the follow-up assessment to evaluate the selectivity of our sample. No differences between completers and non-completers of the follow-up assessment emerged for the baseline variables BMI ($p > .1$), subjective appraisal of (all ps $> .1$) and satisfaction with the intervention (all ps $> .07$) at post-assessment, baseline as well as post-intervention craving and depressive symptoms (all ps $> .4$), as well as treatment expectations ($p > .1$). However, completers reported significantly higher scores on the URICA subscale action ($t(382) = 2.30$, $p = .022$, $d = 0.24$) and non-completers reported significantly higher

scores on the URICA subscale precontemplation ($t(382) = 2.78$, $p = .006$, $d = 0.29$) with small effect sizes indicating that readiness for change was slightly higher in completers.

4 Discussion

4.1 Main findings

The present study was conducted as a one-year follow up of an RCT on the efficacy of imaginal retraining in overweight or obese women (Moritz, Göritz, et al., 2019). No significant group differences were found for the primary (craving for high-calorie food, VAS) and secondary outcomes speaking against the long-term efficacy of imaginal retraining in this population. However, the low completion rate (45.3%) as well as the low use of the intervention (less than half of participants used the technique and only one third of the user sample applied the technique at least on a monthly basis) may have resulted in a reduced power and a Type-II error. In contrast, a similar follow-up study evaluating the long-term efficacy of IR for smoking cessation suggests that participants who had used the technique in the previous year reported greater reductions in craving compared to those who did not use the technique (Gehlenborg et al., 2021). This is in line with meta-analyses on computer-based ABM supporting its long-term efficacy only in substance-use populations (E. B. Jones & Sharpe, 2017).

The subjective appraisal of the intervention was good and comparable to the initial study. For example, about three quarters of the user sample would recommend the technique and about 60% stated that the intervention helped them reduce their high-calorie eating behavior. Yet, compared to the initial RCT, fewer participants used the manual regularly in the previous year and more participants stated that the intervention should be used in combination with psychotherapy. This is in line with research showing that guided self-help interventions in eating disorders are more effective and result in higher adherence compared to unguided ones (Kass et al., 2014; Loeb et al., 2000). Therefore, the integration of

professional guidance, such as by motivational booster sessions via telephone or video calls from a professional, may be a promising addition to the imaginal training technique and should be evaluated in future studies. Increasing the frequency of use of the self-help technique may be especially important as we found dosage effects for a variety of outcomes in this follow-up study (namely, FCQ-T-r total, FCQ-T-r lack of control over eating, FCQ-T-r thoughts/preoccupation with food, FCQ-T-r intentions to consume food, FEV cognitive restraint), indicating that a higher usage of the intervention is associated with greater symptom reduction.

4.2 Limitations

Our study faces some limitations that need to be acknowledged in the interpretation of the findings. First, group allocation in the follow-up study was not randomized as in the initial trial but was based on self-reported usage of the intervention in the previous year (all participants had received the self-help manual after the six-week intervention period and the following post assessment). This nonrandomized post-hoc group allocation may have resulted in baseline differences between the groups that impacted usage of the intervention and symptom change from baseline to follow-up assessment. In fact, we found that users compared to nonusers reported stronger craving as well as higher readiness for change at baseline, which may have resulted in stronger symptom reductions at follow-up. Moreover, due to the different group allocation, findings of the follow-up assessment cannot be directly compared to findings of the initial RCT.

Second, only 45.3% of the initial RCT's participants took part in the follow-up study. This self-selected participation may have biased study results in unknown ways. However, comparisons of completers and non-completers of the follow-up assessment indicated only slight differences in readiness for change and no differences on weight-related and psychopathological measures at baseline or post assessment. Moreover, subjective appraisal

of imaginal retraining and satisfaction with treatment was comparable between completers and non-completers.

Third, we did not measure approach bias. Future studies should examine the impact of imaginal retraining on approach bias for high-calorie foods using computerized assessments such as the approach avoidance task (e.g., Lender et al., 2018). Finally, we used self-report measures in the initial RCT as well as in the present one-year follow-up study. Using expert rating scales and implicit measures in future studies may allow for more differentiated conclusions on the efficacy of and mechanisms of change in imaginal retraining.

Fourth, besides several advantages of the imagery version of ABM compared to a computerized variant that we pointed out throughout the manuscript, a self-administration of the intervention may also reduce internal validity as it does not ensure that the exercises are carried out accurately. However, this applies to all self-help interventions. Furthermore, this limitation was addressed by standardized delivery of the intervention using a video tutorial that could be watched repeatedly.

Fifth, the initial RCT included participants with the subjective desire to reduce their cravings for high-calorie foods. However, we did not assess participant's initial motivation to join the study in more detail. Future studies should assess the specific aims and goals of participants joining imaginal retraining as this might have an effect on the efficacy of the intervention.

Lastly, as more than 95% of users indicated that the manual would make more sense in combination with psychotherapy, future studies should investigate the efficacy of imaginal retraining in combination with face-to-face psychotherapy.

4.3 Conclusion

The present study does not report evidence for the long-term efficacy of imaginal retraining for overweight and obesity. Only upon high usage of IR, improvement was found.

However, low completion rate and usage of the intervention may have resulted in a Type-II error. Findings on patients' acceptance of the intervention were promising. Future studies on imaginal retraining should incorporate professional guidance or electronic reminders to increase adherence and assess the long-term effects of the intervention in RCTs. We should also pursue the question if IR is better suited for substance use disorders (e.g., tobacco, alcohol) than overeating and relatedly whether the effects are greater if abstinence from the problem substance can be completely achieved as in smoking and alcohol consumption unlike eating.

Table 1

Group differences in baseline demographics, eating scales, psychological well-being and treatment motivation in the initial study. Means (M) and standard deviations (SD, in parentheses).

Variable	Full Sample (N = 174)	Users (n = 78)	Nonusers (n = 96)	Statistics
Baseline characteristics				
Age in years	49.48 (10.93)	49.21 (11.00)	49.70 (10.92)	$t(172) = 0.30$, $p = .768$
Height in cm	165.52 (6.65)	166.26 (7.34)	164.93 (5.99)	$t(172) = -1.32$, $p = .190$
Weight in kg	90.24 (18.12)	90.92 (18.40)	89.68 (17.97)	$t(172) = -0.45$, $p = .655$
BMI	32.92 (6.31)	32.92 (6.54)	32.92 (6.14)	$t(172) < 0.01$, $p = .997$
Obesity (BMI ≥ 25 < 30/ BMI ≥ 30 < 35/ BMI ≥ 35) in %	41.4/28.7/29.9	41.0/28.2/30.8	41.7/29.2/29.2	$\chi^2(2) = 0.06$, $p = .973$
Eating scales				
VAS	56.84 (24.17)	61.58 (22.06)	52.99 (25.21)	$t(172) = -2.36$, $p = .019$
FCQ-T-R Total	46.58 (14.15)	49.12 (15.09)	44.52 (13.06)	$t(172) = -2.15$, $p = .033$
FCQ-T-R Lack of control	16.61 (5.15)	17.62 (5.37)	15.80 (4.84)	$t(172) = -2.34$, $p = .020$
FCQ-T-R Thoughts/ preoccupation	13.20 (5.64)	13.92 (6.20)	12.61 (5.10)	$t(148.57) = -1.50$, $p = .136$
FCQ-T-R Intentions	6.30 (2.23)	6.73 (2.37)	5.96 (2.06)	$t(153.62) = -2.26$, $p = .025$
FCQ-T-R Emotions	6.76 (2.44)	6.95 (2.67)	6.60 (2.25)	$t(172) = -0.92$, $p = .357$
FCQ-T-R Triggers	3.70 (1.16)	3.90 (1.05)	3.54 (1.23)	$t(171.54) = -2.06$, $p = .041$
FEV Cognitive restraint	8.39 (4.18)	8.73 (4.49)	8.11 (3.90)	$t(172) = -0.97$, $p = .335$
FEV Disinhibition	9.46 (3.72)	9.95 (3.62)	9.06 (3.77)	$t(172) = -1.57$, $p = .118$
FEV Hunger	7.17 (3.46)	7.68 (3.56)	6.75 (3.33)	$t(172) = -1.77$, $p = .078$
Psychological well-being				
BDI	14.26 (10.06)	15.62 (10.55)	13.16 (9.56)	$t(172) = -1.61$, $p = .109$
WHOQOL	3.52 (0.89)	3.46 (0.99)	3.56 (0.81)	$t(147.56) = 0.73$, $p = .469$
Motivation and expectations				
URICA Precontemplation	2.10 (0.75)	2.03 (0.78)	2.15 (0.73)	$t(172) = 0.98$, $p = .330$
URICA Contemplation	4.07 (0.81)	4.24 (0.72)	3.93 (0.85)	$t(172) = -2.62$, $p = .010$
URICA Action	3.97 (0.69)	4.12 (0.68)	3.85 (0.69)	$t(172) = -2.59$, $p = .010$
CEQ	5.57 (1.81)	5.45 (1.90)	5.67 (1.74)	$t(172) = .789$, $p = .431$

Notes. BMI: Body Mass Index; BDI-II: Beck Depression Inventory (second version); CEQ: Credibility Expectancy Questionnaire; FCQ-T-R: Food Cravings Questionnaire-Trait-reduced; FEV: Three-Factor Eating Questionnaire; URICA: University of Rhode Island Change Assessment Scale; VAS: Visual Analogue Scale; WHOQOL: Global item of the WHOQOL-BREF.

Table 2

Symptom change over time for users compared to nonusers

Variable		Baseline	Post	Follow-Up	Group*time interaction
VAS	Users	61.58 (22.06)	52.69 (20.07)	57.05 (20.19)	$B = -0.072$, $SE = 0.069$, $t(281.886) = -1.054$, $p = .293$, [−0.207; 0.063]
	Nonusers	52.99 (25.21)	47.03 (21.68)	53.65 (20.51)	
Weight	Users	90.92 (18.32)	90.41 (18.55)	88.19 (18.70)	$B = -0.029$, $SE = 0.019$, $t(177.671) = -1.542$, $p = .125$, [−0.066; 0.008]
	Nonusers	89.68 (17.91)	88.48 (17.63)	88.51 (17.77)	
FCQ-T-r total	Users	49.12 (15.09)	44.32 (15.80)	42.05 (15.84)	$B = -0.042$, $SE = 0.036$, $t(273.030) = -1.173$, $p = .242$, [−0.113; 0.029]
	Nonusers	44.52 (13.06)	43.16 (13.44)	41.22 (13.17)	
FCQ-T-r lack of control	Users	17.62 (5.37)	15.60 (5.67)	14.97 (6.03)	$B = -0.020$, $SE = 0.011$, $t(171.647) = -1.748$, $p = .082$, [−0.042; 0.003]
	Nonusers	15.80 (4.84)	15.07 (4.89)	14.72 (5.09)	
FCQ-T-r thoughts/preoccupation	Users	13.92 (6.20)	12.88 (6.04)	11.50 (5.57)	$B = -0.023$, $SE = 0.013$, $t(199.020) = -1.834$, $p = .068$, [−0.048; 0.002]
	Nonusers	12.61 (5.10)	12.57 (5.35)	11.79 (4.86)	
FCQ-T-r intentions	Users	6.73 (2.37)	5.99 (2.35)	5.77 (2.43)	$B = -0.008$, $SE = 0.005$, $t(172.356) = -1.635$, $p = .104$, [−0.018; 0.002]
	Nonusers	5.96 (2.06)	5.88 (2.13)	5.66 (2.05)	
FCQ-T-r emotions	Users	6.95 (2.67)	6.53 (2.61)	6.42 (2.56)	$B = 0.005$, $SE = 0.006$, $t(197.397) = 0.843$, $p = .400$, [−0.006; 0.015]
	Nonusers	6.60 (2.25)	6.34 (2.31)	5.90 (2.26)	
FCQ-T-r triggers	Users	3.90 (1.05)	3.32 (1.21)	3.38 (1.31)	$B < -0.001$, $SE = 0.003$, $t(206.153) = -0.064$, $p = .949$, [−0.007; 0.006]
	Nonusers	3.54 (1.23)	3.30 (1.11)	3.16 (1.14)	
FEV cognitive restraint	Users	8.73 (4.49)	10.07 (4.81)	10.19 (4.50)	$B = 0.011$, $SE = 0.010$, $t(329.659) = 1.152$, $p = .250$, [−0.008; 0.031]
	Nonusers	8.11 (3.90)	8.27 (4.10)	8.51 (3.96)	
FEV disinhibition	Users	9.95 (3.62)	8.56 (3.75)	8.42 (3.91)	$B = 0.013$, $SE = 0.008$, $t(173.572) = 0.167$, $p = .868$, [−0.014; 0.017]
	Nonusers	9.06 (3.77)	8.47 (3.52)	7.88 (3.87)	
FEV hunger	Users	7.68 (3.56)	6.75 (3.67)	6.71 (3.76)	$B = 0.005$, $SE = 0.008$, $t(329.532) = 0.637$, $p = .524$, [−0.011; 0.021]
	Nonusers	6.75 (3.33)	6.86 (3.46)	5.92 (3.45)	
BDI-II	Users	15.62 (10.55)	13.05 (10.02)	13.54 (10.02)	$B = 0.004$, $SE = 0.018$, $t(258.757) = 0.199$, $p = .842$, [−0.032; 0.040]
	Nonusers	13.16 (9.56)	10.80 (9.44)	10.99 (9.21)	

WHOQOL	Users	3.46 (0.99)	3.56 (0.82)	3.44 (0.91)	$B = -0.004$, $SE = 0.002$, $t(329.558) = -1.842$, $p = .066$, [−0.008;
	Nonusers	3.56 (0.81)	3.63 (0.79)	3.72 (0.75)	0.0003]

Notes. Means and standard deviations (in brackets). Results of linear mixed effects models (group*time interaction) with unstandardized regression coefficients (*B*), standard error (*SE*), *t*-statistics, and confidence intervals. BDI-II: Beck Depression Inventory (second version); FCQ-T-r: Food Cravings Questionnaire-Trait-reduced; FEV: Three-Factor Eating Questionnaire; VAS: Visual Analogue Scale; WHOQOL: Global item of the WHOQOL-BREF. Controlled for: baseline scores on URICA contemplation, URICA action, FCQ-T-r, and VAS.

Table 3

Symptom change over time for intervention group (IG) compared to waitlist control group (WLC)

Variable		Baseline	Post	Follow-Up	Group*time interaction
VAS	IG	57.24 (22.35)	49.52 (20.20)	55.63 (20.45)	$B = 0.008$, $SE = 0.059$, $t(228.365) = 0.139$, $p = .889$, [−0.107; 0.123]
	WLC	56.44 (25.98)	49.83 (21.98)	54.71 (20.41)	
Weight	IG	90.73 (20.02)	90.14 (19.76)	89.06 (19.50)	$B = 0.006$, $SE = 0.019$, $t(176.984) = 0.302$, $p = .763$, [−0.032 0.043]
	WLC	89.74 (15.95)	88.66 (16.29)	57.67 (16.76)	
FCQ-T-r total	IG	46.54 (14.19)	42.08 (14.12)	42.29 (14.89)	$B = 0.050$, $SE = 0.030$, $t(328.653) = 1.689$, $p = .092$, [−0.008; 0.109]
	WLC	46.62 (14.19)	45.24 (14.88)	40.90 (13.93)	
FCQ-T-r lack of control	IG	16.71 (5.10)	14.74 (5.00)	15.10 (5.63)	$B = 0.017$, $SE = 0.011$, $t(328.587) = 1.459$, $p = .145$, [−0.006; 0.039]
	WLC	16.52 (5.22)	15.88 (5.48)	14.56 (5.42)	
FCQ-T-r thoughts/preoccupation	IG	12.94 (5.81)	12.17 (5.46)	11.84 (5.35)	$B = 0.021$, $SE = 0.012$, $t(173.097) = 1.707$, $p = .090$, [−0.003; 0.046]
	WLC	13.46 (5.48)	13.23 (5.85)	11.48 (5.02)	
FCQ-T-r intentions	IG	6.33 (2.25)	5.67 (2.17)	5.78 (2.36)	$B = 0.006$, $SE = 0.005$, $t(329.046) = 1.061$, $p = .289$, [−0.005; 0.016]
	WLC	6.28 (2.23)	6.18 (2.27)	5.63 (2.09)	
FCQ-T-r emotions	IG	6.92 (2.46)	6.36 (2.41)	6.28 (2.42)	$B = 0.002$, $SE = 0.005$, $t(329.778) = 0.439$, $p = .661$, [−0.008; 0.013]
	WLC	6.60 (2.23)	6.50 (2.49)	5.63 (2.09)	
FCQ-T-r triggers	IG	3.63 (1.24)	3.14 (1.19)	3.29 (1.22)	$B = 0.005$, $SE = 0.003$, $t(328.874) = 1.617$, $p = .107$, [−0.001; 0.011]
	WLC	3.77 (1.09)	3.46 (1.11)	3.23 (1.23)	
FEV cognitive restraint	IG	8.16 (4.33)	9.33 (4.35)	8.90 (4.42)	$B = -0.012$, $SE = 0.010$, $t(329.802) = -1.185$, $p = .237$, [−0.031; 0.008]
	WLC	8.62 (4.03)	8.90 (4.70)	9.63 (4.12)	
FEV disinhibition	IG	9.31 (3.89)	8.16 (3.57)	7.99 (3.87)	$B = 0.004$, $SE = 0.008$, $t(328.314) = 0.470$, $p = .638$, [−0.012; 0.019]
	WLC	9.61 (3.56)	8.85 (3.67)	8.25 (3.92)	

FEV hunger	IG	6.92 (3.34)	6.32 (3.33)	6.03 (3.59)	$B = 0.004$, $SE = 0.008$, $t(328.457) = 0.496$, $p = .620$, [−0.012; 0.020]
	WLC	7.41 (3.57)	7.28 (3.71)	6.51 (3.62)	
BDI-II	IG	14.32 (9.40)	11.70 (9.29)	12.13 (8.83)	$B = 0.008$, $SE = 0.018$, $t(258.502) = 0.451$, $p = .653$, [−0.028; 0.044]
	WLC	14.20 (10.73)	12.00 (10.22)	12.14 (10.44)	
WHOQOL	IG	3.57 (0.84)	3.62 (0.71)	3.63 (0.85)	$B < -0.001$, $SE = 0.002$, $t(329.282) = -0.075$, $p = .940$, [−0.004; 0.004]
	WLC	3.46 (0.94)	3.57 (0.88)	3.55 (0.82)	

Notes. Means and standard deviations (in brackets). Results of linear mixed effects models (group*time interaction) with unstandardized regression coefficients (*B*), standard error (*SE*), *t*-statistics, and confidence intervals. BDI-II: Beck Depression Inventory (second version); FCQ-T-r: Food Cravings Questionnaire-Trait-reduced; FEV: Three-Factor Eating Questionnaire; VAS: Visual Analogue Scale; WHOQOL: Global item of the WHOQOL-BREF. Controlled for: baseline scores on URICA contemplation, URICA action, FCQ-T-r, and VAS. All participants received access to the intervention after completion of the post survey of the randomized controlled trial (prior to the follow-up assessment).

Table 4

Satisfaction with Imaginal Retraining (adapted version of the Patient Satisfaction Questionnaire; ZUF-8)

	User (n = 78)	
Item	Mean (SD)	Positive appraisal
How do you rate the quality of the manual? (excellent (1), good (2) vs. less good (3), not good (4))	2.03 (0.57)	77.0%
Did you receive the type of treatment you expected to receive? (not at all (1), not really (2) vs. in general yes (3), yes absolutely (4))	2.63 (0.81)	53.9%
To what extent did the manual meet your needs? (it nearly met all my needs (1), it met most of my needs (2) vs. it met a few of my needs (3), it did not meet my needs (4))	2.48 (0.80)	48.7%
Would you recommend the manual to a friend with similar symptoms? (definitely not (1). probably not (2) vs. probably yes (3), absolutely (4))	3.13 (0.90)	74.3%
How happy are you about the extent of the help you have received through using the manual? (dissatisfied (1), somewhat dissatisfied (2) vs. mostly satisfied (3), very satisfied (4))	2.92 (0.79)	65.8%
Did the manual help you cope with your problems more successfully? (yes, it helped me absolutely (1), yes, it helped me a little (2) vs. no, it did not help me that much (3), no, it did not help me at all (4))	2.20 (0.59)	62.8%
How satisfied are you with the manual in general? (very satisfied (1), mostly satisfied (2) vs. somewhat unsatisfied (3), unsatisfied (4))	2.14 (0.70)	69.3%
Would you use the manual again? (definitely not (1), probably not (2) vs. probably yes (3), yes (4))	2.89 (0.99)	64.1%

Table 5

Subjective appraisal of Imaginal Retraining for consumption of high-calorie food

	Users (n = 78)	
Item	Mean (SD)	Endorsement in % (absolutely applies through applies a little)
I think the manual is good for self-help and self-guidance.	2.92 (0.82)	97.4%
My consumption of high-calorie food decreased because of the application of the program.	1.87 (0.90)	60.2%
I think the content of the manual was comprehensible.	3.44 (0.68)	98.7%
I think the manual was helpful.	2.73 (1.03)	85.9%
I was able to use the manual on a regular basis.	1.47 (0.72)	37.2%
I had to force myself to use the manual.	2.64 (1.08)	80.8%
I think the manual would make more sense if it were used in combination with psychotherapy.	2.91 (0.87)	94.9%
The manual is not applicable to my eating behavior.	1.95 (1.04)	56.4%
I ate less high-calorie food because of the manual.	1.94 (0.97)	59.0%

Notes. Scores range from 1 (does not apply at all) to 4 (absolutely applies)

Conflict of Interest Statement

S.M. and S.K. developed the imaginal retraining technique. The authors have no further conflict of interest to declare.

Funding Sources

The study was funded by overhead sources and a research grant of the European Union (ERC-2016-StG-Self-Control-677804). The funding source had no involvement in study design, in the collection, analysis, and interpretation of data, in writing the report and in the decision to submit the article for publication.

Statement of Ethics

The local ethics committee for psychologists at the University Hospital Hamburg-Eppendorf, Germany approved the research project (LPEK-0104). Moreover, the project was conducted in accordance with the World Medical Association Declaration of Helsinki. Study participation was voluntary. All participants gave electronic informed consent**.**

Author Contributions

Josefine Gehlenborg: conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft.

Anja Göritz: Investigation, resources, writing – review & editing.

Steffen Moritz: Conceptualization, supervision, resources, writing – review & editing.

Simone Kühn: Conceptualization, supervision, resources, funding acquisition, writing – review & editing.

All authors approved the final version of the manuscript to be published and agreed to be accountable for all aspects of the work.

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