Received: 23 February 2018 | Revised: 7 May 2018 | Accepted: 9 May 2018

DOI: 10.1002/erv.2607

RESEARCH ARTICLE

WILEY

Evaluation of an approach–avoidance training intervention for children and adolescents with obesity: A randomized placebo-controlled prospective trial

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Funding information
German Statutory Pension Insurance Association (Deutsche Rentenversicherung Bund), Grant/Award Number: 8011-106-31/31.113

Summary

This study evaluated the efficacy of approach–avoidance training as an additional treatment for children and adolescents with obesity seeking inpatient treatment. Two hundred thirty-two participants (8–16 years, 53.9% girls) were randomly assigned either to multisession approach–avoidance (IG) or to placebo training (CG). As outcomes, cognitive biases post intervention, body mass index, eating behaviour, food intake, self-regulation, and weight-related quality of life were assessed, also at 6- and 12-month follow-up. Modification of approach–avoidance bias was observed, but lacked in transfer over sessions and in generalization to attention and association bias. After 6 months, the IG reported less "problematic" food consumption, higher self-regulation, and higher quality of life; effects did not persist until the 12-month follow-up; no significant interaction effects were observed regarding weight course. Despite there was no direct effect on weight course, approach–avoidance training seems to be associated with promising effects on important pillars for weight loss. Further research concerning clinical effectiveness is warranted.

KEYWORDS

approach–avoidance training, child, cognitive bias modification, intervention, obesity

1 | INTRODUCTION

Obesity is a serious health problem, with 9.6% of boys and 10.3% of girls affected in Germany (Brettschneider et al., 2015). Moreover, obesity often persists into adulthood and is associated with alarming physical and psychological consequences (Sanders, Han, Baker, & Cobley, 2015), emphasizing the need for early treatment. Although lifestyle interventions have been found to lead to significant weight loss in the short term, long-term treatment success is insufficient (Altman & Wilfley, 2015). Thus, novel approaches are required to ensure sustained treatment effectiveness.

Recent literature emphasizes the relevance of automatic cognitive mechanisms in the regulation of eating behaviour. Dual-process models draw a distinction between a reflective, conscious, and slow information processing system, and an impulsive, fast, and automatic one (Strack & Deutsch, 2004). Eating is considered as a highly automatic behaviour, triggered by internal (e.g., emotions) and external (e.g., palatable food) stimuli. Compared with persons with normal weight, individuals with obesity show a more positive association with food, and increased attention and approach to food (Jansen, Houben, & Roefs, 2015). Interventions that alter these cognitive biases might therefore be a promising treatment target (Turton, Bruidegom, Cardi, Hirsch, & Treasure, 2016).

One such approach is approach–avoidance training (AAT). First evidence suggests that even a single session of AAT can alter unhealthy consumption of alcohol, nicotine, and food (Jones, Hardman, Lawrence, & Field, 2017; Kakoschke, Kemps, & Tiggemann, 2017). Multiple sessions seem to be even more effective (Eberl et al., 2014). With one exception (Becker, Jostmann, Wiers, & Holland, 2015), previous studies supported the trainability of an avoidance reaction to high-caloric food (Brockmeyer, Hahn, Reetz, Schmidt, & Friederich, 2015; Dickson, Kavanagh, & MacLeod, 2016; Fishbach & Shah, 2006; Maas, Keijsers, Rinck, Tanis, & Becker, 2015; Schumacher, Kemps, & Tiggemann, 2016). However, effects on food consumption were inconsistent: While two studies observed significant effects (Fishbach & Shah, 2006; Schumacher et al., 2016), two did not (Becker et al., 2015; Dickson et al., 2016). Brockmeyer et al. (2015) reported a reduction of eating disorder symptoms. All of these studies examined adults, but there is also preliminary evidence that AAT is applicable to children and adolescents with overweight (Warschburger, Gmeiner, Morawietz, & Rinck, 2017).

In their critical evaluation of the merits of cognitive bias modification programmes to treat overweight, Jones et al. (2017) recommended the inclusion of relevant risk samples, because these are the ones who should benefit from the training. Additionally, the authors criticized the small sample sizes and lack of adequate control groups in previous studies and suggested not only training the avoidance of high-caloric food but also training individuals to approach low-caloric food. Moreover, studies often lack follow-up assessments, and there are no controlled intervention trials for children and adolescents with obesity. To our knowledge, no study has investigated long-term effects of such training. Therefore, in a randomized, placebo-controlled prospective study, we evaluated the efficacy of an AAT intervention in a large clinical sample of children and adolescents with obesity. Our training comprised both avoiding high-caloric stimuli and approaching low-caloric stimuli. We examined trainability and generalization to other cognitive biases (attention, association) as well as long-term effects on relative weight (primary outcome), eating behaviour, food intake, self-regulation, and quality of life (secondary outcomes) after 6 and 12 months.

2 | METHOD

2.1 | Procedure

A detailed description of the trial is provided elsewhere (Warschburger, 2015). AAT was implemented supplementary to the multidisciplinary treatment as usual in three specialized clinics. The inpatient stay usually lasted 4–6 weeks (depending on the coverage by the health insurance companies). During that time, all children and adolescents participated in a cognitive behavioural group training that aimed to support the children and adolescents to modify their lifestyle (nutritional behaviour; activity behaviour) in order to lose weight. In addition, the children and adolescents participated in regular exercise classes and received a balanced diet.

Participants were allocated either to an intervention group (IG) receiving the AAT or to a control group (CG) receiving placebo training. Training was implemented on 6 days over two consecutive weeks at the beginning of the inpatient stay. Computer-based data were collected at the beginning, throughout, and at the end of training. Questionnaire data and anthropometric data were collected at the beginning and end of the inpatient stay as well as 6 and 12 months afterwards. Anthropometric data were assessed by medical personnel of the clinic during treatment and by family doctors at follow-up. Families and their doctors received a monetary incentive. Ethical approval was obtained from the local ethics committee. The study was preregistered at the German Clinical Trials Register DRKS (ID DRKS00007879).

2.2 | Participants

Five hundred twenty-two out of 1,019 screened children and adolescents fulfilled our age-related (8–16 years) and weight-related (body mass index [BMI] > 97th percentile) inclusion criteria. The eligible families were asked to provide informed assent (children) and written informed consent (parents). Exclusion criteria are displayed in Figure 1.

2.3 | Sample characteristics

The final sample included 232 children and adolescents (53.9% female) aged between 8 and 16 years ($M = 13.09$, $SD = 1.84$) with a mean baseline BMI standard deviation score (BMI-SDS) of 2.7 ($SD = 0.47$). About 45.3% were classified as obese and 54.7% as severely obese. On average, inpatient stay lasted 5.29 weeks ($SD = 1.45$), and mean BMI-SDS at the end of the inpatient treatment was 2.42 ($SD = 0.51$). With respect to their socio-economic status, 36.5%/51.9%/11.5% belonged to the low/middle/high socio-economic status group, respectively ($n = 208$). There were no significant group differences between the IG ($n = 110$) and CG ($n = 122$) concerning age, $t(230) = -0.91$, $p = .362$; BMI-SDS, $t(230) = -0.87$, $p = .385$; socio-economic status, Winkler index: $t(206) = -0.37$, $p = .715$; or gender, $\chi^2(1) = 3.67$, $p = .055$.

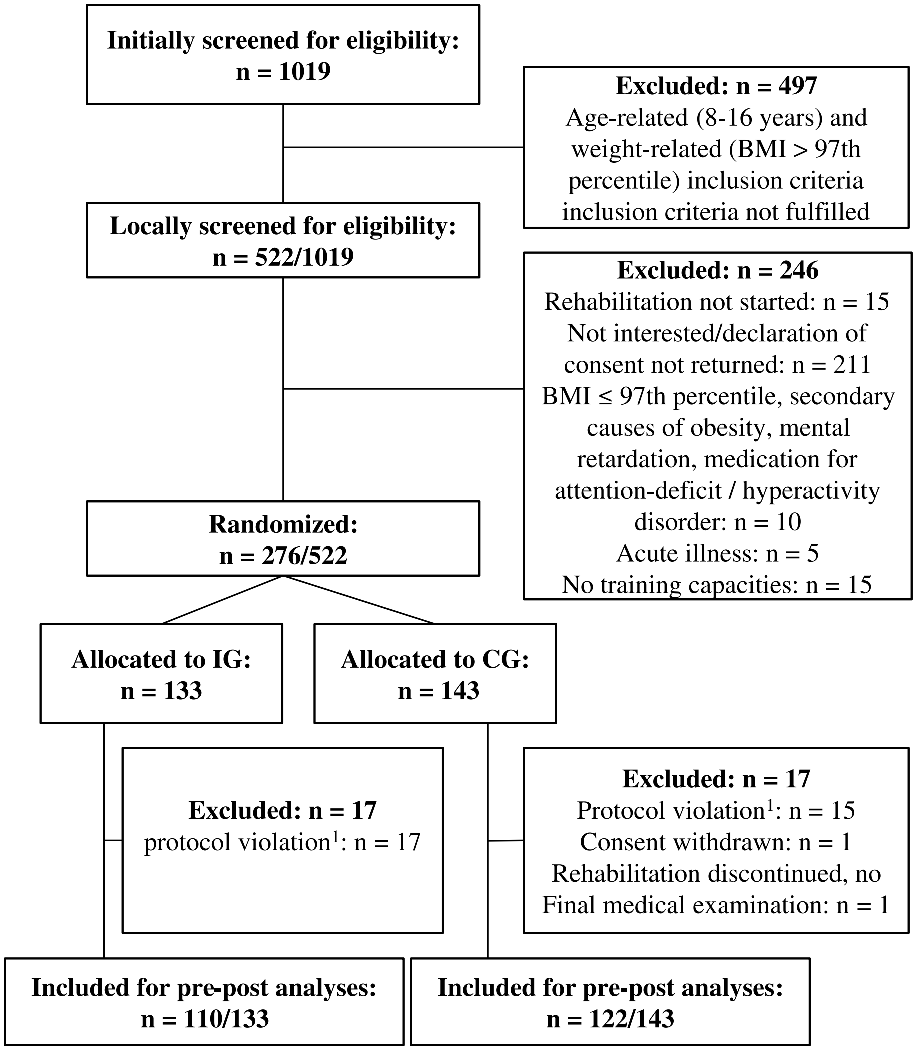

FIGURE 1 Flow chart of included and excluded participants. BMI = body mass index; CG = control group; IG = intervention group; [1]fewer than three training sessions, incorrect treatment allocation

2.4 | Materials and measures

2.4.1 | Sociodemographic and anthropometric data

Based on parents' report, socio-economic status was assessed using the Winkler index (Winkler & Stolzenberg, 1999). Age and gender of the participants were obtained from medical report, and their height and weight were assessed by medical personnel with calibrated devices to determine age- and gender-specific BMI percentiles and BMI-SDS (Kromeyer-Hauschild et al., 2001). Children and adolescents were either classified as obese (BMI percentile >97) or classified as severely obese (BMI percentile >99.5).

2.4.2 | Approach–avoidance training and bias

We implemented an AAT intervention including pictures of snacks and vegetables on circular and square plates. Children and adolescents were instructed to pull circular plates towards them and to push square plates away using a joystick. Approach and avoidance reactions were visualized by increasing and decreasing the size of the pictures. In the IG, an implicit learning paradigm was implemented: Vegetables were placed on circular plates and snacks on square plates to train approaching vegetables and avoiding snacks. In the CG, vegetables and snacks were presented equally on circular and square plates (for further details, see Table S1). Reaction times and error rates were registered. Based on mean values, compatibility scores (C-scores) were calculated (Wiers, Eberl, Rinck, Becker, & Lindenmeyer, 2011). Positive C-scores indicate a training effect, that is, a faster avoidance of snacks and approach of vegetables. Hunger, appetite, and mood were assessed with single items at the beginning and end of every training session; no potential confounding influences were found.

2.4.3 | Implicit association bias

We applied a modified version of the Implicit Association Test (Greenwald, Nosek, & Banaji, 2003). Stimuli (pictures of high-caloric snacks/neutral objects; attributes with positive/negative valence) had to be assigned to combinations of target categories (snacks and objects) and attribute categories (good and bad) displayed on both sides of a screen (for details, see Table S1). Implicit association bias (IAB) difference scores (IAB D-scores) were calculated to indicate whether the response latency was faster for blocks with combinations that were either congruent (snacks and good) or incongruent (snacks and bad) with the expected association bias. Positive IAB D-scores indicate a positive implicit association with snacks.

2.4.4 | Attention bias

To determine the attention bias (AB), we applied a modified version of the dot probe task (Miller & Fillmore, 2010; for details, see Table S1). Following the pairwise presentation of high-caloric snack pictures and nonfood pictures (neutral objects and animals), participants were asked to indicate the location of a cross appearing on the left or the right side of the screen. AB difference scores (AB D-scores) were calculated to determine whether the reaction time was faster if the cross replaced a food or a nonfood picture. Positive AB D-scores indicate an increased attention for snacks.

2.4.5 | Response inhibition

Depending on the participants' age, a computer-based (≥12 years) or a paper-and-pencil version (<12 years) of the Stroop colour-naming task (Stroop, 1935) was used to assess response inhibition (for details, see Table S1).

Participants were asked to indicate the font colour of a written colour word that appeared on the screen. Stroop interference scores determined whether the reaction was faster depending on the congruence of meaning and colour. Higher scores indicate higher interference and lower response inhibition.

In the paper-and-pencil Stroop test (Archibald & Kerns, 1999), children were instructed to name the colours of fruits and vegetables presented in the correct or false colour as quickly as possible. Stroop interference scores were calculated (Röthlisberger, Neuenschwander, Michel, & Roebers, 2010), with higher scores indicating higher interference and lower response inhibition. Test–retest reliability of the paper-and-pencil Stroop test reached $r = .87$ to $r = .93$ (Archibald & Kerns, 1999).

2.4.6 | Self- and proxy report

Details regarding the following questionnaires are presented in the supplements (Table S2). Children and parents reported on the children's usual food consumption based on a list of food items (Warschburger, Kröller, Haerting, Unverzagt, & van Egmond-Fröhlich, 2016) that were categorized into "problematic" and "unproblematic" subscales (Hauner et al., 2014). Higher scores indicate a higher intake of foods on the respective subscale. Internal consistency was Cronbach's $\alpha = .64$ for the "unproblematic" subscale and Cronbach's $\alpha = .74$ for the "problematic" subscale in the self-report, and Cronbach's $\alpha = .68$ for both scales in the proxy report. The disinhibition of eating due to internal and external cues was assessed using the German Eating Disturbance Questionnaire (FSE; Warschburger, Petermann, & Fromme, 2005). Children and parents gave information on children's eating behaviour in response to internal (e.g., anger) and external (e.g., smell or sight of food) stimuli. Higher scores indicate higher disinhibited eating. Cronbach's α reached $\alpha = .89$ for the self-report and $\alpha = .91$ for the proxy report. To assess self-control, the Brief Self-Control Scale (Tangney, Baumeister, & Boone, 2004) was translated into German and adapted for children. Higher values indicate higher self-control. Internal consistency reached Cronbach's $\alpha = .74$. To measure weight-related self-efficacy, a modified version of the weight-specific self-efficacy questionnaire for children and adolescents with overweight (GW-SW-KJ; Warschburger et al., 2005) was administered. Higher scores indicate higher weight-related self-efficacy. The internal consistency was Cronbach's $\alpha = .86$. Children's quality of life was assessed with the weight-specific quality of life questionnaire for children and adolescents with overweight and obesity (GW-LQ-KJ; Warschburger et al., 2005). A sum score was calculated and adjusted to a range from 0 to 100. Higher values illustrate a higher weight-related quality of life. In this sample, the scale reached Cronbach's $\alpha = .84$.

2.5 | Analyses

2.5.1 | Data preparation

Missing data at baseline were imputed by EM-algorithm (based on the recommendation by Wirtz, 2004). Due to the relatively high dropout rates, imputation for follow-up data was not possible. We therefore refrained from conducting the planned intention-to-treat analyses and instead conducted per-protocol analyses. A dropout analysis revealed that dropout at the 6-month follow-up was not predicted by age, gender, socio-economic status, baseline BMI-SDS, change of BMI-SDS during rehabilitation, group assignment, or completing the training successfully (defined as increase in approach–avoidance bias [AAB] reaction time C-score). After 12 months, dropout was higher in the IG than in the CG, $\theta(1) = 6.22$, $\beta = -0.69$, $OR = 0.5$, $p = .013$, and was associated with a smaller change in BMI-SDS during rehabilitation, $\theta(1) = 7.01$, $\beta = 3.39$, $OR = 29.7$, $p = .008$.

2.5.2 | Immediate training effects

Trainability was examined by mixed-factor ANCOVA with group as between-subject factor, time as within-subject factor, and number of sessions as covariate. Change across sessions was analysed by comparing baseline to posttraining AAB of the last session. As this value might reflect the immediate but not the generalized training effects, we conducted a more conservative analysis, with baseline and pretraining AAB of the last session (= second last assessment) as dependent variables. Analyses were conducted for reaction time and error C-scores. Generalizations to AB, IAB, and inhibition were tested via mixed-factor ANOVA. Variables with a significant outcome correlation were considered as covariates: age for analyses with paper-and-pencil-measured inhibition ($r = -.37$, $p = .001$) and gender for computer-measured inhibition — girls showed lower inhibition than boys, $t(153) = 1.98$, $p = .049$.

2.5.3 | Long-term training effects

Long-term effects of the AAT were analysed via mixed-factor AN(C)OVA. We included baseline BMI-SDS for analyses of self-efficacy ($r = .16$, $p = .013$), self-control ($r = .17$, $p = .01$), and quality of life ($r = -.18$, $p = .008$); gender for analyses with quality of life—girls reported lower scores than boys, $t(203) = 2.06$, $p = .04$—as covariates. Analyses were conducted separately for the 6- and 12-month follow-up, respectively. Primary outcome was BMI-SDS; secondary outcomes were self-efficacy, self-control, inhibition, disinhibition of eating, food consumption, and weight-related quality of life.

3 | RESULTS

3.1 | Immediate training effects

The mean baseline AAB was 54.16 ($SD = 231.45$, range − 561.34 to 858.35), indicating an average avoidance of snacks and approach to vegetables, difference to zero: $t(230) = 3.53$, $p = .001$; $n = 227$, $n = 5$ missing due to high error rates. AAB did not differ between groups, $t(225) = -0.7$, $p = .484$, or according to gender, $t(225) = 1.05$, $p = .295$, and was not associated with age ($r = -.12$, $p = .071$) or BMI-SDS ($r = -.007$, $p = .916$). In the IG, we observed positive training effects on AAB reaction time and error rate C-scores after the last training, but only for the error rate when analyses were conducted with the second-to-last assessment. The detailed course of AAB over all sessions and additional analyses are depicted in the supplements (see Figure S3 and Tables S4–S5).

We did not observe an effect on IAB or AB (see Table 1). Training was not associated with changes in computer-based, $F(1,141) = 0.95$, $p = .332$, or paper-and-pencil-based inhibition measures, $F(1,72) = 1.07$, $p = .305$.

TABLE 1 Mean scores (standard deviations) of cognitive biases and pre-post comparisons over the groups in mixed-factor ANOVA

			IG		CG		*n*	ANOVA: interaction time × group		
			M	*SD*	*M*	*SD*		*F*	*p*	η^2
AAB	baseline	RT	65.37	229.37	43.81	233.85				
		ER	0.01	0.15	0.08	0.35				
	before last training	RT	24.91	155.21	−9.2	179.32	227[a]	0.1	.752	<.01
		ER	0.04	0.13	0.01	0.12	**232**	**6.17**	**.014**	**.03**
	after last training	RT	105.14	199.91	−4.23	188.85	**225**[a]	**5.25**	**.023**	**.02**
		ER	0.01	0.16	−0.03	0.14	**232**	**6.73**	**.01**	**.03**
AB	baseline		0.31	0.56	0.28	0.58				
	after last training		0.25	0.46	0.32	0.47	193[b]	2.36	.126	.01
IAB	baseline		−2.35	35.72	2.68	40.62				
	after last training		3.1	39.98	3.33	46.17	214[c]	0.36	.55	<.01

Note. AAB = approach–avoidance bias (positive scores indicate a higher avoidance of snacks/approach to vegetables); AB = attention bias (positive scores indicate an increased attention to snacks); IAB = implicit association bias (positive scores indicate a positive and negative scores a negative association with snacks); RT = reaction time; ER = error rate; ANOVA = analysis of variance; bold characters indicate significant results.

[a]Missing data are due to high error rates.

[b]Missing data are due to 17 cases with more than 10% slow latencies; for 22 cases, no data were available.

[c]Missing data are due to 5 cases with too slow or missing reactions; for 13 cases, no data were available.

3.2 | Long-term training effects

No significant interaction effects were observed for any of the outcomes at the 12-month follow-up. At the 6-month follow-up, compared with the CG, the IG showed a more positive course with respect to self-efficacy, self-control, consumption of "problematic" food, and quality of life. Effect sizes were in the small range. No effect on BMI-SDS course was observed (see Table 2).

4 | DISCUSSION

In light of the high prevalence of paediatric obesity and the disappointing long-term effects of interventions, novel treatment approaches are required. One such novel approach is AAT. Previous results on AAT are promising but are mainly based on student samples, and data on weight-related and long-term effects are lacking. To close this gap, we examined a multisession AAT intervention for children and adolescents with obesity in a prospective, randomized-controlled trial with long-term follow-up. Contrary to previous studies, the training was realized as "add-on training" in the context of an inpatient multimodal lifestyle intervention, hence better reflecting clinical practice. We were able to show that AAT is applicable in paediatric clinical samples, and, with some restrictions, that it is able to modify the AAB to snacks. No effect on the primary outcome BMI-SDS course was observed. Regarding secondary outcomes, we observed effects on self-regulation skills, food consumption, and weight-related quality of life at the 6-month follow-up, but not at the 12-month follow-up.

It is difficult to integrate our results into the existing literature, because our study differs from previous studies in manifold ways: First, we trained children and adolescents rather than adults; second, we focused on a clinical group rather than a healthy sample (exception: Brockmeyer et al., 2015); third, we applied multisession rather than single-session training (exception: Brockmeyer et al., 2015); and fourth, all studies used different stimulus material, which might affect the magnitude of the training effect. Fifth, although some studies compared training and placebo groups (Becker et al., 2015; Maas et al., 2015), others compared groups that were trained to approach versus avoid food (Dickson et al., 2016; Fishbach & Shah, 2006; Schumacher et al., 2016); one pilot study did not include a control group (Brockmeyer et al., 2015). Data on error rates have not been previously reported.

With respect to the question of general trainability, our findings support data from a small pilot study (Warschburger et al., 2017) and suggest that AAT is also suitable for children and adolescents with obesity. In line with other studies using single sessions (Dickson et al., 2016; Fishbach & Shah, 2006; Maas et al., 2015; Schumacher et al., 2016), we observed a modification of the AAB after the last training session. However, assessment of AAB directly after training (as conducted by Dickson et al., 2016; Maas et al., 2015; Schumacher et al., 2016) might overestimate the effect of the training. When performing a more conservative analysis, with the assessment before the last training block, we did not find an effect for the AAB based on reaction times but still observed that the IG made fewer errors than the CG. Previous studies that incorporated a delay after the training yielded inconsistent results: Although Becker et al. (2015) found no training effect of a single session of AAT, Brockmeyer et al. (2015) did find such an effect, though with multisession training. This indicates that multiple sessions might be superior to single sessions with respect to learning transfer. Although we investigated the course of AAB, our data do not allow reliable conclusions concerning the optimal application rate. Hence, future studies should directly compare single- and multiple-session training. Multiple sessions of a highly standardized training intervention with a repetitive design might also be too boring for children (Warschburger et al., 2017). A gamification of computer-based applications for children might be more appealing (Boendermaker, Prins, & Wiers, 2015).

Taken together, although we found a general learning effect, a more conservative analysis calls for caution when interpreting our results. Nevertheless, these first positive effects suggest that AAT might be effective as an add-on treatment for obesity. Compared to results from the domain of alcohol use (Kakoschke et al., 2017), the present evidence is less convincing. The treatment of obesity might be more challenging: Treatment of alcohol addiction aims at total abstinence, whereas healthy eating cannot be reduced to the complete avoidance of snacks. In addition, there is not always a clear distinction between "unhealthy" and "healthy" foods.

It was further expected that AAT would also induce changes in the implicit association, AB, and inhibition. In line with other studies from the nutrition context (Becker et al., 2015; Maas et al., 2015), and contrary to evidence from the domain of alcoholism (Wiers et al., 2011; approach–avoidance–Implicit Association Test; $\eta^2 = .13$), no transfer to implicit associations was observed. We were unable to replicate the results of two studies that observed positive effects of AAT on AB (Brockmeyer et al., 2015; Maas et al., 2015). So far, there is no convincing evidence of a significant association between cognitive biases, suggesting that they

TABLE 2 Long-term training effects regarding BMI-SDS, self-regulation, eating behaviour, and weight-related quality of life

				Baseline			6-month follow-up						12-month follow-up					
				Descriptive data			Descriptive data			Interaction group × time			Descriptive data			Interaction group × time		
Theoretical construct				*n*	*M*	*SD*	*n*	*M*	*SD*	*F*	*p*	η^2	*n*	*M*	*SD*	*F*	*p*	η^2
BMI-SDS			IG	110	2.73	0.46	62	2.47	0.6	2.52	.115	.02	49	2.52	0.62	1.2	.276	.01
			CG	122	2.67	0.48	69	2.49	0.58				63	2.53	0.56			
Self-regulation																		
Weight-related self-efficacy[a]			IG	110	3.26	0.91	60	3.3	0.88	**5.12**	**.025**	**.04**	51	3.36	0.85	0.23	.632	<.01
			CG	122	3.29	0.79	68	3.11	0.81				79	3.36	0.75			
Self-control[a]			IG	110	3.12	0.62	60	3.24	0.77	**6.63**	**.011**	**.05**	51	3.26	0.79	1.74	.19	.01
			CG	122	3.13	0.57	67	3.03	0.67				79	3.19	0.54			
Eating behaviour																		
Food consumption	Problematic[b]	Self-report	IG	110	2.76	0.82	60	2.48	0.71	**6.3**	**.014**	**.05**	51	2.63	0.77	0.95	.331	.01
			CG	122	2.54	0.83	66	2.57	0.78				78	2.5	0.73			
		Proxy report	IG	110	3.11	0.75	61	2.53	0.73	0.04	.843	<.01	53	2.61	0.72	1.34	.249	.01
			CG	122	3.21	0.89	70	2.65	0.86				77	2.61	0.79			
	Unproblematic[b]	Self-report	IG	110	3.93	1.02	60	4.23	0.84	2.92	.09	.02	51	3.89	1.08	0.33	.569	<.01
			CG	122	4.21	0.92	66	4.07	0.87				78	4.12	1.04			
		Proxy report	IG	110	3.69	1.05	61	4.14	1.03	0.01	.913	<.01	53	3.79	0.95	0.42	.518	<.01
			CG	122	3.84	1.05	70	4.21	1.00				77	3.99	1.02			
Disinhibition of eating[a]	Self-report		IG	110	2.24	0.65	59	2.12	0.61	0.47	.495	<.01	51	2.06	0.73	0.91	.341	.01
			CG	122	2.26	0.73	68	2.15	0.72				78	2.12	0.67			
	Proxy report		IG	110	2.61	0.67	61	2.29	0.64	0.93	.337	.01	52	2.27	0.71	0.44	.509	<.01
			CG	122	2.63	0.73	70	2.45	0.72				76	2.32	0.74			
Weight-related quality of life[c]			IG	110	44.39	20.33	60	58.35	18.7	**4.13**	**.044**	**.03**	51	59.71	22.23	<0.01	.959	<.01
			CG	122	45.4	19.46	67	54.82	24.18				79	58.11	22.82			

Note. BMI-SDS = body mass index standard deviation score; IG = intervention group; CG = control group; bold characters indicate significant results.

[a]Range of scale 1–5.

[b]Range of scale 1–6.

[c]Sum scores adjusted to a range from 0 to 100.

represent different independent facets (Warschburger, Gmeiner, & Morawietz, submitted for publication). Our results suggest that there is no transfer to inhibition. Some studies in the context of alcoholism considered inhibition as a potential moderator between cognitive bias and behaviour, although this thesis could not be confirmed (Eberl et al., 2013, 2014). Due to the very large age range in our study, we administered both a paper-and-pencil and a computerized Stroop test, which are reported to be uncorrelated (Penner et al., 2012). Accordingly, due to power problems, it was not possible to include inhibition as a moderator.

We were unable to observe significant effects on weight course. On the one hand, the implementation of the AAT in an inpatient setting as an "add-on treatment" increases the external validity of our results. On the other hand, however, the influence of the extensive lifestyle intervention diminishes the power of our analyses, particularly in view of the high attrition rates. An outpatient setting might be more advantageous in order to detect the pure effect of the AAT.

At the 6-month follow-up, promising, albeit small effects emerged for self-regulation (self-efficacy, self-control), underlining the positive effects of the AAT. Self-regulation skills are considered as crucial in the handling of food temptations (Baumeister, 2002), and self-efficacy in particular has been shown to predict successful weight loss (Teixeira et al., 2015). These variables were not considered or reported as outcomes in recent AAT studies.

Notably, self-reported "problematic" food consumption after 6 months was also positively affected by AAT (small effect). The literature shows divergent results in this regard: Directly after training, two studies showed positive effects on preferences or consumption (Fishbach & Shah, 2006; Schumacher et al., 2016), whereas others did not (Becker et al., 2015; Dickson et al., 2016). Follow-up assessment in recent AAT research took place a maximum of 4 weeks after training. One study observed reduced eating disorder symptoms and craving but did not include a control group (Brockmeyer et al., 2015). Another study revealed mixed results: While craving was not reduced, the training group reported less consumption of ready meals (Becker et al., 2015). Unfortunately, the self-report was not supported by the proxy report and proved to be unstable after 12 months. Nevertheless, this can be considered as a first tentative hint for a beneficial treatment effect. The excessive consumption of high-caloric food is an important maintaining factor in obesity (de Ridder, Kroese, Evers, Adriaanse, & Gillebaart, 2017), and even small reductions (as provoked by AAT) might be associated with positive weight and health outcomes.

Furthermore, with regard to quality of life, an important outcome concerning mental health was modified. Altogether, AAT yielded first promising results. To stabilize effects in the long term, the implementation of booster sessions and selective efficacy in subgroups (e.g., with regard to inhibition or binge eating) should be considered.

4.1 | Strengths and limitations

As a major strength, it should be mentioned that this is the first study to evaluate a food-specific, multiple-session AAT intervention in youth. Moreover, the prospective design allowed us to examine intervention effects over the longer term. To ensure high external validity, the study not only focused on individuals with obesity but also implemented the AAT training as an "add-on treatment" supplementing the established multidisciplinary lifestyle approach (Oude Luttikhuis et al., 2009). The sample size was large, and the sample was representative for children and adolescents in inpatient obesity rehabilitation with respect to the BMI-SDS and socio-economic status (Warschburger et al., 2016). Investigators, children/adolescents, and parents were blinded to treatment allocation and research hypotheses. Randomization was computer based. Furthermore, the primary outcome, BMI-SDS, was objectively assessed by trained personnel who were not directly involved in the study (Warschburger, 2015). Diverse relevant outcome variables were assessed as self- and proxy report, applying standardized and validated measures.

Several limitations also need to be considered. First, there was a high dropout during follow-up, which slightly exceeds the rates reported in similar samples (Karlson & Rapoff, 2009), although we invested considerable time and effort (e.g., individual birthday messages) to minimize the attrition. Feedback from the participants suggested that the medical consultation constituted a major barrier. Due to this high dropout, we had to refrain from the scheduled intention-to-treat analyses. Thus, distortion due to selective dropout cannot be excluded and jeopardizes data validity (Warschburger & Kröller, 2016). In line with current evidence (Skelton & Beech, 2011), individuals with less weight reduction during inpatient treatment were particularly more likely to drop out. The implementation of a per-protocol analysis restricts the generalizability of the results obtained. Future studies should therefore consider home visits to reduce attrition (Skelton & Beech, 2011). Second, the follow-up data mainly rely on self-report, in some cases supported by proxy report. Although this is not a problem for the assessment of subjective perceptions such as self-efficacy or quality of life, the validity of the self-reported food consumption may be questioned. Despite correlations between self-reported dietary intake and objective markers (Merson, Pezdek, & Saywitz, 2017), it would be beneficial to assess additional objective indicators, for example, bogus taste tests.

To conclude, our data suggest that AAT is promising and easy to implement in the treatment of paediatric obesity and might even be associated with longer term effects on weight-related outcomes. Yet it has to be considered that our training did not affect our primary outcome BMI-SDS. Therefore, clinical conclusions with respect to its clinical effects should be drawn with caution. We did not find that the effects on "problematic" food consumption, higher self-regulation, and higher quality of life remained stable over the course of 1 year; therefore, the implementation of booster sessions might be advisable.

FUNDING

This work was supported by the German Statutory Pension Insurance Association (Deutsche Rentenversicherung Bund) under Grant 8011-106-31/31.113.

CONFLICTS OF INTEREST

We declare that there are no conflicts of interest.

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How to cite this article: Warschburger P, Gmeiner M, Morawietz M, Rinck M. Evaluation of an approach–avoidance training intervention for children and adolescents with obesity: A randomized placebo-controlled prospective trial. *Eur Eat Disorders Rev*. 2018;26:472–482. https://doi.org/10.1002/erv.2607