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# Predictors and moderators of three online interventions for eating disorder symptoms in a randomized controlled trial

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## Abstract

**Objective:** To optimize treatment recommendations for eating disorders, it is important to investigate whether some individuals may benefit more (or less) from certain treatments. The current study explored predictors and moderators of an automated online self-help intervention “Featback” and online support from a recovered expert patient.

**Methods:** Data were used from a randomized controlled trial. For a period of 8 weeks, participants aged 16 or older with at least mild eating disorder symptoms were randomized to four conditions: (1) Featback, (2) chat or e-mail support from an expert patient, (3) Featback with expert-patient support, and (4) a waitlist. A mixed-effects partitioning method was used to see if age, educational level, BMI, motivation to change, treatment history, duration of eating disorder, number of binge eating episodes in the past month, eating disorder pathology, self-efficacy, anxiety and depression, social support, or self-esteem predicted or moderated intervention outcomes in terms of eating disorder symptoms (primary outcome), and symptoms of anxiety and depression (secondary outcome).

**Results:** Higher baseline social support predicted less eating disorder symptoms 8 weeks later, regardless of condition. No variables emerged as moderator for eating disorder symptoms. Participants in the three active conditions who had not received previous eating disorder treatment, experienced larger reductions in anxiety and depression symptoms.

**Discussion:** The investigated online low-threshold interventions were especially beneficial for treatment-naïve individuals, but only in terms of secondary outcomes, making them well-suited for early intervention. The study results also highlight the importance of a supportive environment for individuals with eating disorder symptoms.

**Public Significance:** To optimize treatment recommendations it is important to investigate what works for whom. For an internet-based intervention for eating disorders developed in the Netherlands, individuals who had never received eating disorder treatment seemed to benefit more from the intervention than those who had

received eating disorder treatment, because they experienced larger reductions in symptoms of depression and anxiety. Stronger feelings of social support were related to less eating disorder symptoms in the future.

**KEYWORDS**

eating disorders, eHealth, expert patient, internet-based intervention, moderators, predictors, randomized controlled trial, recursive partitioning

## 1 | INTRODUCTION

Internet-based interventions for eating disorders have repeatedly been found to be effective in reducing eating disorder symptoms (Linardon et al., 2020; Loucas et al., 2014; Melioli et al., 2016; Pittock et al., 2018). However, individual trajectories of recovery differ considerably between patients (de Vos et al., 2022). Personalizing treatment, to make it more effective given the characteristics of an individual in a certain context (precision medicine; Hamburg & Collins, 2010), happens frequently in clinical practice (Perlis, 2016), but lacks empirical validation. Research regarding moderators and predictors of treatment outcome attempts to realize such data-informed treatment recommendations. Predictors refer to variables (often participant characteristics) that are predictive of outcome, regardless of which treatment was given. Moderators are variables that define groups that have a better or worse outcome given a specific treatment. Research dedicated to precision medicine has become increasingly sophisticated (DeRubeis, 2019). For example, Huibers et al. (2015) built a model to predict if individuals suffering from depression would benefit more from cognitive therapy or interpersonal psychotherapy using multiple predictors and moderators (personalized advantage index; DeRubeis et al., 2014). van Bronswijk, DeRubeis, et al. (2021) extended this method by applying a machine learning approach to select the predictors and moderators that were used in the model. However, the model did not generalize to a new dataset (van Bronswijk, Buijniks, et al., 2021). These examples show that personalized treatment recommendations may be feasible and effective, but that the selection of meaningful predictor and moderator variables and their practical application are still challenging. This highlights the importance of continued effort to find individual predictors and moderators of treatment outcome to, ultimately, make prospective predictions about what treatment works for whom under what circumstances.

For eating disorders, predictors and moderators that consistently predict treatment outcome have not yet been identified (Linardon et al., 2017). Previous studies do suggest that psychiatric comorbidity, eating disorder duration, and self-esteem may be important in predicting treatment outcome and recovery (Cooper et al., 2016; Lydecker & Grilo, 2022; van Bree et al., 2023). In their systematic review, Vall and Wade (2015) identified several baseline predictors of better treatment outcome, including fewer binge or purge behaviors, fewer concerns about shape or weight, greater motivation to recover, lower depression and fewer other comorbidities, and better interpersonal functioning. Importantly, different predictors and moderators may be relevant in internet-based interventions compared to face-to-face settings

(Andersson et al., 2008). When looking at predictors of treatment outcome in the context of internet-based interventions for eating disorders specifically, better treatment outcome is predicted for individuals with less comorbid psychopathology and those that report problems with binge eating rather than restrictive eating (Aardoom et al., 2013). Additionally, motivation to change, body dissatisfaction, and personality traits have been found to predict treatment outcome in technology-based interventions for eating disorders (Levallius et al., 2020; Wagner et al., 2015).

Several studies have investigated moderators of treatment outcome in the context of internet-based interventions for eating disorders. While Kass et al. (2014) did not find any moderating variables, Völker et al. (2014) found that effects of the investigated internet intervention (student bodies) were weaker for participants with more baseline purging behaviors and who presented restrictive eating. Additionally, in a study conducted by Aardoom et al. (2017), where Featback, a fully automated internet-based intervention for eating disorders with and without psychologist support, was compared to a waiting list control condition (WLC), higher levels of anorectic psychopathology was associated with poorer outcome for people receiving Featback without any guidance. Additionally, Featback with and without psychologist support appeared to be especially effective compared to the control condition for individuals with mild to moderate baseline bulimic symptoms.

Taken together, previous research indicates that congruous predictors and moderators in internet-based interventions for eating disorders are not yet established. However, some characteristics, like the presented eating disorder symptoms, motivation to change, and interpersonal functioning, may be important in predicting treatment outcome and identifying subgroups of individuals that benefit from certain intervention elements like human guidance. To optimize treatment recommendations regarding online interventions for eating disorders, it is important to further investigate what works for whom. The current study aimed to examine predictors and moderators of outcomes of Featback, an automated online self-help program, online chat or e-mail support from a recovered expert patient, and their combination.

## 2 | METHODS

### 2.1 | Study design and participants

This study was performed as part of a randomized controlled trial (Rohrbach et al., 2019), which was preregistered in the Dutch Trial Register (NL7065) and approved by the local medical ethics

committee (METC-LDD, NL64553.058.18). Participants were mostly recruited through a Dutch online eating disorder community (Proud2Bme) in the period from October 2018 until October 2019. They were included when they were 16 years or older and indicated to have at least mild eating disorder symptoms on a screening questionnaire including the weight concern scale (Killen et al., 1994) and the short evaluation of eating disorders (Bauer et al., 2005). Participants who reported severe eating disorder symptoms on the screening questionnaire were not excluded from the study, but were advised to seek professional help.

Participants were randomly allocated to four conditions, (1) Featback, a fully automated online self-help program, (2) Featback plus weekly expert-patient support, (3) weekly expert-patient support, or (4) a WLC. The intervention period lasted 8 weeks. Participants completed six online self-report questionnaires, including baseline (T0), post intervention (T1), and 3 (T2), 6 (T3), 9 (T4) and 12 month (T5) follow-up assessments. Participants were free to utilize other sources of support or treatment during the research period. Results on the effectiveness showed that the three online interventions were more effective than the WLC in reducing eating disorder symptoms, without a clear preference between the three options (Rohrbach, Dingemans, Spinhoven, et al., 2022). The Featback only condition was found to be cost-effective compared to the other three approaches (Rohrbach, Dingemans, van Furth, et al., 2022).

## 2.2 | Interventions

Participants allocated to the Featback condition automatically received a link to a brief 4-item questionnaire that they could complete every week. The four questions inquired after the frequency (on a 4-point scale including “never,” “1–3 days,” “4–6 days,” and “every day”) in which users exhibited worrying about weight or shape, restrictive eating, binge eating, and compensatory behaviors in the past week. After completion, participants received a supportive feedback message containing a summary of symptoms, psychoeducation, and tips or challenges. The feedback message was picked from a message database by an algorithm, based on participants' answers from this week and the week before. Participants in the expert-patient support condition could schedule a 20-min mail or chat appointment with the expert patient they were assigned to once a week. Chats closed automatically after 20 min and e-mails were sent to expert patients before the scheduled appointment so that they could respond at the time of the appointment. Expert patients ( $N = 5$ ) had recovered from an eating disorder and were trained to use their experience to help others via chat and e-mail. Participants in the combined condition had access to both the weekly monitoring questionnaire and expert-patient support. In all three active conditions, participants were urged, and were reminded up to two times, to use the interventions but, ultimately, use was voluntary. Lastly, participants in the WLC did not receive any intervention and were offered 8 weeks of Featback plus expert-patient support after the research period.

## 2.3 | Outcomes

The primary outcome was eating disorder symptoms as assessed with the eating disorder examination questionnaire (EDE-Q 6.0; Fairburn & Beglin, 2008). Symptoms of anxiety and depression as measured with the 4-item patient health questionnaire (PHQ; Kroenke et al., 2009) was used as a secondary outcome measure. Psychometric properties were assessed to be adequate and can be found in the study protocol (Rohrbach et al., 2019). Change scores from baseline to post intervention were used for all outcome variables.

## 2.4 | Statistical analyses

Missing data were handled using multiple imputation, effectively creating 100 imputed datasets (see Rohrbach, Dingemans, Spinhoven, et al., 2022 for details). Model-based recursive partitioning (Fokkema et al., 2018; Hothorn & Zeileis, 2015), also known as tree-based modeling, was used to detect possible predictors and moderators of treatment outcome. Recursive partitioning is especially useful for exploration purposes and detecting treatment-subgroup interactions, because it can handle multiple variables simultaneously and automatically detects (higher-order) interactions between predictor variables (Fokkema et al., 2018). Variables that were tested as both predictor and moderator were age (in years); educational level (high, middle, or low); body mass index (BMI); motivation to change assessed with three self-developed items (on a scale from 1 to 10) on the perceived importance of change, confidence in the ability to change, and readiness to change; eating disorder treatment history (yes or no); duration of eating disorder (in years); number of binge eating episodes in the past month; number of purging episodes in the past month; eating disorder pathology (EDE-Q); anxiety and depression (PHQ); self-efficacy measured with the general self-efficacy scale (Schwarzer & Jerusalem, 1995); experienced social support measured with the 12-item social support list (van Eijk et al., 1994); and self-esteem measured with the Rosenberg self-esteem scale (Rosenberg, 1965).

In all analyses, effects of all 13 possible predictors or moderators measured at baseline were assessed. For detecting moderators, it was investigated which baseline characteristics possibly moderated the effect of time by condition on the outcomes. Analyses comparing the four conditions were performed for both the EDE-Q (primary outcome) and the PHQ (secondary outcome). In case a significant moderator variable emerged, indicating a different time-by-condition effect between at least two of the four conditions when participants were grouped according to the moderator variable, 95% confidence intervals around the time-by-condition effect sizes were used to identify differences between conditions. The confidence intervals did not account for the searching of the tree structure, making them narrower than appropriate, and should thus be interpreted with care.

## 2.4.1 | Software and settings

All analyses were performed in R (R Core Team, 2021) using packages *partykit* (version 1.2–15) (Zeileis et al., 2008) and *glmertree* (version 0.2.1) (Fokkema et al., 2018). The former package was used to fit linear-model (LM) trees, for detecting predictors of outcome. Detecting moderators of treatment effects involves repeated measures over time for every participant, requiring the use of mixed-effects modeling. Package *glmertree* therefore introduced linear mixed-model (LMM) trees, which extends LM trees with a random-effects structure to account for repeated measures or multilevel structures. These recursive partitioning methods are described by Fokkema et al. (2018) and Zeileis et al. (2008). A more extensive description of how recursive partitioning works and how it was applied in the current study can be found in the [Supplemental Materials](#). A summary is provided here.

The packages implement model-based recursive partitioning (Zeileis et al., 2008) to detect subgroups that differ in terms of their mean value on the treatment outcome, or that differ in terms of the effect of treatment on the outcome. It uses so-called parameter stability tests to detect which covariates (predictors or moderators) are most strongly associated with differences in these parameters. In these parameter stability tests, an algorithm is used that statistically tests parameter instability with respect to each of the covariates. It picks the covariate that is most strongly associated with the parameter differences and implements a split to create subgroups that are as homogeneous as possible in terms of their value on the treatment outcome (in the case of predictors), or in terms of the effect of treatment on the outcome (in the case of moderators). Thus, for detecting predictors, the main parameter of interest was the mean value on the (primary and secondary) treatment outcomes. For detecting moderators, the main parameter of interest was the time-by-condition effect on these outcomes. The covariates were the 13 possible predictors or moderators.

Detecting moderators of the time-by-condition effect involved repeated measures from the same participants. In traditional analyses, mixed-effects models would be employed to account for this. Similarly, the use of LMM trees accounts for the repeated nature of the data in the current analyses.

To obtain a final model from the 100 imputed datasets, the simple stacking approach for multiply imputed data was used (Wood et al., 2008), because pooling the estimates from each imputed dataset (e.g., Buuren & Groothuis-Oudshoorn, 2011) is not possible in nonlinear methods like decision trees. In other words, the imputed data were concatenated into a single dataset, and an observation weight of  $1/M$  (where  $M$  is the total number of imputed datasets; 100 in this case) was applied to counter the inflation of sample size.

We maintained  $\alpha = .05$  for evaluating statistical significance of moderators and predictors implementing a split. We applied a Bonferroni correction to the  $p$ -values of the parameter stability tests to account for testing the effects of 13 predictor or moderator variables. This resulted in a rather conservative correction for multiple testing, which was deemed appropriate for the current explorative study.

## 3 | RESULTS

### 3.1 | Participants

In total, 355 participants were recruited. Baseline characteristics of participants are presented in Table 1. The online measurement at post intervention was completed by 280 (78.9%) participants and no other data were missing. There was no indication that drop-out differed between conditions,  $\chi^2 = 3.99$ ,  $p = .29$ . Reasons for dropping out, based on 26 responses, were declined interest in the research or intervention, the feeling that participation took too much time, and the feeling that the research or intervention was not helpful. Of the participants that completed the post-intervention measurement, 150 (53.6%) indicated that they had pursued professional help (mostly a psychologist) for disordered eating or body dissatisfaction in the previous 8 weeks. Table 2 presents information on intervention usage and satisfaction ratings.

### 3.2 | Predictors

Baseline eating disorder psychopathology strongly predicted eating disorder psychopathology at post intervention (partial  $\eta^2 = .64$ ), and baseline symptoms of anxiety and depression strongly predicted symptoms of anxiety and depression at post intervention (partial  $\eta^2 = .29$ ). In both cases, higher baseline psychopathology was predictive of higher post-intervention psychopathology. After controlling baseline symptomatology and allocated condition, experienced level of social support at baseline was found to be a significant predictor of outcome in terms of eating disorder symptoms. On average, participants who experienced higher levels of social support at baseline were more likely to have greater reductions in eating disorder symptoms at post intervention (Figure 1). Effects of condition and subgroups on post-intervention levels of eating disorder symptoms were medium to small (Table 3). No predictors for symptoms of anxiety and depression were found.

### 3.3 | Moderators

For eating disorder symptoms (primary outcome), no moderator variables were found. In other words, no subgroups of participants were identified who benefited more (or less) from one of the online interventions in terms of eating disorder symptoms. For symptoms of anxiety and depression, however, treatment history emerged as a moderating variable in the analysis. Figure 2 presents the tree with effect size estimates in the terminal nodes. In node 3, which consisted of the subgroup with individuals that did not previously receive eating disorder treatment, intervention effects were stronger (i.e.,  $d$ -values were lower) compared to the WLC. Confidence intervals around the effect sizes suggested no differences between the three active interventions. For individuals who did receive previous eating disorder treatment, receiving only expert-patient support resulted in smaller reductions of symptoms of anxiety and depression, with no differences between the other three conditions.

**TABLE 1** Baseline characteristics of participants.

Characteristics	Featback (N = 88)	Featback + expert patient support (N = 90)	Expert patient support (N = 87)	Waiting list (N = 90)	Total sample (N = 355)
<b>Gender</b>					
Female (%)	82 (93.2)	89 (98.9)	84 (96.6)	88 (97.8)	343 (96.6)
Male (%)	5 (5.7)	1 (1.1)	1 (1.1)	2 (2.2)	9 (2.5)
Other (%)	1 (1.1)	0 (.0)	2 (2.3)	0 (.0)	3 (.8)
<b>Nationality</b>					
Dutch (%)	78 (88.6)	80 (88.9)	80 (92)	81 (90)	319 (89.9)
Belgian (%)	9 (10.2)	9 (10.0)	6 (6.9)	8 (8.9)	32 (9.0)
Other (%)	1 (1.1)	1 (1.1)	1 (1.1)	1 (1.1)	4 (1.1)
<b>Education</b>					
Low (%)	5 (5.7)	12 (13.3)	12 (13.8)	18 (20)	47 (13.2)
Middle (%)	33 (37.5)	31 (34.4)	34 (39.1)	35 (38.9)	133 (37.5)
High (%)	50 (56.8)	47 (52.2)	41 (47.1)	36 (40)	174 (49)
<b>Marital status</b>					
Married/living together (%)	20 (22.7)	22 (24.4)	26 (29.9)	30 (33.3)	98 (27.6)
Living alone (%)	68 (77.3)	66 (73.3)	58 (66.7)	58 (64.4)	250 (70.4)
Divorced (%)	0 (.0)	1 (1.1)	3 (3.4)	2 (2.2)	6 (1.7)
Widow (%)	0 (.0)	1 (1.1)	0 (.0)	0 (.0)	1 (.3)
<b>Treatment history for ED</b>					
Yes (%)	46 (52.3)	54 (60.0)	53 (60.9)	49 (54.4)	202 (56.9)
No (%)	42 (47.7)	36 (40.0)	34 (39.1)	41 (45.6)	153 (43.1)
<b>Self-reported diagnosis status</b>					
Officially diagnosed with ED	52 (59.1)	60 (66.7)	52 (59.8)	58 (64.4)	222 (62.5)
No diagnosis, but assumed to have ED	24 (27.3)	22 (24.4)	23 (26.4)	22 (24.4)	91 (25.6)
Eating problems, but likely no ED	12 (13.6)	8 (8.9)	12 (13.8)	10 (11.1)	42 (11.8)
Age (years)	28.0 (1.7)	28.3 (10.4)	26.8 (9.4)	28.1 (12.4)	27.8 (10.8)
BMI (kg/m <sup>2</sup> )	22.2 (7.1)	21.9 (6.2)	22.0 (7.1)	22.4 (7.7)	22.1 (7.0)
Duration of eating problems (years)	10.1 (9.1)	10.3 (8.8)	8.6 (8.2)	11.4 (12.0)	10.1 (9.7)
EDE-Q	3.9 (1.1)	4.1 (1.1)	4.3 (1.0)	4.3 (1.0)	4.1 (1.0)
PHQ-4	7.6 (3.4)	7.5 (3.3)	8.2 (2.9)	7.9 (3.3)	7.8 (3.2)
GSES	25.9 (5.8)	27.4 (5.2)	24.4 (5.4)	26.7 (5.8)	26.1 (5.6)
SSL-12	29.4 (6.7)	30.4 (7.5)	30.0 (6.7)	30.1 (7.0)	30.0 (7.0)
Internet usage (hours per day)	4.2 (2.6)	3.7 (2.2)	3.9 (2.3)	3.4 (2.8)	3.8 (2.5)

Note: Data are presented as means (SD) unless indicated otherwise.

Abbreviations: BMI, body mass index; ED, eating disorder; EDE-Q, eating disorder examination questionnaire; GSES, general self-efficacy scale; PHQ-4 = 4-item patient health questionnaire; SD, standard deviation; SSL-12, 12-item social support list.

## 4 | DISCUSSION

The aim of the current study was to investigate possible predictors and moderators of outcome for Featback, a fully automated internet-based intervention for eating disorders, chat or e-mail support from an expert patient, and their combination. High experienced social support at baseline predicted less eating disorder symptomatology at post intervention. This is in line with a qualitative study that presented social support as having a large influence on recovery from an eating disorder according to recovered

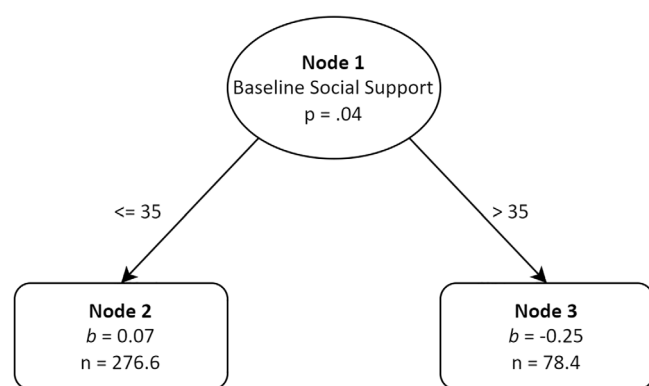
individuals (Linville et al., 2012). Accordingly, better interpersonal functioning has frequently been associated with better outcomes (Arcelus et al., 2013; Stice et al., 2017; Vall & Wade, 2015). The results of the current study, then, substantiate earlier research and extend it to a sample recruited in the context of low-threshold online interventions and highlight the importance of a good social support system for the recovery process. Furthermore, high baseline eating disorder symptoms predicted high follow-up eating disorder symptoms. The same was true for baseline symptoms of anxiety and depression, which is in line with previous findings (Tunvirachaisakul

**TABLE 2** Intervention usage and satisfaction.

Category	Feedback (N = 88)	Feedback + expert patient support (N = 90)	Expert patient support (N = 87)	Total sample (N = 265)
Participants with adequate dose <sup>a</sup> (%)	74 (84.1)	34 (37.8)	48 (55.2)	156 (58.9)
Participants with 0 sessions (%)	2 (2.3)	6 (6.7)	17 (19.5)	25 (9.4)
Participants with 1 session (%)	4 (4.5)	4 (4.4)	7 (8.0)	15 (5.7)
All sessions completed (%)	40 (45.5)	11 (12.2)	14 (16.1)	65 (24.5)
Intervention satisfaction <sup>b</sup> (SD)	5.8 (1.8)	7.1 (1.7)	7.4 (1.6)	6.7 (1.8)

<sup>a</sup>Participants were designated as having received an adequate dose when they completed 5 (out of 8) Feedback sessions if they were randomized to the Feedback condition, 5 (out of 8) expert-patient sessions if they were randomized to the expert-patient support condition, or 5 (out of 8) Feedback, and 5 (out of 8) expert-patient support sessions if they were randomized to the combination condition.

<sup>b</sup>Intervention satisfaction was rated on a scale from 1 (completely unsatisfied) to 10 (completely satisfied); based on 70, 63, and 62 (195 total) responses in the Feedback, Feedback + expert-patient support, and expert patient support conditions, respectively.



**FIGURE 1** Linear model tree for treatment outcome as captured by EDE-Q. *p*-Value in root node is from the parameter stability test for the respective predictor. *b* reflects mean treatment outcomes on the EDE-Q, corrected for effects of EDE-Q baseline and condition. Non-integer node sizes are due to imputation of baseline values on the predictor; imputed values differ within patients to reflect uncertainty. EDE-Q, eating disorder examination questionnaire.

**TABLE 3** Predictors of treatment outcome (EDE-Q and SSL).

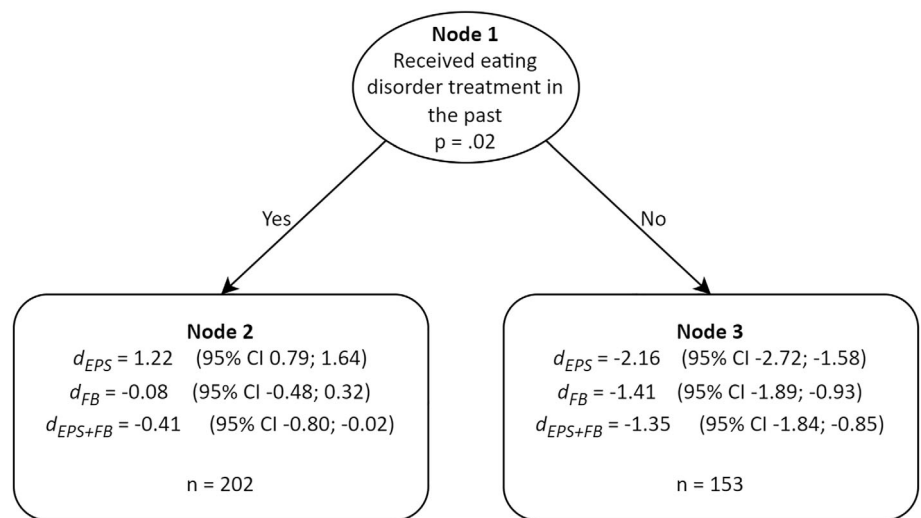
Outcome	Predictor	Partial $\eta^2$
EDE-Q (post intervention)	EDE-Q (baseline)	.64
	Condition	.06
	Node/subgroup: baseline SSL	.03

Abbreviations: EDE-Q, eating disorder examination questionnaire; SSL, social support list.

et al., 2018). These results are not unexpected as the same variable measured at baseline and follow-up are often strongly correlated (Frison & Pocock, 1992). Nonetheless, they suggest that individuals who present themselves with high levels of symptomatology are generally expected to have worse outcomes. Other outcome predictors that have previously been found, like motivation to change, binge eating episodes and employment (Matherne et al., 2022; Wagner et al., 2015), were not replicated.

Regarding moderators, analyses did not identify subgroups of participants who benefited more or less from a particular intervention in terms of eating disorder symptoms, which is in line with a study by Kass et al. (2014). Feedback and online expert-patient support comprise brief low-threshold interventions designed to serve individuals with different eating disorder symptoms. As such, the content changes according to the symptoms a user presents. Possibly, this responsiveness makes it unlikely to detect moderators for eating disorder symptoms for these interventions. That is, perhaps all three interventions had a similar effect on participants as the intervention adjusted to their needs. More generally, the results are in accordance with reported difficulties in identifying moderators of treatment outcome for eating disorder outcomes (Linardon et al., 2017), which is echoed in other areas of psychiatry (Erceg-Hurn et al., 2023). That a moderating effect of past eating disorder treatment was found on symptoms of anxiety and depression, but not on eating disorder symptoms, might be because the support and information the interventions provide make users feel relief, more in control, and less anxious about the future, but only for treatment-naïve individuals. Indeed, a higher sense of control and self-efficacy have been associated with lower anxiety and depression (Keeton et al., 2008; Tahmassian & Jalali Moghadam, 2011). However, in the current study, self-efficacy of participants in the intervention conditions did not increase more than in the control condition, contradicting the idea that the interventions increased a sense of control in individuals with no eating disorder treatment history. An alternative explanation is that negative previous treatment experiences make individuals less sensitive to next treatments. Accordingly, in pain treatment it was found that a negative experience with pain medication reduced the response to a second treatment (Kessner et al., 2014). Similarly, studies regarding the pharmacological treatment of depression reported higher chances for success when there was no such previous treatment (Blumberger et al., 2011; Buchalter et al., 2019). Concordantly, treatment-naïve individuals appear to be more responsive to treatment. While this effect was visible for symptoms of anxiety and depression, this may not have affected eating disorder symptoms because they are notoriously hard to treat (Halmi, 2013). For

**FIGURE 2** Linear mixed-effects model tree for treatment-effect moderation on the PHQ. EPS, expert-patient support; FB, Featback; PHQ, patient health questionnaire.



participants who did have previous eating disorder treatment experience, expert-patient support only performed worse than the WLC in reducing feelings of anxiety and depression. Perhaps being confronted with and comparing oneself with a recovered individual while having the experience of unsuccessful previous treatment increased feelings of hopelessness or fear to not recover themselves. Indeed, such upward comparisons have been found to decrease self-evaluation (Collins, 1996; Wayment et al., 2020).

Taken together, the findings suggest that low-threshold interventions, like Featback and online expert-patient support, are especially helpful in relieving secondary symptoms for individuals that never received treatment for their eating problems before. This is interesting, given that such easily accessible interventions may be well-equipped to reach this group of treatment-naïve individuals (Kazdin et al., 2017). More generally, a strong social support system appears to be beneficial for eating disorder related outcomes.

#### 4.1 | Strengths and limitations

Strengths include the randomized allocation of a large number of participants and multiple imputation procedures to account for missing data. A limitation of moderator analyses in general is that adequate power is challenging to acquire, requiring more participants than recruited in the current study. This in combination with the stringent Bonferonni correction increased the chance of type II errors (false negative). Another shortcoming was that a limited set of predictor and moderator variables could be included in the analysis. Investigating more variables may have been useful in identifying relevant predictors or moderators. Third, all assessments, including diagnosis status, were self-reported which may have presented recall bias and measurement inaccuracies. Self-report measures were chosen to maintain the low-threshold intervention context and to ensure participants experienced anonymity. Last, participants were free to undergo treatment aside from the appointed intervention. The analyses did not control these

separate treatments, which may have influenced the results slightly. However, the effect was expected to be negligible as psychological health care visits did not influence the results on the effectiveness of the three investigated online interventions (Rohrbach, Dingemans, Spinhoven, et al., 2022).

#### 4.2 | Implications and future directions

First, findings highlight the importance of social support for better eating disorder outcomes in a sample recruited in the context of low-threshold internet interventions. Further exploring key sources of social support for individuals with an eating disorder, the association between social support and treatment (outcome), and how it can be strengthened might be fruitful research avenues. For example, it might be interesting to investigate how online and offline social support differ in their influence on eating disorder outcomes.

The findings of this study suggest that Featback and online expert-patient support can be particularly valuable for reducing symptoms of anxiety and depression in individuals with no previous eating disorder treatment experience. Consequently, such low-threshold interventions may be especially helpful in the early stages of the development of an eating disorder. A valuable research endeavor, then, would be to investigate the best approaches for reaching this group of individuals who are at risk for or have beginning symptoms of an eating disorder. To this end, it would be worthwhile to collaborate with experts in the area of communication and marketing and with individuals currently suffering from an eating disorder about how and when to offer internet interventions.

#### 4.3 | Conclusion

This study investigated predictors and moderators of three online interventions aimed at reducing eating disorder symptoms. High levels

of experienced social support were predictive of reductions in eating disorder symptoms (regardless of treatment), indicating the importance of a supporting social environment for favorable outcomes. Additionally, no moderators were found for eating disorder related outcomes. However, the three internet-based interventions were found to be especially valuable in reducing symptoms of anxiety and depression in individuals who had never received eating disorder treatment before. The findings suggest that such low-threshold treatments might be especially useful in the context of early detection and intervention. Given the exploratory nature of this study, these findings require replication in other studies.

## AUTHOR CONTRIBUTIONS

**Pieter Rohrbach:** Conceptualization; data curation; investigation; methodology; project administration; validation; writing – original draft; writing – review and editing. **Marjolein Fokkema:** Conceptualization; methodology; resources; software; validation; visualization; writing – original draft; writing – review and editing. **Philip Spinhoven:** Conceptualization; funding acquisition; methodology; project administration; supervision; writing – original draft; writing – review and editing. **Eric F. van Furth:** Conceptualization; funding acquisition; methodology; project administration; supervision; writing – review and editing. **Alexandra E. Dingemans:** Conceptualization; funding acquisition; methodology; project administration; supervision; writing – original draft; writing – review and editing.

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## CONFLICT OF INTEREST STATEMENT

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## DATA AVAILABILITY STATEMENT

Data, materials and code are available from <https://doi.org/10.17026/dans-z6z-ctye> upon reasonable request.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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