A systematic review and meta-analysis exploring effects of third-wave psychological therapies on hearing-related distress, depression, anxiety and quality of life in people with audiological problems

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ABSTRACT

Purpose:

There is growing evidence supporting the use of third-wave psychological therapies, such as mindfulness-based interventions (MBIs) and acceptance and commitment therapy (ACT), for people with long-term or chronic physical health conditions. We conducted a systematic review and meta-analysis to critically evaluate the effectiveness of third-wave interventions for improving hearing-related distress and psychological wellbeing in people with audiological problems.

Method:

We searched online bibliographic databases and assessed study quality. We conducted random-effects meta-analyses if at least two randomized controlled trials (RCTs) examined hearing-related distress, depression, anxiety or quality of life in people with audiological problems. Findings of pre-post studies were summarized narratively.

Results:

We identified 15 studies: 6 RCTs and 9 pre-post studies. The methodological quality of studies was mostly poor-to-moderate and sample sizes were typically small (overall n=750). Most studies focused on tinnitus (n=12), MBIs (n=8) and ACT (n=6). Statistically significant improvements in hearing-related distress were found with ACT and MBIs vs. controls and other treatments at post-intervention in people with tinnitus, while improvements in depression and anxiety were only found for ACT vs. controls at post-intervention. However, gains were either not maintained or not examined at follow-up and there was no evidence for improvements in quality of life.

Conclusions:

At present, there is insufficient evidence to recommend the use of third-wave interventions for improving hearing-related distress or psychological wellbeing in people with audiological problems. There is some evidence that ACT and MBIs may be useful in addressing hearing-related distress in people with tinnitus, but only in the short-term. However, findings should be interpreted with caution given the small number of studies with generally small sample sizes and mostly poor-to-moderate

methodological quality. More high quality, adequately powered, double-blind RCTs, particularly in audiological problems other than tinnitus, are needed to draw firm conclusions and meaningful clinical recommendations.

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KEYWORDS: third-wave therapies; audiology; systematic review; meta-analysis;

INTRODUCTION

Audiological problems, such as hearing loss and tinnitus, are common in the population and represent a significant public health concern. Over 1.5 billion people today are living with hearing loss, defined as having an average hearing threshold of 20 decibels or greater in hearing level at 0.5, 1, 2 and 4 kilohertz, and the prevalence is expected to rise to 2.5 billion by 2050 (World Health Organization [WHO], 2021). Tinnitus is a subjective symptom characterized by a perception of sound (e.g. ringing, buzzing) in the absence of an external stimulus (Tunkel et al., 2014). Studies have reported a wide range of prevalence rates from 5.1% to 42.7% (McCormack et al., 2016), which may be partially explained by the fact that different methods have been used to diagnose tinnitus, which in turn may be an effect of the lack of a universal definition of tinnitus.

Hearing loss and tinnitus are associated with a range of negative outcomes, including increased risk of falls and dementia (Lin & Ferrucci, 2012; Livingston et al., 2017), reduced physical health (Genther et al., 2013), increased psychological distress (Genther et al., 2013; Marks et al., 2019; Tambs, 2004), increased suicidal ideation (Marks et al., 2019), poorer quality of life (Preminger & Meeks, 2010) and impairments in everyday functioning (Genther et al., 2014; Tambs, 2004). Moreover, problems in working life, for instance, stigma and discrimination, communication difficulties, reduced productivity and relatively low earnings, are often encountered as a result of audiological impairments (Shield, 2019). Unsurprisingly, symptoms of anxiety have been reported in 31.3% and 10.2-95% of those with hearing loss and tinnitus, respectively, while symptoms of depression have been reported in 22.5% and 9.8-80%, respectively (Carlsson et al., 2014; Ziai et al., 2017). These prevalence rates are much higher than reported in the global population (anxiety: 3.6%, depression: 4.4%; WHO, 2017).

Although hearing aids are an effective treatment for alleviating hearing handicap, there is mixed or limited evidence of efficacy of hearing aids for reducing anxiety and depression in people with hearing problems (Cieśla et al., 2016; Lawrence et al., 2020). Both the American Psychiatric Association (APA) and the National Institute for Health and Clinical Excellence (NICE) guidelines recommend cognitive behavioral therapy (CBT)

for common mental health problems such as depression and anxiety (APA, 2010; NICE, 2011). Conventional CBT is focused on alleviating distress or symptoms and aims to change how one thinks, feels and behaves in emotional situations (Beck & Beck, 2011). It does this through techniques such as challenging the validity of negative thoughts or trying to eliminate or solve problems. Although a systematic review and meta-analysis of randomized controlled trials (RCTs) reported that CBT significantly decreased tinnitus distress (Hesser et al., 2011), there is low certainty to support its use for depression and anxiety in people with tinnitus due to the methodological quality of evidence (Fuller et al., 2020). Furthermore, there is little research on CBT for other audiological problems.

In contrast to CBT, third-wave psychological therapies such as mindfulness-based cognitive therapy (MBCT), mindfulness-based stress reduction (MBSR), acceptance and commitment therapy (ACT), dialectical behavior therapy (DBT), compassion-focused therapy (CFT) and meta-cognitive therapy (MT) aim to change how a person relates to their internal experiences such as thoughts, feelings and bodily sensations (Hayes, 2004; see supplemental table for a fuller description of each therapy). Although third-wave therapies differ conceptually and methodologically, the approaches share three common components and processes: to produce greater psychological openness to one's experiences, to become more aware of the present moment, and to motivate meaningful action (Hayes et al., 2011). These types of therapies have been argued to be more befitting for improving outcomes in objectively difficult or immutable situations, such as living with long-term health conditions like chronic pain, neurological conditions and acquired brain injuries (Hughes et al. 2017; Kangas & McDonald, 2011; Robinson et al., 2019). There is currently no curative treatment for most forms of hearing loss or tinnitus (Hurley & Walczak, 2020), and psychological therapies cannot directly treat such physiological conditions. Therefore, equipping individuals with skills to accept and adapt to their audiological impairment and find ways to live life as best as they can alongside these difficulties may be a more pragmatic approach than trying to control or get rid of distressing and difficult experiences.

In support of the potential effectiveness of third-wave therapies for people with audiological problems, individual studies have reported evidence for therapies such as ACT for reducing hearing-related distress in those with hearing problems (Molander et al., 2018) and MT for reducing tinnitus distress (Ferraro et al., 2019). Furthermore, a recent systematic review reported preliminary evidence for the effectiveness of mindfulness-based interventions (MBIs) for reducing tinnitus distress (Rademaker et al., 2019). However, relatively little is known about the effectiveness of MBIs for audiological problems other than tinnitus (e.g. hearing loss and deafness) or other types of third-wave therapies for tinnitus and other audiological conditions.

Therefore, this systematic review aimed to: (1) critically evaluate the evidence for third-wave therapies for improving hearing-related distress and psychological wellbeing in people with audiological problems; (2) assess the clinical effectiveness of third-wave therapies compared to active or non-active controls and other treatments at post-intervention; and (3) examine the maintenance of any effects at follow-up.

MATERIAL AND METHODS

This review was conducted and reported according to PRISMA guidelines (Page et al., 2021; see Appendix A for the PRISMA checklist) and was registered with Open Science Framework (OSF; ref: osf.io/cqte7).

Search strategy

Searches were conducted on the following databases from date of inception to 23 March 2020: Embase, PsychINFO, Web of Science, PubMed and CINAHL. The search terms are shown in Appendix B. Grey literature, specifically Open Grey, was also searched using the same keywords. References of relevant published reviews and studies were also manually searched.

Inclusion/exclusion criteria

Studies were included based on the following criteria:

- Involved adults (aged ≥18 years) with any audiological problem, as defined by Oh and Lee (2016), including issues with tinnitus, balance and hearing (see full list in Appendix B);
- Involved a common third-wave psychological therapy, as defined by O'Connor et al. (2018), including ACT, DBT, MBCT, MBSR and MT (see full list in Appendix B);
- Used either an RCT, observational cohort study (i.e. pre-post), case-control study or single-case experimental design;
- Reported data on validated hearing-related distress, depression, anxiety or quality of life outcomes;
- Reported in English.

Interventions including a small component of a third-wave therapy (e.g. yoga or tai chi), behavioral activation without third-wave therapy components or where most of the intervention content was not consistent with common third-wave therapies were not included in the review. RCT protocols, qualitative studies, systematic reviews, meta-analyses, meeting abstracts, conference reports or case studies with no control (or not using a single case experimental design) were also excluded.

Study selection

After removal of duplicates, titles and abstracts were independently screened to identify potentially eligible studies for retrieval. Full texts of retrieved articles were then screened for eligibility against the inclusion and exclusion criteria. These processes were completed by two independent reviewers (BW and PK, BT or LP). Where there was uncertainty, disagreements were resolved through discussion with a third reviewer (RG).

Assessment of study quality

The methodological quality of RCTs was evaluated using the Cochrane Collaboration Risk of Bias tool 2 (RoB 2; Sterne et al., 2019), which assesses five known domains of bias: bias arising from the randomization process, bias due to deviations from intended intervention, bias due to missing outcome data, bias in measurement of outcome and bias in selection of the reported results. Each domain was rated as low or high risk of bias, or

some concerns. The Effective Public Health Practice Project (EPHPP) Quality Assessment Tool for Quantitative Studies (EPHPP, 2009) was used to assess the methodological quality of non-RCTs. Each study was rated as weak, moderate or strong for the first six components of the tool (selection bias, study design, confounders, blinding, data collection methods and withdrawal and drop-outs), which determined the global rating for the study. Descriptive information was provided for the last two components of the tool (integrity of study intervention and analyses), though they do not contribute to the global rating. In addition to the above tools, factors that may confound or influence the interpretation or generalizability of results were also identified. The quality of studies was completed by two independent reviewers and disagreements were resolved through discussion with a third reviewer, as described previously.

Data extraction and data synthesis

Study, demographic and intervention characteristics, as well as study results (including means, standard deviations, etc.) were independently extracted by two reviewers and disagreements were resolved through discussion with a third reviewer, as described previously. Following previous guidance (Cochrane Consumers and Communication Review Group, 2016; Valentine et al., 2010) random-effects meta-analyses were performed where two or more RCTs reported on the same type of audiological condition, third-wave therapy and category of outcome: hearing-related distress, depression, anxiety and quality of life. Studies that did not use validated tools to measure the abovementioned outcomes were not included in the meta-analyses. Means and standard deviations (or standard errors) for each outcome, in each condition, and at each timepoint (post-intervention, 1-5 month, 6-12 month and >12 month follow-up) were extracted and data were submitted to separate meta-analyses with respect to outcome and timepoint using Review Manager software (version 5.4; The Cochrane Collaboration, 2020). Random-effects meta-analyses using a DerSimonian and Laird estimator based on inverse variance weights were conducted due to anticipated heterogeneity in treatment effects as a result of between-study variations in clinical and study factors. Pooled effect sizes were calculated using Hedges' g, whereby standardized mean differences were adjusted for small sample bias (Hedges & Olkin, 1985). The I^2 statistic was used to quantify heterogeneity, with values of 25%, 50% or 75% suggesting low,

moderate or high level of heterogeneity, respectively (Higgins et al., 2003). Subgroup analyses were used to explore causes of significant heterogeneity, where possible. Publication bias was estimated using funnel plots (test of asymmetry) for meta-analyses that included at least ten studies, as previously recommended (Higgins & Green, 2011). As it is not recommended to analyze pre-post standardized mean differences within a meta-analysis (Cuijpers et al., 2017), the findings of pre-post studies were summarized in a narrative synthesis.

RESULTS

Study characteristics

The search identified 1,827 records: 18 publications relating to 15 separate studies are included in the review after screening for inclusion criteria (see Figure 1). Three studies reported two publications each, in the form of the main publication and secondary data analyses (Hesser et al., 2012, 2014; Husain et al., 2019 and Zimmerman et al., 2019) or follow-up data (Gans et al., 2014, 2015). No potentially eligible studies reported in non-English were found. Table 1 presents study characteristics. Of the fifteen included studies, six adopted an RCT design, while the rest (n=9) were pre-post studies. Among the six RCTs, two included a non-active waitlist control, one included an active control of an online discussion forum and five included another form of treatment as the comparator: relaxation therapy/training, CBT, tinnitus retraining therapy. Sample sizes ranged from 7 to 205, with a combined total of 750 participants at enrolment. Studies were most frequently conducted in the USA (n=4), Sweden (n=4) and the UK (n=3). All studies used self-report questionnaires as their primary outcome measure and outcome assessments were conducted pre-intervention and immediately post-intervention. Most studies (n=11) included longer-term follow up assessments, with follow-ups ranging from 4 weeks post-intervention to 18 months post-baseline (or 15.5 months post-intervention).

Participant characteristics

The majority of studies (n=10) used self-referral to recruit their participants and most studies (n=13) did not select participants on the basis of psychological distress or psychiatric comorbidities. Only one study selected participants who reported significant psychological distress (McKenna et al., 2017), while another included

participants with psychiatric comorbidities (Hassinen & Lappalainen, 2018). The most commonly examined audiological problem was tinnitus (n=12), followed by Deaf/deafness (n=2) and hearing problems (n=1). The manner in which audiological problems were diagnosed varied among the studies: some requested formal evidence of diagnosis by a specialist (n=6), others required participants to score over a specified value on self-report questionnaires (n=5) and a few conducted a pure-tone threshold assessment (n=3). Four studies did not explicitly state the diagnostic criteria for audiological problems, though participants were recruited from audiology-related services in three of these studies. In most studies, participants were typically male (range= 31-100%, median= 55.0%, IQR= 14.5%) and in their early 50s (range= 20-83, mean= 52.2, SD= 7.1). Very few studies reported ethnicity data (n=2) and those that did reported sample comprising >70% Caucasian participants.

Intervention characteristics

Table 2 presents a summary of intervention characteristics. A wide variety of third-wave therapies was examined, with ACT being the most frequently assessed intervention (n=6), followed by MBCT (n=4) and MBSR or variants (n=3). On average, interventions consisted of eight sessions (SD= 1.3, range= 4-9), with each session, on average, lasting approximately 95 minutes (SD= 35.1, range= 40-150 mins). With the exception of one study which did not report the mode of therapy (Roland et al., 2015), interventions were most typically delivered in groups (n=7) or a combination of group and individual delivery (n=1). Most therapies were adequately manualized (n=11), while manualization in the remaining studies was partially adequate or unclear. All interventions, except one (Dehnabi et al., 2017), were delivered by professional therapists or postgraduate students with experience in delivering the third-wave intervention(s), though specialists with hearing-related experience were only included in three studies (Gans et al., 2014; Hassinen & Lappalainen, 2018; McKenna et al., 2018).

Meta-analysis

The meta-analytic results for the outcomes listed below are presented for tinnitus alone as there are insufficient studies to perform an analysis for other audiological conditions.

Hearing-related distress

As shown in Figure 2, there was a large statistically significant pooled effect size of -1.10 (95% confidence interval [95% CI]= -1.51 to -0.70) at post-intervention, favoring ACT over controls for hearing-related distress. When ACT was compared to other treatments, a smaller but statistically significant pooled effect size of -0.55 (95% CI= -0.94 to -0.15) in favor of ACT was observed at post-intervention. However, these gains were not maintained at 6-12 month follow-up (Hedges' g =-0.19, 95% CI= -0.95 to 0.56), and there was evidence of moderate heterogeneity in effect sizes.

There was a statistically significant benefit of MBIs over other treatments for hearing-related distress at post-intervention (Hedges' g= -0.39; 95% CI= -0.74 to -0.04). It was not possible to examine whether gains were maintained at follow-up as this was only assessed in one study (McKenna et al., 2017).

Depression

As shown in Figure 3, there was a statistically significant benefit of ACT over controls for depression at post-intervention (Hedges' g= -0.50; 95% CI= -0.88 to -0.11). However, this benefit was not seen when compared to other treatments at post-intervention (Hedges' g= -0.31; 95% CI= -1.03 to 0.42) or at 6-12 month follow-up (Hedges' g= 0.05; 95% CI= -1.06 to 1.17), with moderate to high heterogeneity in effect sizes being found in both analyses.

There was a small, non-significant pooled effect size in favor of MBIs compared to other treatments for depression at post-intervention (Hedges' g= -0.28; 95% CI= -0.60 to 0.04) and at 1-5 month follow-up (Hedges' g= -0.28; 95% CI= -0.60 to 0.04).

Anxiety

As shown in Figure 4, there was a statistically significant benefit of ACT over controls for anxiety at post-intervention (Hedges' g= -0.79; 95% CI= -1.18 to -0.40). However, this benefit was not seen when compared to other treatments at post-intervention (Hedges' g= -0.50; 95% CI= -1.23 to 0.22) or at 6-12 month follow-up (Hedges' g= 0.00; 95% CI= -0.77 to 0.77). There was also evidence of moderate heterogeneity in effect sizes in both analyses.

There was a small, non-significant pooled effect size in favor of MBIs in comparison to other treatments for anxiety at post-intervention (Hedges' g= -0.29; 95% CI= -0.61 to 0.02) and at 1-5 month follow-up (Hedges' g= -0.17; 95% CI= -0.58 to 0.24).

Quality of life

Quality of life was only examined in RCTs of ACT for people with tinnitus (see Figure 5). Minimal to small, non-significant pooled effect sizes were found when ACT was compared to controls at post-intervention (Hedges' g= 0.18; 95% CI= -0.42 to 0.677), other treatments at post-intervention (Hedges' g= -0.08; 95% CI= -0.52 to 0.37) and other treatments at 6-12 month follow-up (Hedges' g= -0.22; 95% CI= -1.10 to 0.65). There was evidence of moderate to high heterogeneity in effect sizes in these analyses. There was evidence of moderate to high heterogeneity in effect sizes in these analyses.

Causes of heterogeneity

It was not possible to explore the causes of heterogeneity due to the low number of studies.

Publication bias

No tests of publication bias were conducted as these are not recommended for meta-analyses that include less than ten studies (Higgins & Green, 2011).

Narrative synthesis of pre-post studies

Hearing-related distress

As shown in Table 3, the effectiveness of third-wave therapies on measures of hearing-related distress was examined in seven pre-post studies. All seven studies reported statistically significant pre-post changes in hearing-related distress measures: four of these examined MBIs (Gans et al., 2014; Husain et al., 2019; McKenna et al., 2018; Roland et al., 2019), two examined ACT (Drey, 2017; Hesser et al., 2009), and one examined MT (Ferraro et al., 2019). Four out of six studies reported maintenance of treatment gains at follow-up: three examined MBIs (Gans et al., 2015; McKenna et al., 2018; Roland et al., 2015) and one examined MT (Ferraro et al., 2019).

Depression and anxiety

Depression and anxiety were examined in six pre-post studies. Four reported statistically significant pre-post changes in depression and/or anxiety: two examined ACT (Drey, 2017; Hassinen & Lappalainen, 2018), one examined MT (Ferraro et al., 2019), and one examined MBI (Dehnabi et al., 2017), though the reporting of main findings was poor in the latter study. One study examining MBI chose to report effect sizes instead of significance levels due to small sample size and found moderate to large improvements for both depression and anxiety (Gans et al., 2014). Two studies included follow-up assessments and only one of these reported maintenance of treatment benefits for anxiety but not depression at 3 months post-intervention (Ferraro et al., 2019).

Quality of life

Quality of life was examined in two pre-post studies. Findings were mixed: one study examining ACT reported no significant pre-post changes (Drey, 2017), while the other study of MBI reported moderate to large improvements (based on effect size as significance levels were not reported due to small sample size; Gans et al., 2014). Neither of these studies conducted follow-up assessments.

Clinically Significant Changes, Reliable Deterioration and Adverse Events

Clinically significant changes for measures of hearing-related distress, indicated by reliable change indices or minimum clinically important differences, were examined in three RCTs and three pre-post studies. Only one RCT with an active control group examined clinically significant changes and found a significant between-group difference in the proportion of participants showing reliable changes at post-intervention (ACT: 60%, 21/35; control: 16%, 5/32; Hesser et al., 2012). When compared to other treatments, only one out of three RCTs reported a significant difference in the proportion of participants showing reliable changes at 6 months of intervention (ACT: 55%, 12/22; tinnitus retraining therapy: 20%, 4/20; Westin et al., 2011). No significant differences between the third-wave therapy condition and other treatments were reported in the remaining two RCTs (Hesser et al., 2012; McKenna et al., 2017). Clinically significant changes at post-intervention were seen for both pre-post studies of MBIs: 60% (9/15) and 50% (91/182) of participants (Husain et al., 2019; McKenna et al., 2018, respectively). All three pre-post studies of MBIs that included a follow-up assessment reported that 58% (7/12), 52.8% (96/182) and 62% (8/13) of participants showed reliable improvements at follow-ups (Husain et al., 2019; McKenna et al., 2018; Roland et al, 2015).

Reliable deterioration was reported in two studies, with reported rates being low. Three out of 39 in MBI and 3/36 participants in relaxation therapy (McKenna et al., 2017), along with 1/22 participants in ACT and 2/20 participants in tinnitus retraining therapy (Westin et al., 2011) showed reliable deterioration on hearing-related distress. Adverse events were only reported two studies: no adverse events were reported in one study (Gans et al., 2014), while two events were reported in the other study, though these were considered to be unrelated to the intervention (McKenna et al., 2017).

Quality assessment and critical appraisal

As shown in Table 4, all six studies were judged to be at an overall high risk of bias. With the exception of one RCT (Arif et al., 2019), risk of bias due to missing outcome data was mostly low. In contrast, risk of bias due to measurement of the outcome was judged to be high in all six studies. The methodological quality of pre-post

studies was generally moderate (see Table 5), with the exception of one study rated as weak (Dehnabi et al., 2017) and one study rated as strong (McKenna et al., 2018). For most studies, good reliability and validity of data collection methods were reported (n=7), while selection bias was rated as weak since self-referral was often used (n=7). No study provided information regarding blinding of outcome assessors, leading to a rating of moderate according to the EPHPP tool.

Factors that may influence or confound the generalizability and interpretation of results are presented in Table 6. Self-referral was allowed in most studies (n=10), while it was unclear for three. The majority of studies did not provide details about ethnicity (n=13). Six studies did not indicate whether a formal assessment of audiological problems was conducted (i.e. a formal diagnosis by a clinician and/or audiogram assessment with threshold criteria detailed). It was unclear for the majority of studies if concurrent psychotherapy was allowed (n=11) or if participants received psychotherapy in the 3 months prior to study commencement (n=15). Only two studies reported screening of cognitive impairment. Finally, sample sizes were small in ten studies (n<15 participants per condition), while only four out of the fifteen studies performed a sample size calculation.

DISCUSSION

In summary, our meta-analysis found no differences between ACT and controls and/or other treatments for quality of life in people with tinnitus, while there were insufficient studies to examine the effects of MBIs for this outcome. There was some evidence that both ACT and MBIs improved hearing-related distress in comparison to controls and other comparators in people with tinnitus at post-intervention, but the effects were either not maintained at follow-up or not examined in enough studies to permit a meta-analysis. ACT, but not MBIs, improved depression and anxiety in this population when compared to controls at post-intervention. However, again, these effects were not maintained at follow-up or were not observed when ACT was compared to other treatments at post-intervention. Reports of reliable improvements on measures of hearing-related distress in 50%-60% participants from pre-post studies of ACT and MBIs support the meta-

analytic findings. However, findings should be interpreted with caution given the small number of included studies with relatively small sample sizes and the mostly poor-to-moderate methodological quality.

Overall, the findings of the current review are consistent with previous meta-analysis and systematic reviews of third-wave therapies for tinnitus (Rademaker et al., 2019), chronic pain (Hughes et al., 2017) and neurological conditions (Robinson et al., 2019). Third-wave therapies may be particularly beneficial to those with physical health conditions as they can equip individuals with skills to accept and adapt to their new situation in life and their current abilities, and help them to live their lives in important and meaningful ways alongside their physical health condition. Possible theoretical frameworks for improvements in outcomes include: (1) re-constructing the individual's identity with the focus of 'here-and-now' actual self, rather than the 'hoped-for' self; (2) setting realistic and measurable goals; and (3) re-engaging in activities that individuals can still do with their loved ones (Kangas & McDonald, 2011). In keeping with our findings, a recent meta-analysis of ACT for chronic pain did not find significant difference in quality of life (Hughes et al., 2017). Measures of quality of life are praised to be multi-dimensional and broadly applicable, but are often criticized for not being sensitive to specific aspects of quality of life for different health conditions (Pequeno et al., 2020). Other similarities between Hughes et al. (2017) and the current review include effect sizes for maintenance of treatment gains were generally smaller than the effect sizes at post-intervention and the strength of evidence was weaker at follow-ups. This could be due to loss of efficacy over time, but could also be due to methodological difficulties in the available evidence, including: small number of studies including a follow-up assessment, moderate-to-high heterogeneity, as well as studies being inadequately powered to account for the dropout rate. The quality of studies of the current review was mostly consistent with other reviews, with the exception of Rademaker et al. (2019) which reported moderate to high quality, while an overall poor-to-moderate quality was reported here. This discrepancy may reflect differences in the use of methodological quality assessment tools and the inclusion of studies (n=7 in Rademaker et al. and n=15 in the current review).

Future research

There is a need for more high quality, large-scale, double-blind RCTs with active comparators to examine short- and long-term effects of third-wave therapies, with validated diagnostic criteria of the audiological problem being examined. Several of the reviewed studies omitted details regarding diagnosis, particularly studies involving participants from audiology clinics. Therefore, the tools and thresholds used for diagnosis of audiological problem should be clearly defined in order that more meaningful recommendations can be made with respect to clinical and/or research practice. Future RCTs should also recruit sufficient participants to be adequately powered to detect minimal clinically important differences between third-wave therapies and control conditions and other treatment comparators. A non-inferiority trial design could be considered to suggest whether third-wave therapies provide at least the same benefit to patients as other treatment comparators such as CBT, which would permit patient choice with respect to interventions (Wang et al., 2017). In addition, future studies should include active controls that control for attention and social support in order to adequately address this issue (Serfaty et al., 2011; Williams et al., 2014). Finally, the cost-effectiveness of third-wave therapies for people with audiological problems should be explored in future studies as little has been reported in this area.

With regards to interventions, the majority of studies focused on MBIs and ACT. Future studies should examine the effectiveness of other types of third-wave therapies such as CFT, DBT and MT in audiological problems. In addition, previous research has suggested the usefulness of ACT-informed physiotherapy for adults with chronic pain (Godfrey et al., 2020; Jacobs et al., 2016). Future studies could similarly examine whether third-wave informed treatments led by professionals with hearing-related experience could be beneficial for people with audiological problems. Furthermore, a minority of studies in this review examined adverse events and/or reliable deterioration (n=3), highlighting another under-researched area. This area requires further investigation as adverse effects of mindfulness-based approaches, including exacerbated psychological problems, have been reported (Farias & Wikholm, 2016). Future studies could examine for whom and under what circumstances third-wave therapies are useful and when they may be contraindicated.

Limitations

To the authors' knowledge, this systematic review and meta-analysis is the first to evaluate the effectiveness of third-wave therapies in people with audiological problems. However, there are a number of limitations of the review. First, as meta-analytic findings only applied to ACT and MBIs in people with tinnitus, findings cannot be generalized to other third-wave therapies or other audiological problems. This represents a large knowledge gap which future research should address. Second, generalizability of findings is further restricted due to a number of demographic and clinical issues. Participants were typically self-referred, hence may have been self-motivated to engage in treatment, and were mostly males in their early 50s with tinnitus, with ethnicity being rarely reported. Furthermore, some participants may not have had clinically significant audiological problems as a formal assessment of audiological problems was not required in some studies. As a result, the findings of the review may not generalize to broader or ethnically diverse populations, those who might be less self-motivated to engage in treatment, and those with clinically significant audiological problems. Third, publication bias and causes of heterogeneity could not be assessed due to the small number of studies included in the meta-analyses. In line with this, the grey literature search was limited to Open Grey and more unpublished studies may have been identified if this search had extended beyond this. We chose not to do this as this may have introduced further bias as studies that are hard to locate tend to have lower methodological quality (Egger et al., 2003). Fourth, our random-effects meta-analyses were performed with two or more studies, following guidance (e.g. Cochrane Consumers and Communication Review Group, 2016; Valentine et al., 2010), and some have argued that at least five studies are required for such analyses (Tufanaru et al., 2015). Fifth, the small sample sizes in the majority of studies means that they might have been underpowered to detect differences in study outcomes, particularly when comparing third-wave therapies to other forms of treatment. Finally, the small number of studies precluded direct, sub-group exploration of which type of third-wave intervention was effective for which type of audiological problem and their effects at different assessment points.

Conclusion

At present, there is insufficient evidence to recommend the use of third-wave interventions for improving hearing-related distress or psychological wellbeing in people with audiological problems. Some evidence tentatively suggests that ACT and MBIs may be useful in addressing hearing-related distress in people with tinnitus, but only in the short term. However, there is insufficient evidence at present to suggest that these treatment gains are maintained at follow-up, or that ACT and MBIs are superior to other treatments in addressing these outcomes. Furthermore, these findings should be interpreted with caution as the methodological quality of studies was generally poor-to-moderate, the number of studies was small, with generally small sample sizes, and many studies were not adequately powered. Whether ACT and MBIs are beneficial in people with audiological problems other than tinnitus, or indeed whether other forms of third-wave therapies are beneficial for audiological conditions remains unclear. This represents a significant knowledge gap and future research should aim to address this. High quality, double-blind RCTs with active comparators and long-term follow-up, that are adequately powered to detect clinically meaningful differences need to be conducted before firm conclusions can be drawn about the efficacy of third-wave therapies for people with audiological problems.

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DISCLOSURE OF INTERESTS

None.

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Legends of Tables and Figures

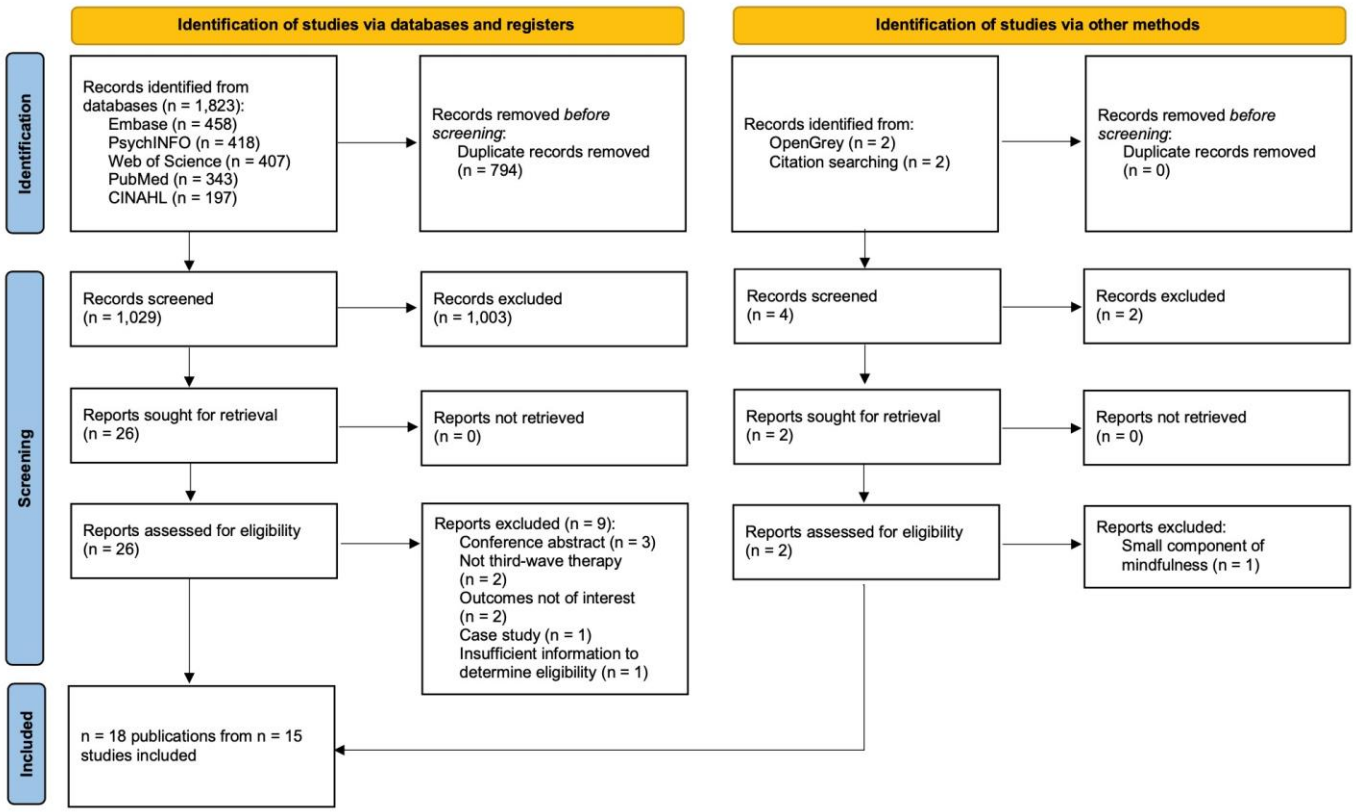
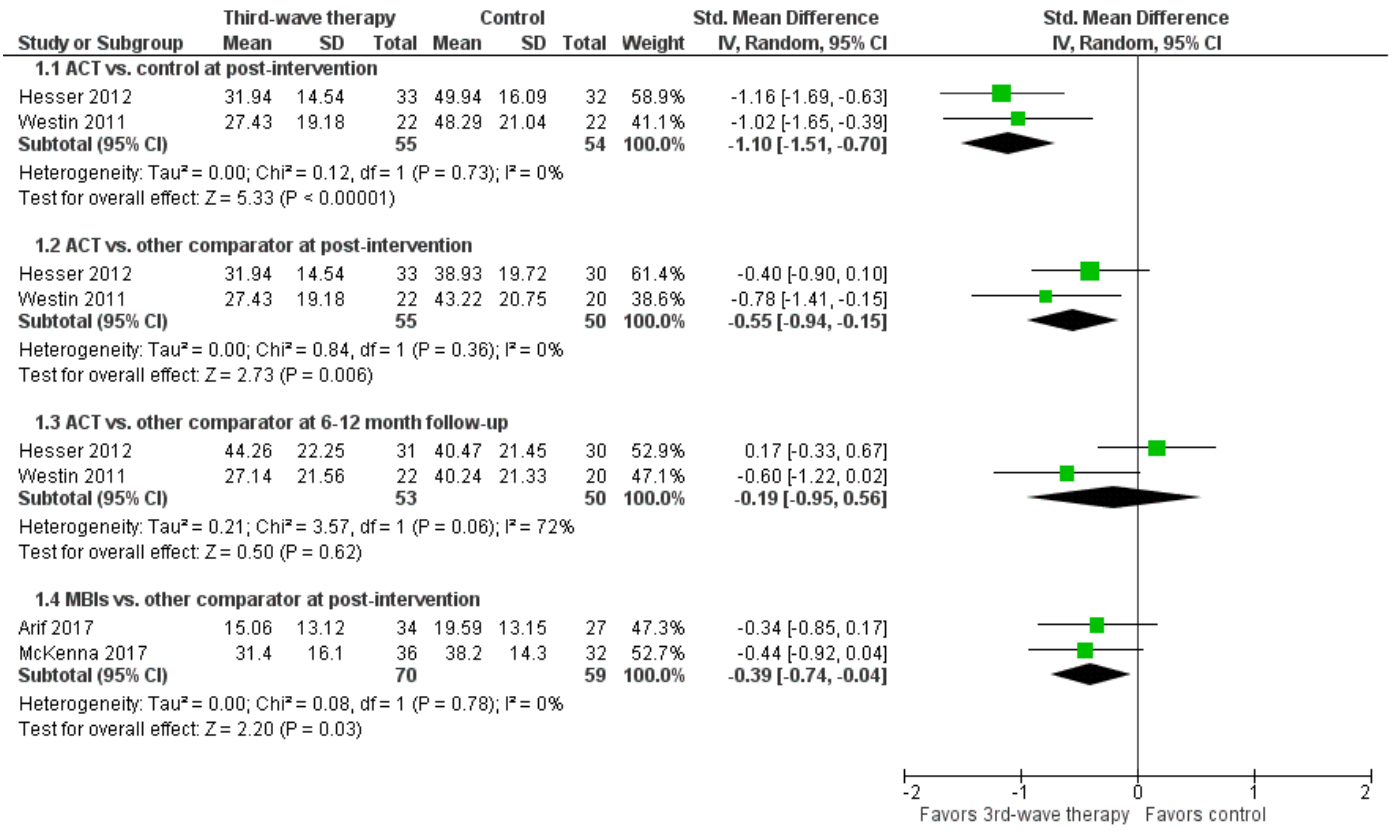


Figure 1: PRISMA flow chart of identification and selection of studies.



Notes: ACT= Acceptance and Commitment Therapy; Chi^2= chi-squared statistic; CI= confidence interval; df= degrees of freedom; I^2= I-squared heterogeneity statistic; IV= inverse variance; MBIs= Mindfulness-Based Interventions; P= p-value; SD= standard deviation; std.= standardized; Tau^2= tau-squared statistic; Z= Z statistic.

Figure 2: Forest plots of third-wave therapies versus controls and other treatments for hearing-related distress at post-intervention and follow-up.

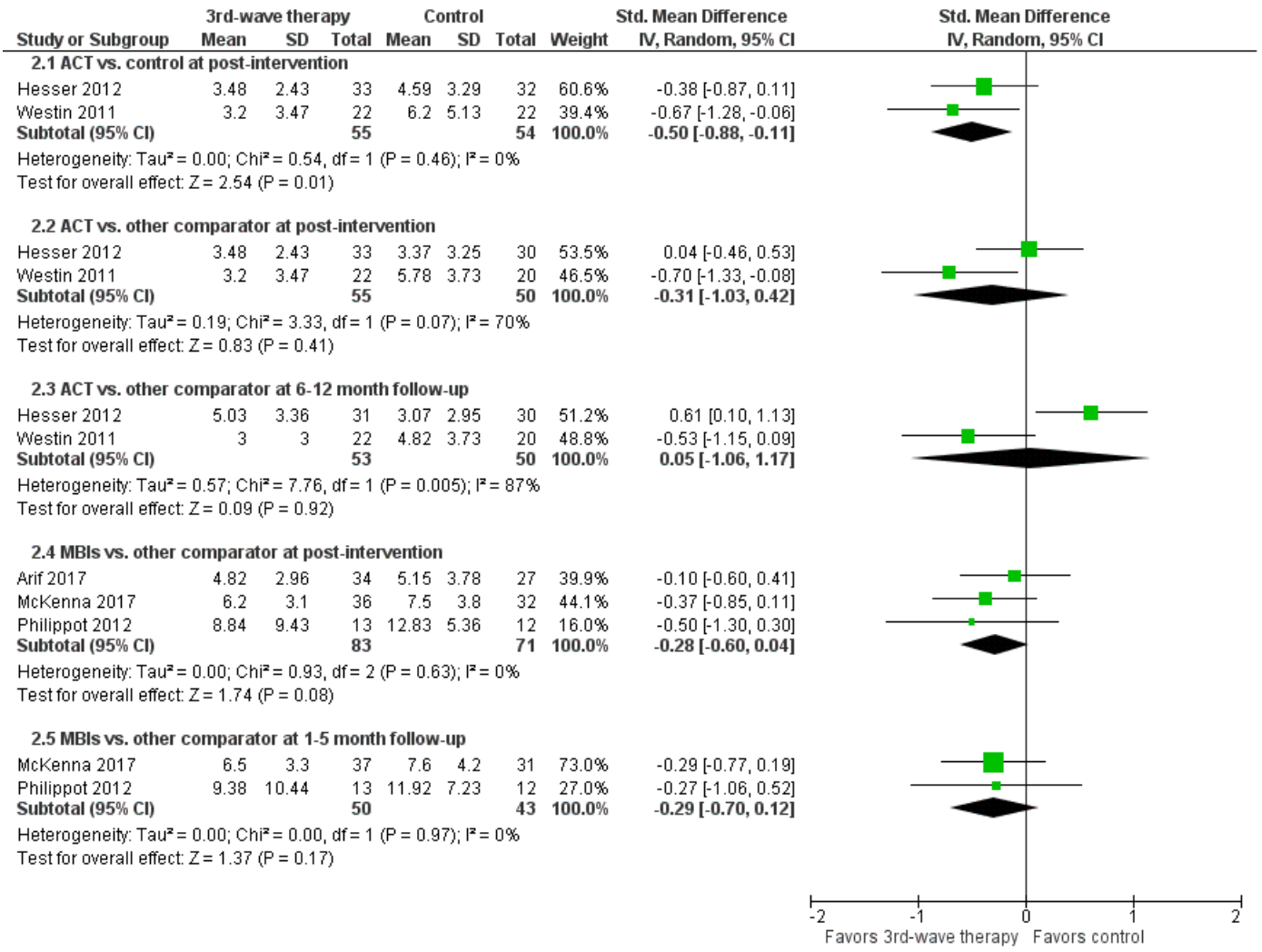


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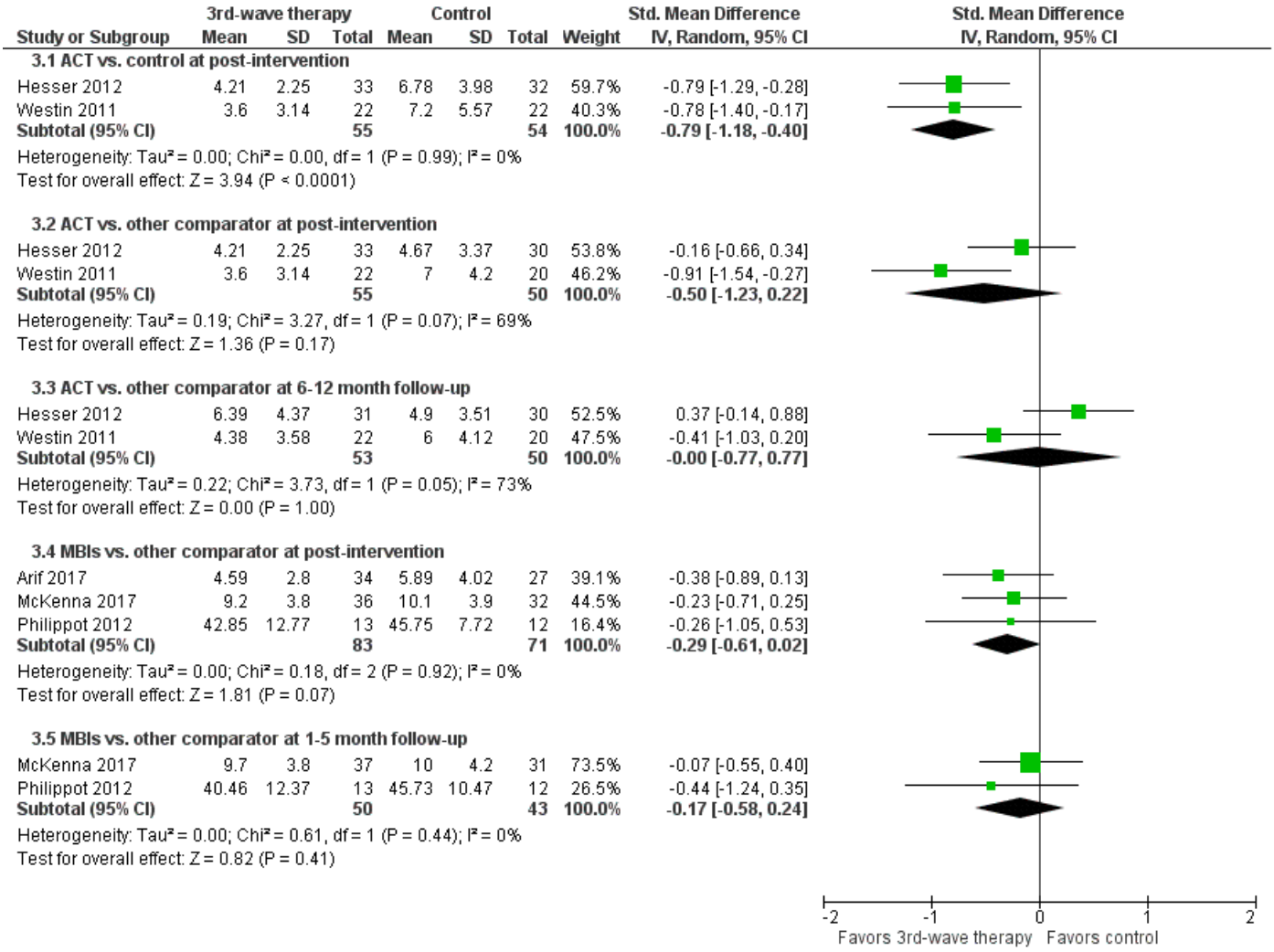
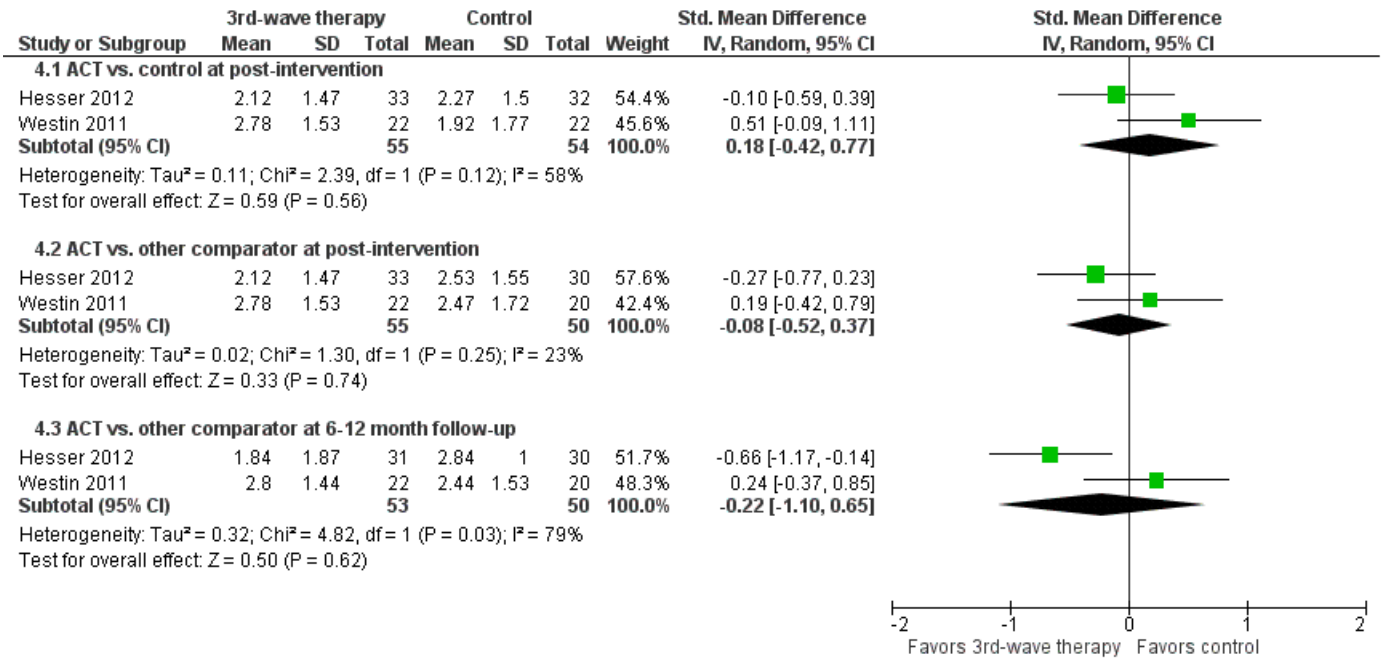
Figure 3: Forest plots of third-wave therapies versus controls and other treatments for depression at post-intervention and follow-up.



Notes: ACT= Acceptance and Commitment Therapy; Chi^2= chi-squared statistic; CI= confidence interval; df= degrees of freedom; I^2= I-squared heterogeneity statistic; IV= inverse variance; MBIs= Mindfulness-Based Interventions; P= p-value; SD= standard deviation; std.= standardized; Tau^2= tau-squared statistic; Z= Z statistic.

Figure 4: Forest plots of third-wave therapies versus controls and other treatments for anxiety at post-intervention and follow-up.



Notes: ACT= Acceptance and Commitment Therapy; Chi^2= chi-squared statistic; CI= confidence interval; df= degrees of freedom; I^2= I-squared heterogeneity statistic; IV= inverse variance; MBIs= Mindfulness-Based Interventions; P= p-value; SD= standard deviation; std.= standardized; Tau^2= tau-squared statistic; Z= Z statistic.

Figure 5: Forest plots of third-wave therapies versus controls and other treatments for quality of life at post-intervention and follow-up.

Table 1: Study, demographic and clinical characteristics of studies included in the review.

Authors (year)	Country	Type of study	Referral setting	Audiological problem	Diagnostic inclusion criteria	Third-wave Intervention	Tx comparators	n allocated (n of completers)		Mean age (range)	% male
								Intervention	Comparators		
Arif et al (2017)	UK	RCT	Clinical and self-referral	Tinnitus	Conducted a pure-tone audiogram and tympanogram	Mindfulness meditation	RT	42 (34)	44 (27)	55.8 (25-80)	45
Hesser et al (2012) (2014)	Sweden	RCT	Self-referral	Tinnitus	Formal proof of tinnitus dated >6 months	ACT	CBT, online discussion forum	35 (32)	32 (25), 32 (32)	48.5 (NS)	57
McKenna et al (2017)	UK	RCT	Clinical	Tinnitus	Completed medical investigations for tinnitus, tinnitus present >6 months	MBCT	RT	39 (37)	36 (32)	Median age: 50 (NS)	55
Molander et al (2018)	Sweden	RCT	Self-referral	Hearing problems	Score >8 on HHIE-S	ACT	WLC	31 (27)	30 (29)	59.0 (25-83)	33
Philippot et al (2012)	Belgium	RCT	Self-referral	Tinnitus	Medical check-up by hearing-related specialist, tinnitus experienced within past 6 months	MBCT	RT	15 (13)	15 (12)	60.0 (35-79)	60
Westin et al (2011)	Sweden	RCT	Clinical and self-referral	Tinnitus	Pure-tone threshold ≤30dB HL up to 2kHz testing frequency, score ≥28 on THI	ACT	TRT, WLC	22 (21)	20 (18), 22 (22)	50.9 (20-72)	53
Dehnabi et al (2017)	Iran	Observational cohort	Unclear	Deafness	NS	MBSR	Control[a]	12 (NS)	12 (NS)	NS	67
Drey (2017)	USA	Observational cohort	Self-referral	Tinnitus	Formal proof of tinnitus dated >6 months prior treatment	ACT	NA	7 (7)	NA	32.6 (27-39)	100
Ferraro et al (2019)	Italy	Observational cohort	Clinical and self-referral	Tinnitus	NS (patients were from Audiology Unit)	Metacognitive therapy	NA	12 (9)	NA	49.1 (NS)	56
Gans et al (2014) (2015)	USA	Observational cohort	Clinical and self-referral	Tinnitus	Medical check-up by audiologist, score ≥20 on THI	MBTSR	NA	10 (8)	NA	58.0 (38-70)	75

Authors (year)	Country	Type of study	Referral setting	Audiological problem	Diagnostic inclusion criteria	Third-wave Intervention	Tx comparators	n allocated (n of completers)		Mean age (range)	% male
								Intervention	Comparators		
Hassinen & Lappalainen (2018)	Finland	Observational cohort	Community (Service Centre for the Deaf)	Deaf	NS (participants were from service centre)	ACT	NA	16 (NS)	NA	43.8 (20-60)	56
Hesser et al (2009)	Sweden	Observational cohort	Unclear	Tinnitus	score ≥30 on THI	ACT	NA	24 (NS)	NA	52.7 (34-72)	33
Husain et al (2019) Zimmerman et al (2019)	USA	Observational cohort	Self-referral	Tinnitus	Pure-tone threshold ≤30dB HL up to 2kHz testing frequency, score ≥28 on THI	MBCT	NA	21 (15)	NA	55.5 (25-72)	47
McKenna et al (2018)	UK	Observational cohort	Clinical	Tinnitus	Medically and audiologically assessed, tinnitus present >3 months	MBCT	NA	205 (182)	NA	59.0 (27-83)	43
Roland et al (2015)	USA	Observational cohort	Clinical and self-referral	Tinnitus	NS (patients were from clinic)	MBSR	NA	16 (13)	NA	55.0 (32-65)	31

Notes:

[a]No information on the type of control group.

ACT: Acceptance and Commitment Therapy; CBT: Cognitive Behavioral Therapy; HHIE-S: Hearing Handicap Inventory for the Elderly – screening version; MBCT: Mindfulness-Based Cognitive Therapy; MBSR: Mindfulness-Based Stress Reduction; MBTSR: Mindfulness-Based Tinnitus Stress Reduction; n: number; NA: not applicable; NS: not specified; RCT: randomized controlled trial; RT: Relaxation Therapy/Training; THI: Tinnitus Handicap Inventory; TRT: Tinnitus Retraining Therapy; Tx: treatment; WLC: wait-list control.

Table 2. Intervention characteristics of studies included in the review.

Study (year)	Intervention arm	Control arm	Mode of intervention	Number of sessions	Duration of session (in mins)	Manualized therapy?	Therapist(s) professional background	Therapist(s) training to deliver intervention	Supervision of therapist(s) to deliver intervention
Arif et al (2017)	Mindfulness meditation	RT	Individual	5	40	Partially adequate[a]	1 experienced therapist	NS	NS
Hesser et al (2012) (2014)	ACT	CBT; online discussion forum	Online	8	NA	Adequate	1 licensed psychologist and 4 Master's students in clinical psychology	Yes	Yes
McKenna et al (2017)	MBCT	RT	Group	8	120	Adequate	2 clinical psychologists (experience in CBT and RT)	Yes	Yes
Molander et al (2018)	ACT	WLC	Online	8	NS	Adequate	4 Master's students; 1 licensed psychologist (experience in CBT and ACT)	Yes	Yes
Philippot et al (2012)	MBCT	RT	Group	7	135	Adequate	2 PhD level psychotherapists (experience in mindfulness and RT)	Yes	Yes
Westin et al (2011)	ACT	TRT; WLC	Individual	5 – 10	60	Adequate	6 Master's students in clinical psychology; 2 clinical psychologists	Yes	Yes
Dehnabi et al (2017)	MBSR	Unclear	Group	8	NS	Unclear	NS	NS	NS
Drey (2017)	ACT	NA	Individual	4	60	Partially adequate[b]	PhD student (theoretical knowledge of ACT)	Yes	Yes
Ferraro et al (2019)	Metacognitive therapy	NA	Group	8	90	Unclear	4 trained psychotherapists	NS	NS
Gans et al (2014) (2015)	MBTSR	NA	Group	8	150	Adequate	1 licensed clinical psychologist (trained in MBSR and psychological impact of deafness and hearing difficulty)	Yes	Yes
Hassinen & Lappalainen (2018)	ACT	NA	Individual and group	7 – 11	65	Adequate	9 voluntary counsellors (have been working with deaf or deaf-blind clients for >3 years)	Yes	Yes

Study (year)	Intervention arm	Control arm	Mode of intervention	Number of sessions	Duration of session (in mins)	Manualized therapy?	Therapist(s) professional background	Therapist(s) training to deliver intervention	Supervision of therapist(s) to deliver intervention
Hesser et al (2009)	ACT	NA	Individual	Average 8.7	45 – 75	Adequate	6 Master's students in clinical psychology; 2 clinical psychologists	NS	Yes
Husain et al (2019) Zimmerman et al (2019)	MBCT	NA	Group	8	120	Adequate	Clinical psychology graduate students (had experience leading MBCT groups)	Yes	Yes
McKenna et al (2018)	MBCT	NA	Group	8	120	Adequate	3 clinical psychologists (experience in MBCT, CBT and in working with tinnitus)	Yes	Yes
Roland et al (2015)	MBSR	NA	NS	8	120	Adequate	Certified MBSR instructor	Yes	NS

Notes:

[a]The control group was adequately manualized whereas the manual for mindfulness meditation was not stated.

[b]Only one supporting statement was provided in the appendix which is not referenced in-text.

ACT: Acceptance and Commitment Therapy; CBT: Cognitive Behavioral Therapy; MBCT: Mindfulness-Based Cognitive Therapy; MBSR: Mindfulness-Based Stress Reduction; MBTSR: Mindfulness-Based Tinnitus Stress Reduction; NA: not applicable; NS: not specified; RT: Relaxation Therapy/Training; TRT: Tinnitus Retraining Therapy; WLC: wait-list control.

Table 3. Results of studies included in the systematic review.

Study (year)	Ax periods	Statistical analyses	Primary and secondary outcome measures	Main results	Total sample enrolled (N=) Analyzed sample (n=)	Additional information
Arif et al (2017)	Pre, post	Paired sample t-tests	Primary: TRQ Secondary: HADS	Significant between-group differences for TRQ, where greater differences in mindfulness meditation. Improvements in both groups for all OMs.	N = 86 n = 61	Analyses comparing between- and within-group differences were not stated.
Hesser et al (2012) (2014)	Pre, post, 12-M FU	Linear mixed-effect models with maximum likelihood estimation	Primary: THI Secondary: HADS, QoLI	Significant between-group difference for THI, where lower scores in intervention conditions vs control (ACT Cohen's d=0.68). Significant differences between CBT vs control for HADS-A and QoLI. Significant differences between ACT vs control for HADS-A and HADS-D. No significant differences between CBT and ACT for all OMs. Reliable change for THI reported for 60% in ACT vs 44% in CBT vs 16% in control at post-intervention and 44% in CBT vs 29% in ACT at FU. No significant between group differences between CBT vs ACT for reliable changes.	N = 99 n = 99	2014 publication reported secondary data analyses.
McKenna et al (2017)	Pre, post, 1-M FU, 6-M FU	Linear mixed model	Primary: TQ Secondary: TFI, HADS	Significant reduction from pre-post in both groups for TQ, where lower scores in MBCT vs RT (Cohen's d=0.49). Scores for TQ were not significantly different at 1-M FU, but significantly lower in MBCT vs RT at 6-M FU. Significant reduction from pre-post for HADS in both groups but no significant between-group differences at any other timepoints. Significant reductions for TFI scores in both groups, but group-difference only at 6-M FU (lower in MBCT vs RT; Cohen's d=0.56). Reliable change for TQ reported for 59% in MBCT vs 44% in RT at post-intervention and 62% in MBCT vs 53% in RT at 6-M FU. No significant between group differences for reliable changes.	N = 75 n = 75	Difference between treatments was adjusted for pre-intervention score in each group.
Molander et al (2018)	Pre, post	Linear mixed effect models with maximum likelihood-estimation	Primary: HHIE Secondary: GAD-7, PHQ-9, QoLI	Significant group x time interaction for HHIE (Cohen's d=0.93), PHQ and QoLI, in favor of intervention vs control. No significant group differences for GAD-7.	N = 61 n = 61	_
Philippot et al (2012)	Baseline, pre, post, 3-M FU	2 x 2 ANOVAs	Primary: QIPA Secondary: BDI, STAI	No significant time or group effects for any other OM at pre-post. Significant time x group interaction for cognitive control at pre vs 3-M FU (decreases in MBCT while increases in RT) and not at other time points indicate treatment benefits of MBCT.	N = 30 n = 25	Period between baseline and pre involved psychoeducation.

Study (year)	Ax periods	Statistical analyses	Primary and secondary outcome measures	Main results	Total sample enrolled (N=) Analyzed sample (n=)	Additional information
Westin et al (2011)	Pre, 10-W, 6-M, 18-M	Linear mixed effect models with maximum-likelihood estimation	Primary: THI Secondary: QoLI, HADS	Significant time (pre vs 10-W) x group (ACT vs WLC) interaction for THI (Cohen's d=1.04) and HADS-anxiety, where lower scores in ACT. Significant time (all ax points) x group (ACT vs TRT) interaction for THI (Cohen's d=0.75), where lower scores in ACT. No significant effects of time or treatment for remaining OMs. Treatment gains maintained in ACT for all OMs at 6- and 18-M vs 10W. Reliable change for THI reported for 54.5% in ACT vs 20% in TRT at 6-M FU.	N = 64 n = 62	10-week (i.e. post-intervention in ACT). 18-M (i.e. post-intervention in TRT).
Dehnabi et al (2017)	Pre, post	Analysis of Covariance (ANCOVA)	Primary: Social Phobia Inventory (SPIN): avoidance, fear, physiological	According to the study, it was concluded that intervention leads to a reduction in the total score of social anxiety and its physiological component.	N = 24 n = NS	Poor reporting of findings.
Drey (2017)	Pre, post	Paired sample t-tests	Primary: PHQ-9, STAI-Y, TFI, WHO Overall QoL	Significant pre-post differences for TFI, STAI-Y and PHQ-9. No significant pre-post differences for WWHO Overall QoL.	N = 7 n = 7	_
Ferraro et al (2019)	Pre, post, 3-M FU	Friedman test	Primary: THI, HADS	Significant differences for THI in post and FU vs pre and post vs FU. Significant decreases over time in anxiety subscale but not depression subscale.	N = 12 n = 9	_
Gans et al (2014)	Pre, post	Paired sample t-tests	Primary: THI Secondary: SCL-90-R	Moderate to large improvements seen for THI and the depression and anxiety subscale of SCL-90-R.	N = 10 n = 8	Reported effect size (Cohen's d) rather significance levels due to small sample size.
(2015)	12-M FU	NS		Reported sustained and continued reduction in THI 12 months after participation in intervention.	n=7	No analyses reported for 2015 publication.
Hassinen & Lappalainen (2018)	Pre, post, 6-M FU	Repeated measure design	Primary: BDI, SCL-90	Significant effect for time on anxiety subscales of SCL-90. A non-significant difference for the depression subscale of SCL-90. A non-significant trend was observed for BDI.	N = 16 n = 16	_
Hesser et al (2009)	Pre, before each therapy session, 1-W post-, 6-M FU	NS	Primary: THI	Significant pre vs 6-M FU differences. Decrease from pre vs Session 2 was not significant, but significant difference seen between pre vs Session 3.	N = 24 n = 19	Paper primarily explored mediators of treatment effects.

Study (year)	Ax periods	Statistical analyses	Primary and secondary outcome measures	Main results	Total sample enrolled (N=) Analyzed sample (n=)	Additional information
Husain et al. (2019) Zimmerman et al (2019)	Pre, post, 8-W FU	Friedman tests	Primary: THI, TPFQ, TFI	Significant reduction in TFI between pre vs post, but a non-significant increase from post vs FU. Significant declines in THI and TPFQ between pre vs FU, but non-significant difference between pre vs post.	N = 21	Zimmerman et al. (2019) reported secondary data analyses.
McKenna et al (2018)	Pre, post, 6-M FU	Paired sample t-tests	Primary: TQ	Significant pre-post and pre-FU differences for TQ.	N = 205 n = 182	_
Roland et al (2015)	Pre, post, 4-W FU	Friedman tests, seed-based analyses	Primary: THI, TFI Secondary: PHQ-9, PROMIS-A	Significant pre-post, pre-FU and post-FU differences for THI and TFI. A non-significant pre-post change for PHQ-9. No significant pre-post difference for remaining OMs. Reliable change in THI reported for 62% at post-intervention and 77% at FU.	N = 16 n = 13	Only primary outcomes included a FU assessment.

Notes:

Significance of findings is defined as $p<0.05$.

Ax: assessment; BDI: Beck Depression Inventory; CBT: Cognitive Behavioral Therapy; FU: follow-up; GAD: Generalized Anxiety Disorder; HADS: Hospital Anxiety and Depression Scale; HHIE: Hearing Handicap Inventory for the Elderly; m: month; MBCT: Mindfulness-Based Cognitive Therapy; NS: not specified; OM: outcome measure; PHQ-9: Patient Health Questionnaire – 9; PROMIS-A: Patient-Reported Outcomes Measurement Information System – Anxiety; QoLI: Quality of Life Inventory; QIPA: Tinnitus Psychological Impact Questionnaire; RT: Relaxation Therapy/Training; SCL-90(-R): Symptom Checklist- 90 (Revised); SSTAI: State-Trait Anxiety Inventory; TFI: Tinnitus Functional Index; THI: Tinnitus Handicap Inventory; TPFQ: Tinnitus Primary Function Questionnaire; TQ: Tinnitus Questionnaire; TRQ: Tinnitus Reaction Questionnaire; TRT: Tinnitus Retraining Therapy; w: week; WHO Overall QoL: World Health Organization Overall Quality of Life; WLC: wait-list control.

Table 4. Potential sources of bias in studies included in the systematic review assessed by Cochrane's Risk of Bias.

Study (year)	Cochrane Collaboration Risk of Bias Tool					Overall
	Bias arising from the randomization process	Bias due to deviations from intended intervention	Bias due to missing outcome data	Bias in measurement of the outcome	Bias in selection of the reported result	
Arif et al (2017)	Low	Some concerns	Some concerns	High	Some concerns	High risk
Hesser et al (2012) (2014)	Low	Low	Low	High	Some concerns	High risk
McKenna et al (2017)	Low	Low	Low	High	Low	High risk
Molander et al (2018)	Some concerns	Low	Low	High	Low	High risk
Philippot et al (2012)	Some concerns	Some concerns	Low	High	Some concerns	High risk
Westin et al (2011)	Some concerns	Low	Low	High	Some concerns	High risk

Notes:

An overall risk of bias was rated as follows: low risk = all domains rated as low risk; some concerns = at least one domain rated as some concerns; high risk = at least one domain rated as high risk or multiple domains rated as some concerns.

Table 5. Potential sources of bias in studies included in the systematic review assessed by EPHPP.

Study (year)	EPHPP								Global rating	Further information
	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and dropouts	Intervention integrity	Analyses		
Dehnabi et al (2017)	Weak	Moderate	Weak	Moderate	Strong	Weak	(Q1) Can't tell (Q2) Can't tell (Q3) Can't tell	(Q1) Individual (Q2) Individual (Q3) Can't tell (Q4) Can't tell	Weak	No information about blinding
Drey (2017)	Weak	Moderate	Strong	Moderate	Strong	Strong	(Q1) 80-100% (Q2) Yes (Q3) No	(Q1) Individual (Q2) Individual (Q3) Yes (Q4) Can't tell	Moderate	No information about blinding
Ferraro et al (2019)	Weak	Moderate	Strong	Moderate	Strong	Moderate	(Q1) 80-100% (Q2) Can't tell (Q3) No	(Q1) Individual (Q2) Individual (Q3) Yes (Q4) Can't tell	Moderate	No information about blinding
Gans et al (2014) (2015)	Weak	Moderate	Strong	Moderate	Strong	Strong	(Q1) 80-100% (Q2) Can't tell (Q3) No	(Q1) Individual (Q2) Individual (Q3) Yes (Q4) Can't tell	Moderate	No information about blinding; no analysis reported for FU (2015 study)
Hassinen & Lappalainen (2018)	Moderate	Moderate	Strong	Moderate	Weak	Strong	(Q1) 80-100% (Q2) Can't tell (Q3) No	(Q1) Individual (Q2) Individual (Q3) Yes (Q4) Can't tell	Moderate	No information about blinding
Hesser et al (2009)	Weak	Moderate	Strong	Moderate	Moderate	Strong	(Q1) 80-100% (Q2) Yes (Q3) No	(Q1) Individual (Q2) Individual (Q3) Can't tell (Q4) Can't tell	Moderate	No information about blinding; no data or explanation for absence of data for 1-week post-treatment
Husain et al (2019) Zimmerman et al (2019)	Weak	Moderate	Strong	Moderate	Strong	Moderate	(Q1) 80-100% (Q2) Can't tell (Q3) No	(Q1) Individual (Q2) Individual (Q3) Yes (Q4) Can't tell	Moderate	No information about blinding
McKenna et al (2018)	Moderate	Moderate	Strong	Moderate	Strong	Strong	(Q1) 80-100% (Q2) Can't tell (Q3) No	(Q1) Individual (Q2) Individual (Q3) Yes (Q4) Can't tell	Strong	No information about blinding

Study (year)	EPHPP								Global rating	Further information
	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and dropouts	Intervention integrity	Analyses		
Roland et al (2015)	Weak	Moderate	Strong	Moderate	Strong	Moderate	(Q1) 80-100% (Q2) Can't tell (Q3) No	(Q1) Individual (Q2) Individual (Q3) Yes (Q4) Can't tell	Moderate	No information about blinding

Notes:

Questions under Intervention Integrity: (Q1) What percentage of participants received the allocated intervention; (Q2) Was consistency of intervention measured; (Q3) Is it likely that subjects received an unintended intervention that may influence the results.

Questions under Analyses: (Q1) Indicate unit of allocation; (Q2) Indicate unit of analysis; (Q3) Are the statistical methods appropriate for the study design; (Q4) Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than actual intervention received.

Table 6: Further critical appraisal of studies included in the systematic review.

Study (year)	Unrepresentative sample as self-referral was allowed	Unrepresentative sample due to demographic characteristics	Formal ax of hearing problems	Concurrent psychotherapy allowed	Received psychotherapy 3 months previously	Concurrent psychotropic pharmacotherapy allowed	Screening for cognitive impairment	Treatment adherence checks	Small sample size (n < 15 per group)	Other factors
Arif et al (2017)	Yes	Unclear	Yes	Unclear	Unclear	Unclear	Unclear	Unclear	No	No imputation of missing values
Hesser et al (2012) (2014)	Yes	Unclear	Yes	No	Unclear	Unclear	Unclear	Unclear	No	_
McKenna et al (2017)	No	Yes (80% white)	Yes	Unclear	Unclear	Unclear	Unclear	Yes	No	Selected participants for the presence of significant psychological distress (score >10 on the Clinical Outcomes in Routine Evaluation – Non-Risk)
Molander et al (2018)	Yes	Yes (33% men)	No	Unclear	Unclear	Unclear	Unclear	No	No	_
Philippot et al (2012)	Yes	Unclear	Yes	No	Unclear	Unclear	Unclear	Yes	Yes	No imputation of missing values
Westin et al (2011)	Yes	Unclear	Yes	Unclear	No	Yes	Unclear	Yes	No	Treatment and control conditions differed in duration (ACT for 10 weeks, TRT for 18 months; WLC for 10 weeks)
Dehnabi et al (2017)	Unclear	Yes (67% men)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	No analysis examining or controlling for group differences at baseline (a cohort study)
Drey (2017)	Yes	Yes (100% men; 71% white)	Yes	Unclear	No	Yes	Unclear	Yes	Yes	_
Ferraro et al (2019)	Yes	Unclear	Unclear	No	Unclear	No	Unclear	Unclear	Yes	No imputation of missing values
Gans et al (2014) (2015)	Yes	Yes (75% men)	Yes	No	Unclear	Unclear	Unclear	Unclear	Yes	No imputation of missing values

Study (year)	Unrepresentative sample as self-referral was allowed	Unrepresentative sample due to demographic characteristics	Formal ax of hearing problems	Concurrent psychotherapy allowed	Received psychotherapy 3 months previously	Concurrent psychotropic pharmacotherapy allowed	Screening for cognitive impairment	Treatment adherence checks	Small sample size (n < 15 per group)	Other factors
Hassinen & Lappalainen (2018)	Unclear	Unclear	Unclear	No	Unclear	Yes	Unclear	Unclear	Yes	Included participants with psychiatric comorbidities
Hesser et al (2009)	Unclear	Yes (33% men)	Unclear	Unclear	No	Unclear	Unclear	Yes	No	_
Husain et al (2019) Zimmerman et al (2019)	Yes	Unclear	Yes	Unclear	Unclear	Unclear	Yes	Unclear	Yes	No imputation of missing values
McKenna et al (2018)	No	Unclear	Yes	Unclear	Unclear	Unclear	Unclear	Yes	No	_
Roland et al (2015)	Yes	Yes (31% men)	Unclear	Unclear	Unclear	No	Yes	Unclear	Yes	No information about imputation of missing values

Notes:

Ax: assessment.

Appendix A
PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	p.1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	p.2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p.4-6
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p.6
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	p.6-9
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p.6-7
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	p.6-7
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p.7
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p.7-9
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	p.6-9
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	p.6-9
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	p.7-8
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	p.8-9
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	p.8-9
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	p.8-9
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	p.8-9
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	p.8-9
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	p.8-9

Section and Topic	Item #	Checklist item	Location where item is reported
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	p.8-9
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Figure 1
Study characteristics	17	Cite each included study and present its characteristics.	Table 1, 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Table 4, 5
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Figure 2-5
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	N/A
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	p.10-12, Figure 2-5
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	p.12
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p.15-16
	23b	Discuss any limitations of the evidence included in the review.	p.18
	23c	Discuss any limitations of the review processes used.	p.18
	23d	Discuss implications of the results for practice, policy, and future research.	p.16-17
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	p.6
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	p.6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N/A
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	p.20
Competing interests	26	Declare any competing interests of review authors.	p.20
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Appendix B
Search terms

((mindfulness-based OR acceptance-based OR "third wave" OR "third-wave therapy" OR "third-wave therapies" OR "mindfulness-based cognitive therapy" OR "mindfulness-based stress reduction" OR "compassion-focused therapy" OR "compassion focused therapy" OR "compassionate mind training" OR "behavioral activation" OR "behaviour activation" OR "behavioural activation" OR "behaviour activation" OR "dialectical behavior therapy" OR "dialectical behavioral therapy" OR "dialectical behaviour therapy" OR "dialectical behavioural therapy" OR "metacognitive therapy" OR "cognitive behavioral analysis system of psychotherapy" OR "cognitive behavioural analysis system of psychotherapy" OR "functional analytic psychotherapy" OR "integrative behavioral couple therapy" OR "integrative behavioural couple therapy" OR "acceptance and commitment therapy" OR "acceptance commitment therapy" OR "acceptance commitment training" OR "acceptance and commitment training") AND (tinnitus* OR hearing* OR balance* OR "sound sensitivity" OR hyperacus* OR hypoacus* OR distortion OR diplacusis OR deaf* OR "communication disorder" OR cochlea* OR vestibular OR auditory OR audiolog* OR acoustic OR aural OR ear OR sensory OR otolog* OR otoacoustic)

Supplemental Table 1: Characteristics of third-wave therapies

Name	Mindfulness-based Cognitive Therapy (MBCT)	Mindfulness-based Stress Reduction (MBSR)	Acceptance and Commitment Therapy (ACT)	Dialectical Behaviour Therapy (DBT)	Compassion-Focused Therapy (CFT)	Meta-cognitive Therapy (MT)
Key references	Segal et al. (2002)	Kabat-Zinn (1990)	Hayes et al. (1999)	Linehan (1993a,b)	Gilbert (2009)	Wells (2009)
Goals of therapy	To cultivate non-judgmental, present-focused awareness of one's thoughts, emotions and physical sensations, with an attitude of acceptance and self-compassion	To cultivate non-judgmental, present-focused awareness of one's thoughts, emotions and physical sensations, with an attitude of acceptance and self-compassion	To be more open to and accepting of one's internal experiences (e.g. thoughts, emotions and physical sensations), to become more aware of one's internal experiences in the here-and-now, and to commit to doing things guided by what really matters to oneself	To help oneself engage in functional, meaningful behavior in the presence of intense emotions (e.g. by encouraging acceptance and tolerance of distressing internal experiences)	To foster a compassionate relationship with oneself and others, and to experience inner warmth, safeness and soothing through the development of self-compassion and compassion skills	To modify thoughts and beliefs about one's thinking processes rather than the content of one's thoughts, and to develop skills in attentional control and mindfulness
Mode of delivery	Group	Group	Individual or group	Both individual and group	Individual or group	Individual or group
Who typically provides the therapy*	Psychologists, psychotherapists, CBT therapists and counsellors	Psychologists, psychotherapists, CBT therapists and counsellors	Psychologists, psychotherapists, CBT therapists and counsellors	Psychologists, psychotherapists, CBT therapists and counsellors	Psychologists, psychotherapists, CBT therapists and counsellors	Psychologists, psychotherapists, CBT therapists and counsellors
Average number of sessions	8 (with or without a 1-day retreat)	8 (with or without a 1-day retreat)	6-12	6-12	4-6	8-12
Average duration of each session (mins)	120	120-150	60	60	60 – 120	60-90

Note: * Although psychologists, psychotherapists, CBT therapists and counsellors may typically provide these therapies, audiologists who are trained in these interventions can also deliver them.

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