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Review article

The effects of positive psychology interventions on well-being and distress in patients with cardiovascular diseases: A systematic review and Meta-analysis

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ABSTRACT

Objective: Positive psychology interventions (PPIs) have been found to be effective for psychiatric and somatic disorders. However, a systematic review and meta-analysis of studies examining the effectiveness of PPIs for patients with cardiovascular disease (CVD) is lacking. This systematic review and meta-analysis aims to synthesize studies examining the effectiveness of PPIs and to examine their effects on mental well-being and distress using meta-analyses.

Methods: This study was preregistered on OSF (https://osf.io/95sjg/). A systematic search was performed in PsycINFO, PubMed and Scopus. Studies were included if they examined the effectiveness of PPIs on well-being for patients with CVD. Quality assessment was based on the Cochrane tool for assessing risk of bias. Three-level mixed-effects meta-regression models were used to analyze effect sizes of randomized controlled trials (RCTs).

Results: Twenty studies with 1222 participants were included, of which 15 were RCTs. Included studies showed high variability in study and intervention characteristics. Meta-analyses showed significant effects for mental well-being ($\beta = 0.33$) and distress ($\beta = 0.34$) at post-intervention and the effects were still significant at follow-up. Five of the 15 RCTs were classified as having fair quality, while the remaining had low quality.

Conclusion: These results suggest that PPIs are effective in improving well-being and distress in patients with CVD and could therefore be a valuable addition for clinical practice. However, there is a need for more rigorous studies that are adequately powered and that help us understand what PPIs are most effective for which patient.

1. Introduction

Cardiovascular diseases (CVDs) are a combination of blood vessel and heart diseases [1,2]. CVDs represented almost one third of worldwide deaths in 2019 [2] and have a lifetime risk of almost 55% for men and 38% for women [3]. CVDs are associated with high societal burden, with an estimated annual cost of 169 billion euro in 2006 in the European Union [4] and over 350 billion dollar in 2014–2015 in the United States [5].

CVDs do not only lead to high societal burden and have an impact on physical health, but also have consequences for mental health. Anxiety and depression are common in patients with CVD [6–9]. Major depressive disorder is found in approximately one fifth of CVD patients [8,10–13] and even more experience depressive symptoms [14]. A review on depression rates in patients undergoing a coronary artery bypass surgery estimated that 30 to 40% of those patients experience a depression (either minor, major or a dysthymia) [15]. In a similar vein, about one fifth of CVD patients experience anxiety [6]. A meta-regression on anxiety disorders in patients with a coronary heart disease showed a prevalence of 15.5% for any anxiety disorder and 8.0% for generalized anxiety disorder [16].

Reducing distress in patients with CVD is vital because depression and anxiety are associated with poorer health outcomes in patients with CVD. A large prospective longitudinal cohort study among 2325 patients with (chronic) ischemic heart disease showed a significant association between distress and mortality [7]. Depression is associated with higher mortality in patients with CVD [8,17–19], rehospitalisation [19,20], more days spent in hospital [20], visits to the emergency department

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[20] and clinical heart failure symptoms (e.g. sleep disturbance, [21]). In addition, anxiety is positively associated with mortality [22,23] and hospitalisation [24]. A variety of psychological interventions is available for this patient group, such as mindfulness interventions [25] and cognitive behavioral therapy (CBT) [26]. Although psychological interventions have a significant effect on anxiety, depression and stress, no significant effects were found for mortality in coronary heart disease patients [27].

Besides these findings related to distress, studies suggest that well-being related processes have beneficial effects for patients with CVD. In a meta-analysis, [28] found a prospective link between positive psychology constructs (e.g., well-being, optimism and positive affect) and a reduction in the risk of mortality and rehospitalization. The relationship between positive psychological states such as optimism and cardiovascular outcomes seem to be independent from negative ones such as depression [29]. This suggests that promoting well-being related outcomes can have positive effects on physical health related outcomes in patients with CVD.

Whereas traditional psychology primarily focuses on reducing dysfunctional behavior, cognition and emotion-regulation positive psychology aims to strengthen positive individual and social functioning to promote flourishing [30]. Positive Psychology Interventions (PPIs) aim to foster positive behaviors, feelings and cognitions with activities targeting for example optimism, altruism, gratitude, character strength use [29,31,32]. PPIs not only have positive effects on mental well-being, but also on depression and anxiety in general (non-clinical) samples [31,32]. Recently, [33] performed a large meta-analysis of PPIs and found moderate effects for stress, anxiety, depression, quality of life, and well-being, with CVDs do not only lead to high societal burden and have an impact on physical health, but also have consequences for the mental health of patients. A meta-analysis of PPIs targeted at patients with somatic and psychiatric disorders was performed [34] and found that PPIs significantly improved well-being, and reduced anxiety and depression. In addition, [35] conducted a meta-analysis of PPIs in medically ill patients (e.g., chronic pain, cancer, and heart disease), but focused only on anxiety as outcome. They found a significant moderate effect on anxiety at post-test, which could be maintained until follow-up. Recently, a systematic review and meta-analysis was performed on psychological interventions for patients with a coronary artery disease [36]. They included three multicomponent PPIs and 16 CBT studies and found that interventions were effective in improving anxiety, depression and stress.

To the knowledge of the authors, no comprehensive systematic review and meta-analysis of PPIs for patients with all types of CVD has been conducted. One previous meta-analysis examined the effectiveness of PPIs in CVD [36]. However, they only included studies for patients with coronary artery disease, limiting the scope of their review in terms of type of CVD. Therefore, it remains unclear to what extent PPIs are effective in improving well-being and distress in patients with CVD. The present systematic review and meta-analysis aims to fill this gap in literature by synthesizing studies examining the effectiveness of PPIs in CVD patients. In addition, a meta-analysis will be conducted across included randomized controlled trials to determine whether PPIs are indeed effective in improving well-being and distress.

2. Method

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [37] was used for conducting this systematic review. This study was pre-registered on OSF registries [38].

2.1. Eligibility criteria

The following inclusion criteria were used: the study (1) included patients with a CVD, (2) examined the effectiveness of a PPI, an intervention that is aimed at increasing mental well-being and positive behaviors, feelings and cognitions [32], and (3) mental well-being (e.g. positive affect and satisfaction with life) was included as outcome measure. To get a complete overview of existing PPIs for CVD patients, different study designs were included in the systematic review, including RCTs, quasi-experimental and uncontrolled designs.

Records were excluded if they (1) were not published in a peer-reviewed journal or the article itself was not full peer-reviewed (e.g. the letter to the editor of [39]), (2) were not in English, (3) focused on prevention of those at risk for a CVD, (4) included physical exercise as intervention, (5) were qualitative studies or case studies, (6) published a secondary analysis such as [40] or cross-trial publication such as [41], (7) were published before 1998, as 1998 is seen as the start year of the positive psychology [30] or (8) evaluated the effects of the intervention on non-psychological outcomes, such as biomarkers, such as [42].

2.2. Search strategy

A systematic search for literature was carried out in PsycINFO, PubMed and Scopus on March 29, 2022. The search string consisted of terms related to positive psychology interventions, cardiovascular diseases, mental well-being related outcomes and study design. The first, second and fourth author were consulted on the search string before the search was carried out. The search was limited to title/abstract (PubMed) and article/abstract/keywords (Scopus). Results were limited to English reports published between 1998 and 2022 (PubMed, Scopus) in academic journals (PsycINFO). The search string can be found in Appendix A. Previous (systematic) reviews and meta-analyses on this topic were cross-checked [29,34–36,43,44].

2.3. Study selection

The records retrieved from the electronic database searches were uploaded to Endnote (https://endnote.com). Duplicates were removed with the duplicate finder of Endnote and manually by the first author (KT). Then the remaining records were independently screened to find potentially eligible papers based on the title and abstract and if needed full texts were screened. The first author (KT) and a group of five trained bachelor psychology students who divided the records independently screened all records. Afterwards, the reports selected as relevant by the first author and the reports selected as relevant by the group of students were compared in terms of eligibility, finally resulting in the included papers. Any disagreements concerning eligibility of papers between the first author and the group of students were discussed with the second and fourth author until consensus was reached.

2.4. Data extraction

The extraction of data was conducted by the first author (KT). Data was collected on 1) population characteristics, including gender, age, type of disorder, and sample size (at allocation); 2) study characteristics, including study design, (control) conditions, outcome measures and used questionnaires, assessment points (pre, post, and/or follow up), and retention rate; 3) intervention characteristics: type of PPI, delivery mode, duration (in weeks) and the duration of a session (in minutes), number of sessions, guidance of a therapist (or no guidance); and 4) data to collect effect sizes (either mean and standard deviations pre-, post- and at follow-up) or the effect size mentioned in the paper. Data extraction was cross-checked by the second author. The authors of 12 papers were contacted for additional data needed to calculate an effect size. Reminders were sent if authors did not respond to our initial request. Eventually, three authors provided the requested data.

2.5. Quality assessment

The methodological quality of included RCTs was assessed based on the Cochrane collaboration's tool for assessing risk of bias [45]. Since not all items of this quality assessment are applicable for psychological

studies, only a selection of these items was used for the current study, following [46]. This is in accordance with previous meta-analyses on the effects of (positive) psychological interventions [34,46,47]. This resulted in the following eight criteria: (1) randomization, (2) description of drop-outs, (3) intention-to-treat (ITT) analyses, (4) the presence of qualified professionals, (5) sample size was based on a power-analysis or at least 64 per group, (6) integrity of the treatment, (7) comparability of the baseline and/or corrections to imbalance baseline were made, and (8) an adequate description of inclusion and/or exclusion criteria. See Table B1 in Appendix B for the criteria including a description for each item.

Each criterion was independently scored as absent (0) or present (1) by two authors (KT and JK). Uncertainties were discussed until consensus was reached. The percentage of items scored as present (1) was calculated over all criteria of a study to determine its (methodological) quality. The quality of a study was classified as lower (<70% of the criteria were scored as present), fair (at least 70%, but smaller than 100%) or good (100%). Percentages instead of sum scores were used, because not all criteria were applicable for all studies, since there is no guidance in self-help interventions and therewith the criterion on (guidance of a) qualified professional is not applicable. If this was the case, those items were scored with not applicable (NA), and the percentage of present (1) was calculated based on the remaining items that were actually scored.

2.6. Outcome measures

The primary outcome of the meta-analysis was mental well-being at post-intervention and (if applicable) at follow-up. The secondary outcome was distress (i.e. depression, anxiety and stress). These outcome measures were not further specified in, for example, depression or positive affect, because of the relatively small number of studies included.

2.7. Meta-analyses

For the systematic review, both RCTs and non-RCTs (quasi experimental studies and non- controlled trials) were included. In the meta-analysis, only RCTs were included. Therefore, studies without a control group [48–50] or without randomization [51,52] were not part of the meta-analysis. The data provided in the paper of [53] was not sufficient enough to be used in the meta-analyses and had therefore be excluded from the meta-analysis. Therefore, the data of 14 RCTs was included in the meta-analyses. In line with recommendations, meta-analyses were not specifically corrected for multiplicity testing [54].

Effect size calculation, meta-analyses and publication bias analyses were conducted in R [55] by using the packages metafor [56], dmetar, and esc [57]. If reported in the article or provided upon request, the standardized between- group difference in means and corresponding standard errors were calculated based on means and standard deviations. If this data was not available, the reported effect sizes were directly extracted, and *p*-values were used to calculate the standard error for each effect size. All effect sizes were calculated based on the ITT principle. If ITT data was not available, effect sizes were calculated based on per-protocol analyses. The sampling variance for each effect size was calculated as the square root of the standard error of the effect size [58].

Four separate meta-analyses were performed, for post-test and follow-up for well-being and distress. Three-level mixed-effects meta-regression models implemented in the metafor package [56] were used for all four meta-analyses. A three-level model was chosen, which accounts for effect sizes (level 3) nested within studies (level 2), while at the same time modelling between-study effects. One advantage of this approach is that statistical dependence can be modeled without knowing correlations between dependent effect sizes. Another advantage is that all individual effect sizes will be included in the analyses instead of aggregated effect sizes. This increases the precision and power of the pooled effect [59–62]. All models were also performed with outliers excluded to check for robustness of the findings. An effect size was seen as outlier if the 95% confidence interval of the individual effect size fell within the 95% confidence interval of the pooled estimate.

Cochran's Q statistic was used to determine heterogeneity of effect sizes. A significant Cochran's Q indicates heterogeneity [45]. I^2 statistic was used to calculate the degree of heterogeneity. I^2 values express the percentage of the sum of variance across all included effect sizes [63]. The smaller the percentage (I^2 value), the smaller the heterogeneity (i.e., 25% is classified as low, 50% as moderate, and 75% as high) [63]. I^2 values were reported separately for level 2 (within-study heterogeneity) and level 3 (between-study heterogeneity). Due to the relatively small number of included RCTs ($n = 14$), moderator analyses were not performed.

Risk for publication bias was tested by visual inspection of funnel plots, statistical analyses of asymmetry of the funnel plots and precision effect test and precision-effect estimate with standard error (PET-PEESE) [58,64]. Funnel plots are scatter plots of effect sizes against the standard error. Symmetrical funnel plots indicate low risk for publication bias [58]. Asymmetry of the funnel plot was statistically tested by including the inverse of the sample size as a covariate in the models. An indicator of asymmetry of a funnel plot is a significant relationship between the effect size and the inverse of the sample size [65]. PET-PEESE was used as additional indicator for publication bias, which represents a combined approach. In the PET model, the standard error of the effect sizes is included as potential covariate, and in the PEESE model the squared standard error is used as covariate [46]. The model's intercept can be interpreted as the true effect after correcting for small-study effects [58]. If the PET model's intercept is significantly larger than zero, the PEESE model's intercept should be used [58].

3. Results

3.1. Study selection

The search resulted in 2425 records (Fig. 1). An automatic search for duplicates resulted in the removal of 214 records, and 74 were manually removed duplicates. 2137 records were screened based on title and/or abstract during the first phase. The full texts of 56 studies were reviewed, resulting in the inclusion of 19 reports that met the inclusion criteria. Additionally, checking the included articles in other meta-analyses and (systematic) reviews [29,34–36,43,44] resulted in the inclusion of one additional article. This resulted in a final inclusion of 20 studies.

More than half of the studies were performed in the United States (k = 12), followed by Iran (k = 6), Spain (k = 1), and United Kingdom (k = 1). The first study was published in 2011 [66] and the most recent studies were published in 2022 [67], [68]. These and other characteristics can be found in Table 1 (study characteristics) and Table 2 (population and intervention characteristics).

3.2. Study characteristics

15 of the 20 studies were RCTs, three studies did not include a control condition [48–50] and two had a quasi-experimental design [51,52]. In three studies, the PPI was compared with two control conditions [66], [67], [69]. PPIs were compared to treatment as usual (TAU) (e.g. [70]), CBT [67], patient education programs (e.g. [71]) or waitlist (e.g. [72]). A variety of mental well-being related outcomes (e.g. optimism, positive affect, happiness) and distress (e.g. depression and anxiety) were included. A summary of study characteristics can be found in Table 1.

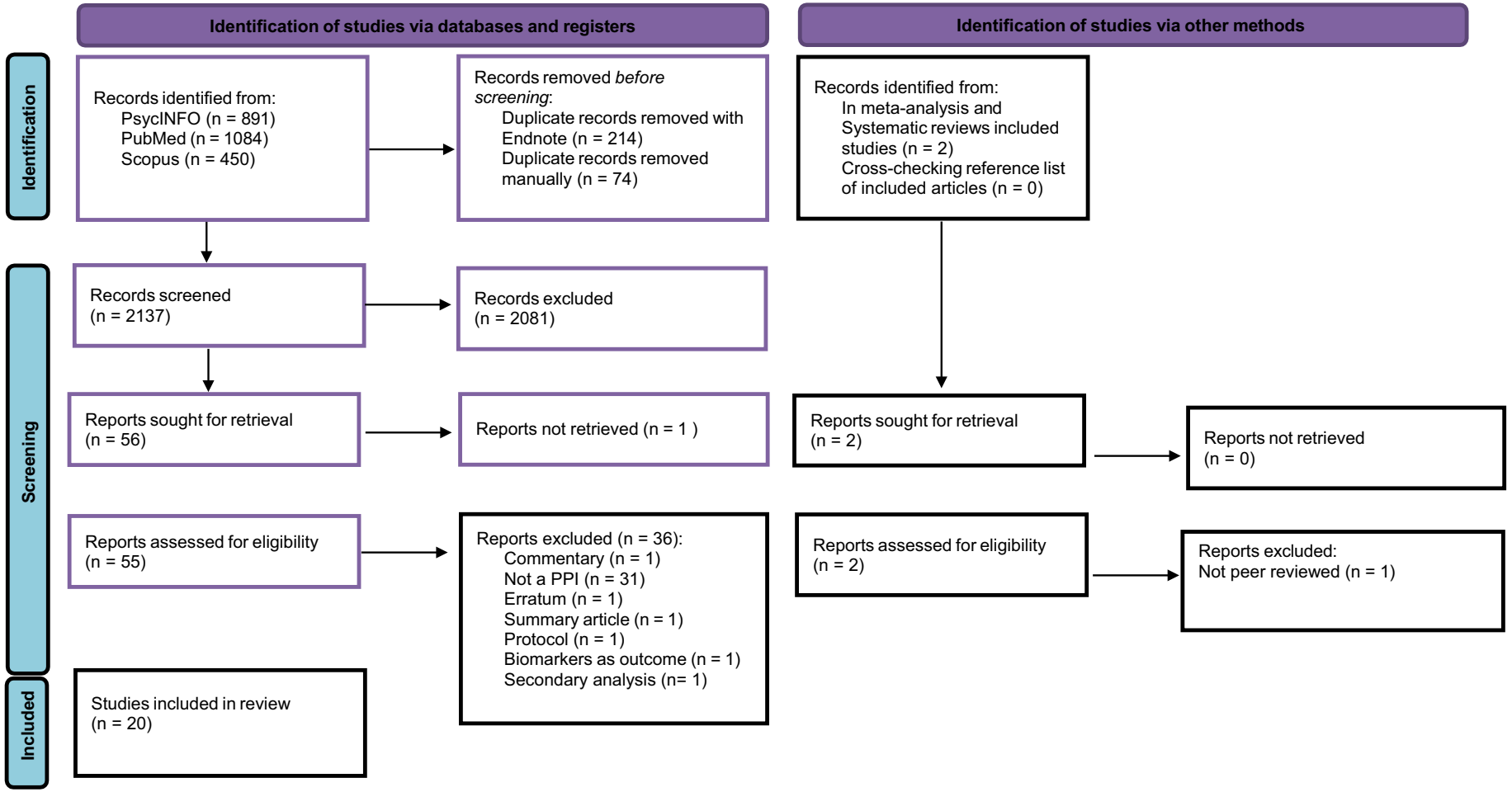

Fig. 1. PRISMA flow diagram of the search and selection of articles.
Note. Adapted from [37].

Table 1
Study characteristics.

Author(s) and year of publication	Study characteristics					
	Design	Control condition (n)	Outcome measures	Questionnaires	Assessment points*	Retention rate PPI-condition
Randomized Controlled Trials						
Carroll et al. (2020) [75]	RCT	Heart Healthy Education (10)	QoL Happiness	QOLI Happiness thermometer	Pre/Post Follow-up (9 months)	72.7%
Celano et al. (2020) [69]	Randomized pilot trial	MI-alone (15) TAU (15)	Positive affect Optimism Depression Anxiety	PANAS LOT-R HADS-D HADS-A	Pre/Post Follow-up (24 weeks)	100%
Cullen et al. (2018) [73]	Pilot RCT	TAU (13)	Emotional distress Well-being	DASS-21 AHI	Pre/Post Follow-up (20 weeks)	71.4%
Ghodsbin et al. (2015) [76]	RCT	? (45)	Spiritual WB	SWBS	Pre/Post Follow-up (11 weeks)	84.4%
Huffman et al. (2011) [66]	Randomized exploratory trial	Active control: relaxation response (7) Attentional control: recollection (7)	Depression Happiness Positive affect Anxiety MH QoL	CES-D SHS CESD-H HADS-A MOS SF-12 MCS	Pre/Post	?
Huffman et al. (2019) [77]	Pilot RCT	MI (23)	Positive affect Anxiety Depression Optimism MH QoL	PANAS HADS-A HADS-D LOT-R MOS SF-12 MCS	Pre/post Follow-up (24 weeks)	83%
Mohammadi et al. (2018) [71]	RCT	Education (30)	Positive affect Negative affect Optimism Hope Happiness Life-satisfaction Anxiety Depression Psychological distress	PANAS PANAS LOT-R AHS OHI SWLS HADS-A HADS-D HADS-T	Pre/Post Follow-up (16 weeks)	96.8%
Nikrahan, Suarez et al. (2016) [78]	Pilot RCT	Waitlist (14)	Happiness Depression Life-satisfaction Hope	OHI BDI-II SWLS DHS	Pre/Post Follow-up (15 weeks)	Seligman PPI: 76.9% Lyubomirksy PPI: 92.3% Fordyce: 66.7%
Nikrahan et al. (2019) [72]	Pilot RCT	Attention-matched (20): Patient Education	Psychological well-being Depression Positive affect Negative affect Optimism	Ryff's PWBS BDI-II PANAS PANAS LOT-R	Pre/Post Follow-up (15 weeks)	100%
Peterson et al. (2012) [53]	RCT	Patient Education (118)	Social support Stress Depression Positive affect Negative affect	MOS SSS PSS CES-D PANAS PANAS	Pre Follow-up (12 months)	?
Redwine et al. (2016) [70]	Pilot RCT	TAU (36)	Gratitude	GQ-6	Pre/Post	70.6%
Sadlonova et al. (2022) [67]	Pilot RCT	TAU (28) CBT (31)	Depression Optimism Happiness Psychological distress	BDI-II LOT-R OHI GHQ-28	Pre/Post Follow-up (15 weeks)	100%
Sanjuán et al. (2016) [79]	RCT	Cardiac Rehabilitation Programme/Waitlist for IV (51)	Depression Positive affect Negative affect	SCL-90-R PANAS PANAS	Pre/Post	87.7%
Terrill et al. (2018) [74]	Pilot	Waitlist (4)	Depression QoL Resilience Social Relationship	PROMIS-DS-F OPQOL CD-RISC SRI	Pre/Post Follow up (20 weeks)	90.9%
Terrill et al. (2022) [68]	Pilot RCT	Waitlist (28)	Depression	PROMIS-D-SF	Pre/Post Follow up (20 weeks)	90%
Non Randomized Controlled Trials						
Carrillo et al. (2021) [48]	Uncontrolled pilot study	–	Happiness Optimism Depression Anxiety Determination	NA	Pre/post Follow-up (8 weeks)	76.5%
Celano, Albanese, et al. (2018) [49]	Randomized factorial trial	–	Positive affect Optimism	PANAS LOT-R	Pre/post Follow-up (16 weeks)	88%

(*continued on next page*)

Table 1 (*continued*)

Author(s) and year of publication	Study characteristics					
	Design	Control condition (n)	Outcome measures	Questionnaires	Assessment points*	Retention rate PPI-condition
			Depression	HADS-D		
			Anxiety	HADS-A		
Celano, Freedman et al. (2018) [50]	Uncontrolled pilot study	–	Positive affect	PANAS	Pre/post	81.8%
			Optimism	LOT-R		
			Depression	HADS-D		
			Anxiety	HADS-A		
Elham et al. (2015) [51]	Quasi-experimental	TAU (33)	Anxiety	STAI	Pre/Post	NA
			Spiritual WB	SWBS		
Huffman et al. (2016) [52]	Non-randomized pilot study	TAU (25)	Positive affect	PANAS	Pre/post	87%
			Anxiety	HADS-A		
			Depression	HADS-D		
			Distress	HADS-T		
			Optimism	LOT-R		

Note. AHI = Authentic Happiness Inventory; AHS = Adult Hope Scale; BDI-II = Beck Depression Inventory-II; CBT = Cognitive Behavioral Therapy; CD-ISC = Connor Davidson Resilience Scale; CES-D = Center for Epidemiologic Studies (D = Depression Scale, H = Happiness); DASS-21 = Depression Anxiety Stress Scales short form; DHS = Dispositional Hope Scale; GHQ-28 = General Health Questionnaire 28 items; GQ-6 = six-item Gratitude Questionnaire; HADS = Hospital Anxiety and Depression Scale (D = Depression Scale, A = Anxiety Scale, T = Total); LOT-R = Life Orientation Test - Revised; MI = Motivational Interviewing; MOS SF 12 MCS = Medical Outcomes Study Short Form 12 Mental Component Score; MOS NA = Not Available, SSS = Medical Outcomes Study Social Support Survey; OHI = Oxford Happiness Inventory; OPQDL = Older People's Quality of Life Questionnaire; PANAS = Positive and Negative Affect Schedule; PSS = Perceived Stress Scale; PROMIS-DS-F = Patient Reported Outcomes Measurement Information System Depression Short Form; PWBS = Psychological Well-being Brief Scale; QoL = Quality of Life; QOLI = Qualtiy of Life Inventory; RCT = Randomized Controlled Trial; SHS = Subjective Happiness Scale; SCL-90-R = Symptoms Checklist Revised); SRI = Social Relationships Index; STAI = Spielberger State Trait Anxiety Inventory; SWLS = Satisfaction With Life Scale; SWBS = Spiritual Well-being Scale; TAU = Treatment As Usual; WB = Well-being.

* Weeks or months calculated from baseline.

3.3. Population characteristics

1222 participants were included, 692 in the PPI conditions (range 7–128 participants) and 530 in the control conditions (range 4–118) as can be found in Table 2. Sample sizes tended to be small, with only two studies including >65 participants [49,53]. The average age of the participants ranged from 52.6 to 70.8 years (M = 60.7). In eleven studies, the majority of the participants was male (range 52–95.2%). Three studies included post-stroke patients [68,73,74], the other studies included patients with a cardiac condition (k = 17). Cardiac conditions included acute coronary syndrome ($n = 4$), coronary artery disease ($n = 3$), heart failure (n = 3), coronary heart disease ($n = 2$), and others ($n = 5$).

Intervention characteristics.

An overview of different PPIs included in the 20 studies can be found in Table 2. Three studies were part of the development (from pilot testing to evaluating) process of a PPI called Positive Emotions after Acute Cardiac Events (PEACE) [49,52,77]. An overview of this six-year development process can be found in [80]. Two interventions were similar, but more intensive [69] or two weeks shorter [50]. Three studies involved single component interventions: positive thinking [76], optimism [71] and gratitude [70]. Nine studies involved a multicomponent intervention [53,66–68,72–75,79]. A multicomponent PPI includes a variety of activities such as acts of kindness, practicing gratitude or meaningfulness that target at multiple mental well-being related components [81]. One study was described as a spiritual/religious intervention [51], one as a text message intervention with partly well-being related messages (e.g. doing novel things to increase life satisfaction, [48] and the last study involved three different multicomponent PPIs [78]. The duration of the intervention varied from three days [51] to 12 weeks (the PEACE intervention, e.g. [77]. The number of sessions varied between three [51] and 28 (text messages, [48]) with a varied session duration of (median) 25 minutes [73] to 120 minutes [71]. 14 PPIs were performed under the guidance of a therapist, for one study it was not described whether there was guidance [76], the remaining five involved a text message intervention [48], self-administered intervention [68], [74], (gratitude) dairy [70], and a workbook combined with positive affect inducing telephone calls [53].

3.4. Quality of the studies

The quality of the RCTs can be found in Table S1 in the supplementary material. The lowest score was 37.5% [66] and the highest score was 87.5% [53,72]. Five of the 15 RCTs scored 70% or above and can therefore be classified as having fair quality [53,67,68,72,74], the other ten studies as having lower quality. A description of the inclusion and exclusion criteria was given in all RCTs, and was therefore the criterion with the highest score across studies. Including a sufficient number of at least 64 participants per condition or conducting a power analysis (and meeting the calculated number) was only met in one study [53].

3.5. Meta-analyses

For well-being, 27 comparisons from 11 studies were analysed at post-intervention, and 23 comparisons from 8 studies at follow-up. For distress, 25 comparisons from 9 studies were analysed at post-intervention, whereas 21 comparisons from 7 studies were analysed at follow- up. A summary of the three-level mixed-effects models can be found in Table 3.

For well-being, a significant effect was found at post-intervention ($\beta = 0.33$, 95% CI: 0.19 to 0.47, $p < 0.001$) and at follow-up ($\beta = 0.34$, 95% CI: 0.02 to 0.65, $p = 0.037$). Significant heterogeneity in effect sizes at post-intervention was found for mental well-being ($Q = 52.85$, $df = 26$, $p = 0.001$). Heterogeneity at level 2 ($\tau 2$ (level 2)) was zero and 0.04 at level 3 ($\tau 2$ (level 3)). The I2 was 52.74% at level 2 and 0.00% at level 3, indicating that just over half of the variance is explained by within-study differences, no variance is explained by between-study differences and 47.26% is explained by sampling error. One outlier was detected for post-test and three for follow-up. After excluding outliers, the pooled effects were slightly smaller, but still significant for post-test ($\beta = 0.29$, 95% CI: 0.17 to 0.42, $p < 0.001$) and follow-up ($\beta = 0.27$, 95% CI: 0.05 to 0.48, $p = 0.017$). The forest plot of included studies can be found in Fig. 2. The forest plot of included studies at follow-up can be found in the Supplementary Material (Fig. S1).

For distress, significant effects were found at post-intervention ($\beta = -0.31$, 95% CI: −0.45 to −0.16, $p < 0.001$) and at follow-up ($\beta = -0.48$,

Table 2
Population and Intervention characteristics.

Author(s) and year of publication	Country	Population characteristics: Type of CVD	Gender (% Male)	Age (M [SD])	Intervention characteristics: Type of PPI (n): Theoretical background	Delivery mode	Duration in weeks	Duration of a session (in minutes)	Number of sessions	Guidance of a therapist
Randomized Controlled Trials										
Carroll et al. (2020) [75]	USA**	ICD*	62%	62 (9)	Quality of Life Therapy (11): Happiness, quality of life and life satisfaction, combined with attention for relapse prevention and promotion of health behavior	In-person or phone based	12	M = 56 (SD = 6)	12	Yes
Celano et al. (2020) [69]	USA**	HF	73%	70.8 (10.3)	PPI + MI (15): See Celano, Freedman et al. (2018)	Phone based	12	?	12	Yes
Cullen et al. (2018) [73]	United Kingdom	Stroke	63%	Median: 57	PoPsTAR (14): PERMA framework of Seligman and Full Life conceptualization.	Face-to-face (one-to-one)	8	25–43	8	Yes
Ghodsbin et al. (2015) [76]	Iran	CAD	44.6%	60.2 (6.9) IV 58.1 (9.1) CC	Positive Thinking (45): Religion, relaxation, positive thinking	Face-to-face	7	75	7	Unclear
Huffman et al. (2011) [66]	USA**	ACS or CHF	NA	NA	PPI (9): gratitude, optimism and altruism	Phone based	8	?	8	Yes
Huffman et al. (2019) [77]	USA**	ACS	77%	60.8 (10.7)	PEACE-IV PPI + MI (24) See Huffman et al. (2016)	Phone based	12	30–45	12	Yes
Mohammadi et al. (2018) [71]	Iran	CHD	77%	52.6 (5.4)	Optimism IV (31): optimism training	Group based	8	120	8	Yes
Nikrahan, Suarez et al. (2016) [78]	Iran	CAD	76.3%	56.6 (8.7)	Seligman PPI (13): enhancing meaningfulness, engagement and a pleasant life. Lyubomirsky PPI (13): enhancing gratitude, optimism, spirituality and coping strategies. Fordyce PPI (15): positive emotion-based cognitive behavioral activities	Group based	6	90	6	Yes
Nikrahan et al. (2019) [72]	Iran	CAD	55%	58.6 (5.9)	Well-being IV (20) targets at eudaimonic well-being (self-acceptance, autonomy, personal growth, positive relationships, environmental mastery and purpose in life)	Group based	8	90	8	Yes
Peterson et al. (2012) [53]	USA	PCI	69.8%	62.1 (11) IV 64.4 (11) CC	Positive affect and self-affirmation combined with patient education (124)	?	?	?	?	?
Redwine et al. (2016) [70]	USA**	HF	95.2% (IV) 86.4% (TAU)	66.2 (7.6)	Gratitude journaling IV (37)	Diary	8	–	–	No
Sadlonova et al. (2022) [67]	Iran	CHD	86.9%	57.6 (8.3)	PPI (25): based on the Lyubomrisky PPI (see Nikrahan et al., 2019): enhancing spirituality, forgivingness, gratitude, optimism, mindfulness, altruïsm (acts of kindness), savoring, positive feelings and developing coping strategies.	Group based	8	90	8	Yes
Sanjuán et al. (2016) [79]	Spain**	Cardiac	82.4%	54.4 (9.1)	Programme to Improve Well-being (57)	Group based	6	60	4	Yes
Terrill et al. (2018) [74]	USA**	Stroke	45%	56 (18.1)	PPI with partner (7): multicomponent approach with the following exercises AoK, gratitude, fostering relationships, savoring, positive focus, spirituality and work towards a goal	Self-administered	8	–	–	No
Terrill et al. (2022) [68]	USA**	Stroke	58.8%	53.4 (16.1)	PPI with partner, ReStoreD (20): multicomponent approach with the following exercises	Self-administered	8	–	–	No

(*continued on next page*)

Table 2 (*continued*)

Author(s) and year of publication	Country	Population characteristics: Type of CVD	Gender (% Male)	Age (M [SD])	Intervention characteristics: Type of PPI (n): Theoretical background	Delivery mode	Duration in weeks	Duration of a session (in minutes)	Number of sessions	Guidance of a therapist
					AoK, gratitude, strengthen relationships, savoring, positive focus, find meaning and achieve a goal					
Non Randomized Controlled Trials										
Carrillo et al. (2021) [48]	USA**	ACS	67.7%	67.9 (8.7)	Text message IV (17): daily well-being and health behavior adherence promoting Messages	Phone based	4	?	28	No
Celano, Albanese et al. (2018) [49]	USA**	ACS	41%	63.1 (12.0)	PEACE-III (See Huffman et al., 2016) optimizing with Booster session Weekly/daily PPI exercises, and with/without MI (128)	Phone based	8	?	8	Yes
Celano, Freedman et al. (2018) [50]	USA**	HF	60%	67.1 (10.8)	PPI (11): goal-setting (on physical activity, medication adherence and diet) combined with PPI that targets gratitude, meaning and strengths.	Phone based	10	?	10	Yes
Elham et al. (2015) [51]	Iran	CVD	59.1%	68.9 (8.3)	Spiritual/religious IV (33): multicomponent approach with the following topics hope, spirituality and religion, strengthening relationships, generosity, and relaxation.	Face-to-face	≥ 3 days	60–90	≥3	Yes
Huffman et al. (2016) [52]	USA**	ACS	52%	60.4 (11.7)	PEACE-II (23): positive emotions (3 good things), strengths, gratitude, meaningful activities, recalling success, and kindness (AoK).	Phone based	8	?	8	Yes

Note. ACS = Acute Coronary Syndrome; AoK = Acts of Kindness; CAD = Caronary Artery Disease; CC = Control Condition; CHF = Congestive Heart Failure; CHD = Coronary Heart Disease; CVD = Cardiovascular Disease; HF = Heart Failure; IV = Intervention; ICD = Implantable Cardioverter Defibrillator; LKM = Loving Kindness Meditation; M = Mean; MI = Motivational Interviewing; PCI = Percutaneous Coronary Intervention; PPI = Positive Psychology Intervention; SD = Standard Deviation; TAU = Treatment As Usual; USA = United States of America.

* Included participants had a ICD because of a systolic left ventricular dysfunction.

** The country the study was conducted in was not mentioned in the paper, therefore the country mentioned in the table is based on the author's affiliation.

Table 3
Three-level random-effects meta-analysis of the effects of the Positive Psychology Interventions on distress and well-being at post-intervention and follow-up.

Outcome	K	Nstudies	β (95% CI)	τ2 (level 2)	τ2 (level 3)	I^2 (level 2)	I^2 (level 3)	Q (*df*)
Post-intervention								
Distress	25	9	−0.31*** (−0.45;-0.16)	0.00	0.03	25.52	0	33.48 (24)
Well-being	27	11	0.33*** (0.19;0.47)	0.00	0.04	52.74	0	52.85 (26)**
Follow-up								
Distress	21	7	−0.48** (−0.78; −0.19)	0.07	0.05	27.3	32.84	51.64 (20)**
Well-being	23	8	0.34* (0.02;0.65)	0.03	0.30	82.74	8.84	90.05 (22)**

CI = Confidence Interval, df = Degrees of freedom, K = Number of included effect sizes, $N_{Studies}$ = Number of studies, significance levels:
* $p < .05$,
** $p < .01$,
*** $p < .001$.

95% CI: −0.78 to −0.19, $p = 0.002$). Non-significant heterogeneity in effect sizes at post-intervention was found for distress (Q = 33.48, df = 24, $p = 0.094$). After excluding outliers (one for post-test and two for follow-up), the pooled effects were, again, slightly smaller, but still significant for post-test (β = −0.29, 95% CI: −0.44 to −0.14, $p < 0.001$) and follow-up (β = −0.40, 95% CI: −0.67 to −0.14, $p = 0.005$). The forest plot of included studies can be found in Fig. 3. The forest plot of included studies at follow-up can be found in the Supplementary Material (Fig. S2).

3.6. Publication bias

No indication asymmetry of included effect sizes was found through visual inspection of the funnel plots for well-being (Fig. S3 in the Supplementary Material) and distress (Fig. S4 in the Supplementary Material). The inverse of sample size was not significantly related to in this study observed effect sizes for both distress ($p = 0.65$) and well-being ($p = 0.50$) at post-test. These findings show that the funnel plot for both well-being and distress were symmetrical, which indicates the absence of publication bias.

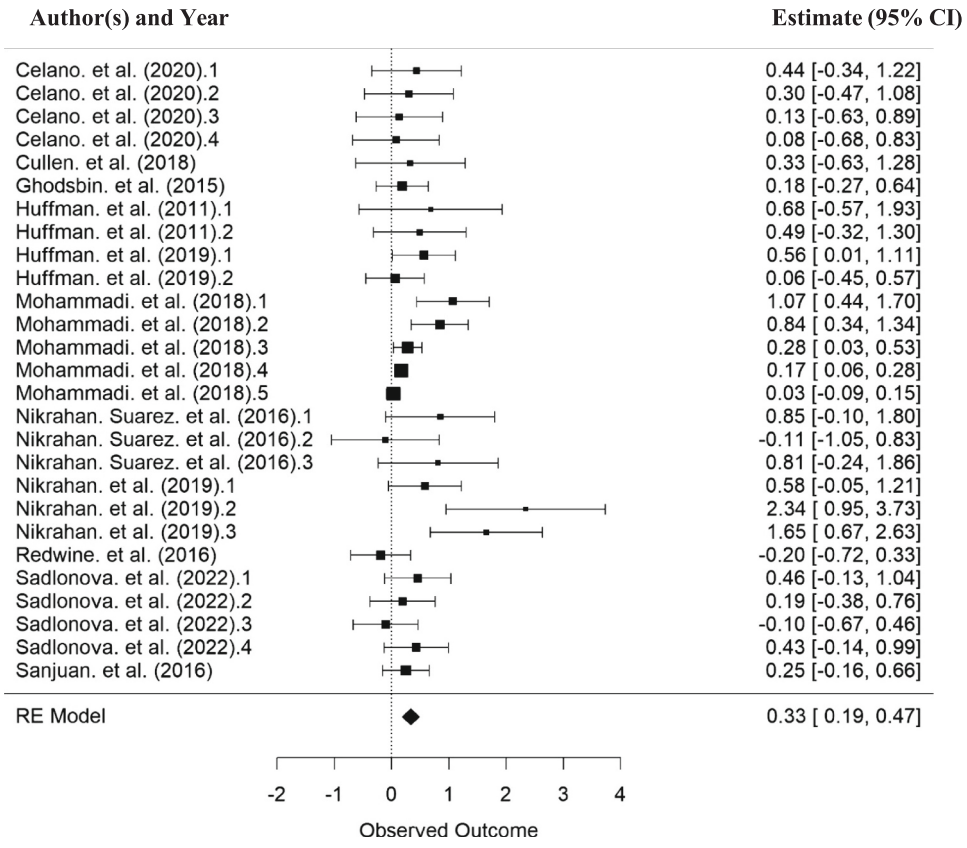

Fig. 2. Forest plot of included studies on well-being at post-intervention.

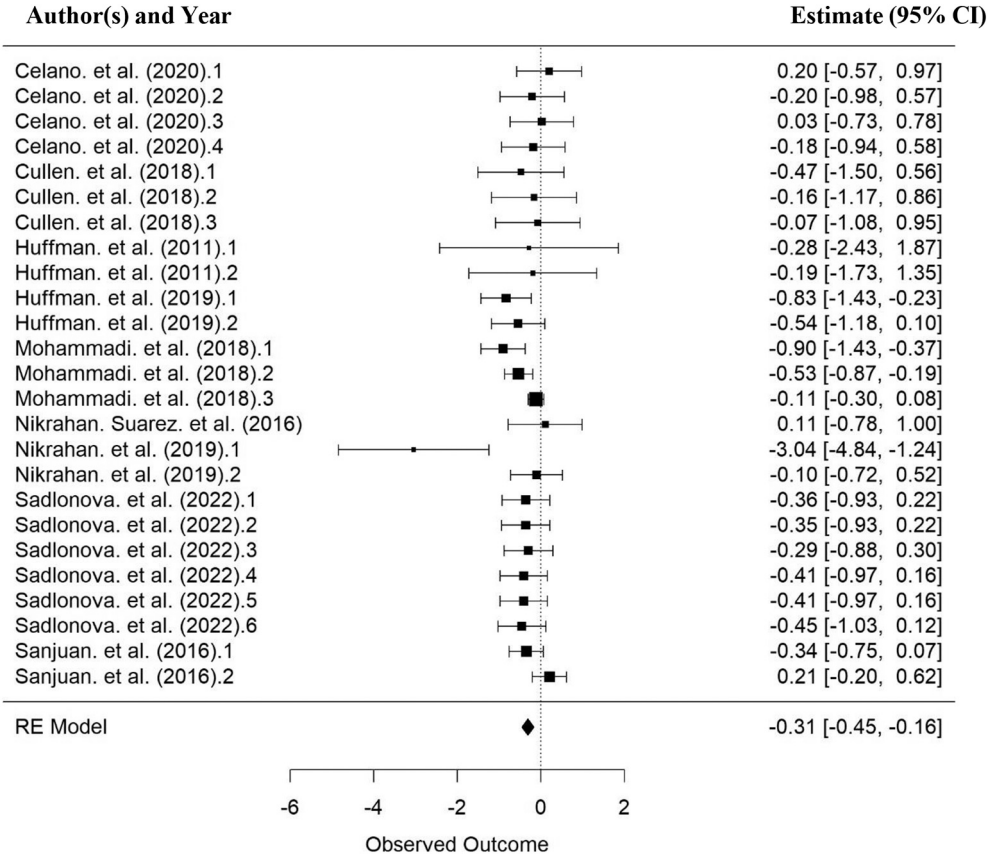

Fig. 3. Forest plot of included studies on distress at post-intervention.

For both well-being and distress at post-test, the PET intercept was not significantly different from zero ($p > 0.10$), therefore the PET intercept was used instead of the PEESE. The PET intercept for well-being ($\beta 0 = 0.08$, $p = 0.81$) was smaller than the effect size found in the primary meta-analysis. The PET intercept for distress ($\beta 0 = -0.42$, $p = 0.18$) was somewhat larger than the effect size found in the meta-analysis.

4. Discussion

PPIs aim to promote mental health and are proven to have a significant effect on mental well- being and depression [32]. A recent large meta-analysis showed that clinical groups can benefit more from PPIs than non-clinical participants [33]. Although several PPIs have been developed for patients with CVDs, a systematic review and meta-analysis is lacking. The current meta-analyses of 14 RCTs revealed significant effects for mental well-being and distress at post-intervention and follow-up compared to control conditions. These findings suggest that PPIs are effective in populations with CVDs in improving mental well-being and distress.

4.1. Main findings

The post-test effect size for mental well-being of 0.33 was slightly larger than the effect size of.

0.28 found by [34] in a clinical sample with both somatic and psychiatric disorders, but smaller than the effect size of 0.57 found by [33] in clinical samples. This finding was not in line with the finding of [36] who found no significant effects on happiness based on two studies in their meta-analysis in a sample of CAD patients. The results based on 14 studies show that the currently studied PPIs do have a significant effect on mental well-being. The follow-up effect size found of 0.34 for mental well-being was slightly smaller than the effect size of 0.41 found by [34]. This finding was not in line with the lack of a significant effect on positive affect found by [36]. The differences with the findings of [36] can be due to comparison in outcome measure that was made. Effects on happiness [36] were compared with effects on mental well-being in the current study, they also based their result on only two comparisons and the results of the current meta-analysis were based on a larger number of comparisons [36]. In addition, the differences with [33] can be due to the inclusion of a combination of mental (16.4%) and physical (13.5%) problems in comparison to patients with a CVD in the current meta-analysis.

A significant effect size of −0.31 was also found for distress at post-intervention, indicating that PPIs were not only effective in increasing well-being, but also in alleviating distress. This was comparable with the effect size for depression, but smaller than the effect size for anxiety by [34]. In contrast, they found a lack of a significant effect on stress based on five comparisons [34]. Our results are similar to the effects found by [36], who also found significant effects on depression and anxiety at post-intervention. The effect size found in the current study for distress was smaller than that for depression, anxiety and stress at post-test in the meta-analysis of [33]. The largest differences with the findings of [33] were the number of included comparisons and the inclusion of a broader group of participants. The effect size found at follow-up for distress was larger than the effect size at post-intervention. This shows that the effect can be sustained and might even be higher in the longer term. However, this must be interpreted with precaution considering the relatively low number of effect sizes and heterogeneity of population characteristics. This effect size is larger than the effect sizes for depression or anxiety found by [34]. In contrast to the non- significant effect on stress directly after the intervention, significant effects at follow-up were found for depression, anxiety and stress by [36]. These findings indicate that, although PPIs are primarily meant to increase mental well-being [32], they can also effectively decrease distress in CVD patients.

Besides the meta-analysis, a systematic review was performed on the characteristics of the included PPIs, participants and performed studies. A large number of the studied interventions were multicomponent PPIs, interventions that comprise multiple (positive psychology) exercises [82]. Based on a large meta-analyses was concluded that interventions with multiple (positive psychology) exercises had a larger effect on stress, depression and mental well-being than single component interventions [33]. One of these multicomponent PPIs was the PEACE intervention. The Positive Emotions after Acute Cardiac Events (PEACE) intervention was developed and improved during four phases, as discussed by [80]. In addition, three single component interventions were included in this study, these interventions targeted at positive thinking, optimism and gratitude.

4.2. Strengths and limitations

One strength of this meta-analysis and systematic review was the pre-registration of the protocol. This protocol was based on best practice recommendations as well as guidelines. The performance of the systematic review and meta-analysis were based on this protocol. However, there were also several limitations. Firstly, the relatively small number of studies resulted in the decision to use composite measures for distress and well-being to increase the power. Therefore, no conclusions on the effect of the interventions on specific aspects of well-being or distress can be drawn and more studies are needed to draw conclusions on the effectiveness of PPIs on mental well-being related outcome measures. Resilience is recommended to be included as outcome measure, since resilience contributes to a quicker recovery [83,84]. Secondly, due to the relatively small amount of studies, it was not possible to test for moderators or differentiate between the different types of CVDs. Thirdly, only RCTs published in peer-reviewed journals were included in this study. While this decision was made to ensure a certain quality of included studies, it also means that gray literature was not included, possibly leading to increased risk for findings suffering from publication bias. Fourthly, this study focused on mental health related outcomes and therefore did not include physical health related outcomes. However, [69] found positive effects of a PPI combined with motivational interviewing on medication adherence and physical activity. In addition, [53] found a significant increase in physical activity that sustained at 12 months follow-up. Therefore, it is recommended to include physical health related outcomes in future studies to understand the effect of PPIs on physical health of CVD patients.

4.3. Implications

Although the current systematic review and meta-analysis focused on PPIs for patients with CVDs including heart and vessel conditions, the majority of interventions in the included studies were targeted at patients with cardiac conditions. This indicates that studied interventions for patients with vessel disorders (e.g. a stroke) are still relatively scarce and the effects of PPIs for this type of CVD should be interpreted with caution. In addition, the number of studies that targeted at a specific type of CVD was low. This indicates that there is space for high quality studies that target at specific types of CVD as well as on vessel disorders to answer the question which CVD patient will benefit the most from which intervention. In addition, studies included in this review used a variety of delivery modes, including self-help, individual and group interventions. Group sessions can contribute to a community feeling and give the opportunity to share experiences, but have a limited opportunity for personalization. Due to the relatively small number of studies in this meta-analysis, we could not examine delivery mode as moderator for the effectiveness of interventions. Further research is needed to be able to get insight in the most effective delivery mode. Timing of the intervention is another interesting point to consider in future research. Some interventions included in our review targeted hospitalized patients before discharge [51,66], while other included patients that were physically stable for at least three months [75]. This raises the question

what could be the most optimal timing of PPIs for patients with CVDs and further research is needed to see what is the most optimal timing in this context. Answers to these questions may contribute to the effectiveness of PPIs for patients with CVD. These insights can also contribute to a personalized approach in terms of development and delivery of interventions and can contribute to an optimal implementation of PPIs in the care offered to CVD patients. In addition, the large majority of studies were performed in the United Stated (60%) and Iran (30%). This shows a lack of studies performed in other cultural contexts, such as Europe.

In addition, the relatively large contribution from studies performed in non-Western countries such as Iran in the current meta-analysis can influence the found effect size, since effect sizes found in those countries are comparably large [85].

Further, the quality of the included RCTs was relatively low, with the fast majority scoring low on an adequate sample size to have enough power to detect significant effects, baseline similarity or intention-to-treat analysis. The majority of smaller studies indicate that the studies on PPIs for patients with a CVD is still a relatively small research field, with space for larger, more thorough and higher quality studies.

5. Conclusion

This study shows that the use of PPIs to support the mental health of CVD patients is still at an early point. Meta-analyses revealed significant effects on mental well-being and distress at post-test and follow-up, showing that PPIs are effective in increasing mental well-being and distress in CVD patients in the short and long term. However, the results also show that larger and high quality studies are mostly lacking. Therefore, considering the promising findings of this meta-analysis, it is suggested to conduct more rigorous studies that are adequately powered, examine the effects of PPIs for different types of PPIs, and that help us understand what PPIs are most effective for which patient. This will help to widen the evidence-base of this field and deliver the optimal intervention to improve the mental health of CVD patients.

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Registration

Open Science Framework (https://osf.io/95sjg).

Declaration of Competing Interest

The third author (G.C.M. Linssen) works as cardiologist for the funder (Ziekenhuisgroep Twente), but declares that this had no influence on the work presented in the paper.

Appendix A. Search string

("well-being" OR well being OR wellbeing OR happiness OR happy OR "life satisfaction" OR "satisfaction with life" OR "positive psych*" OR "positive emotion*" OR "positive feeling*" OR "positive cognition" OR "positive behavio*" OR compassion OR optimism OR gratitude OR kindness OR strengths) AND ("positive psychology" OR intervention* OR therap* OR training* OR exercise OR program* OR treatment*) AND ("cardiovascular disease" OR cvd OR heart AND disease OR heart AND infarct OR heart AND attack* OR angina OR aortic OR peripheral OR coronary* OR cerebrovascular* OR arterial OR "deep vein thrombosis" OR "pulmonary embolism*" OR chd OR stroke OR tia OR "transient ischaemic attack" OR infarct*) AND (effect* OR effic* OR outcome* OR evaluat*) AND (random* OR RCT* OR control* OR non-random* OR pilot*)

Appendix B. Quality assessment

Table B1

Criteria	Present (1)	Absent (0)
Randomization	The way participants were randomized is adequately described in the text.	A description of the way participants were randomized lacks (i.e. mentioning that participants were randomly assigned to a condition, without mentioning how randomization will take place is scored as absent).
Drop-out description	1) The numbers and reasons for drop- out were described (either in text and/or in flow-chart) 2) An analysis of drop-outs was performed 3) There were no drop-outs	A description of drop-outs in terms of numbers and reasons for drop-out was lacking.
Intention-to- treat (ITT) analysis	In case there were drop-outs, an ITT analysis was performed.	In case there were drop-outs it is unclear whether an ITT analysis was performed, or the analysis was based upon completers.
Qualified professionals	The professional(s) that guided the intervention was trained or experienced in guiding the intervention, or was a health professional/ schooled psychologist or psychiatrist.	A description of the training or experience of those that guided the intervention lacks.
Power analysis or $n \geq 64$ per condition	1) The sample size per condition was at least 64. This number is based upon a moderate effect (0.5), t-test, two- sided, $\alpha = 0.05$ and power of 0.8. 2) The authors performed an adequate 3) power analysis and met this number of participants per condition.	The sample size did not reach the calculated power or the minimum of 64 participants per condition.
Treatment integrity	Treatment integrity was reported and checked through: 1) Supervision of those that guided the intervention 2) Intervention sessions recordings 3) Systematic screening through a logbook 4) Protocol adherence	Reporting or checking of treatment integrity lacks.
Baseline compara-bility	Baseline comparability = the absence of significant differences between conditions/groups at the start of the study (baseline) on outcome measures.	1) Baseline comparability assessment lacks. 2) In case there was a baseline imbalance it was not adjusted for.

(*continued on next page*)

Table B1 (*continued*)

Criteria	Present (1)	Absent (0)
	1) Baseline comparability was assessed and explicitly reported whether conditions significantly differed or not AND 2) In case of baseline imbalance, appropriate covariates were used to correct for this baseline imbalance.	
Inclusion and exclusion criteria	An adequate description of the inclusion or exclusion criteria was given.	An adequate description of inclusion or exclusion criteria lacks.

Appendix C. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychores.2023.111328.

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