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Review Article

Positive Psychology Interventions to Improve Wellbeing and Health Behaviour Adherence in Patients with Type 2 Diabetes Mellitus: A Scoping Review and Meta-analyses

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Abstract: The aim of this review was to evaluate the effectiveness of positive psychological interventions (PPIs) to improve well-being and health behaviour adherence among patients with type 2 diabetes mellitus (T2DM). Medline, PsycINFO, the Cochrane register, EMBASE, and Google Scholar were systematically searched to find relevant studies until January 2020. The primary outcome was reduction in risk factors of cardiovascular disease including HbA1c, systolic blood pressure (SBP), and diastolic blood pressure along with improvement in positive affect, optimism, self-efficacy, and health behaviour adherence such as diet, exercise and medication. The secondary outcomes were reduction in depression, anxiety and stress. A random-effect model was used to compare group effect size at post-test. We identified a total of 11 studies (N=1594 participants) with substantial variability in the interventions. Overall, the results provide evidence that multi-component PPIs have a small but significant effect on positive affect, optimism, health behaviour, self-care and BMI. Further, the review demonstrates that PPIs can be effective in the reduction of anxiety and stress symptoms. However, studies included in this review are heterogenous due to methodological variation, therefore, in future more studies across a wide range of PP interventions needs to be included in order to validate the findings and for conclusive evidence.

Keywords: Positive Psychology, Well-being, Health Behaviour Adherence, Depression, Interventions, Effectiveness, Randomized Controlled Trials

1. Introduction

1.1. Diabetes Health Behaviour Adherence

Adhering to diabetes health behavior is vital to prognosis, but a majority of diabetes patients are non-adherent to one or more of this behavior [1]. This possible shortfall in the management of diabetes with suboptimal glycemic control, which renders people more prone to the development of late-stage complications with attendant morbidity and mortality [2]. Psychological factors, both depression and anxiety, have high comorbidity with one another [3] and may play an important role in clinical outcomes and health behaviors. Prevalence of anxiety and depression among patients with T2DM in India was found to be 40% [4] and 45.2% [5, 6] respectively and recognized as the strongest predictor of mortality [7] than many clinical and physiological variables.

Self-management is a crucial component of diabetes care, while the presence of comorbid psychiatric illness can further complicate the management of diabetes [8]. In this specific population, depression is considered by the World Health Organization (WHO), to be a risk factor for poor prognosis, possibly due to known association of depression

with noncompliance to oral medications, along with diet and physical activity and monitoring of blood glucose [9]. However, depression interventions have not consistently led to changes in adherence or outcomes among this population [10]. In contrast to a negative syndrome, positive psychological states such as positive affect, optimism, gratitude and other related constructs play an important role in improving therapeutic adherence. In patients with diabetes, positive constructs have been shown to be positively associated with superior health outcomes including social, physical and health [11].

1.2. The Hypothesised Mechanism Underlying Positive Psychology Interventions

Previous studies which examined the link between PP exercises and clinical outcome have typically based through mental well-being, depressive symptoms and health behaviour adherence. For instance, Huffman et al. [12] theoretical review developed a framework describes the mechanism through which PP intervention promotes health behaviours which were mediated through positive emotions and positive mental health and reduces depression. Similarly, Celano [13] framework showed through positive psychological exercise improves cardiovascular health through improvement positive constructs such as gratitude and optimism and health behaviour adherence such as increased physical activity. Similarly, Kubzansky [14] model showed the direct and indirect relationship linking positive psychological well-being with better cardiovascular health through behavioural pathways (e.g. smoking, physical activity), and psychosocial pathways (mitigating depression, or stress). Positive affect unifies the experiences of contentment, joy and love, on the other hand, negative affect comprised of sadness, distress and fear [15]. This experience may expand a behavioural and cognitive repertoire, including intellectual, social and physical resources, possibly to include treatment adherence and health behaviour conversely (Lianov et al., 2019). Taken together, based on the theoretical underpinnings of PP states have shown to impact clinical outcomes in patients with T2D through positive states and behavioural factors [16].

To our knowledge, little is known about the potential impact of PP interventions for T2DM, and no existing meta-analyses have been undertaken of RCTs strictly through PP interventions focusing on both mental wellbeing and health behaviour adherence among this group. In the past, few studies have been conducted to evaluate interventions comprising both PP and other psychological enhancing components for depression and other health behaviour adherence in clinical populations [17]. One systematic review included 30 studies, including PP interventions (n=4 articles) along with other well-being interventions [18], while the results of this review study showed a promising effect in improving health outcomes.

2. Aims

The meta-analysis aimed to identify effective western-based PP interventions with a control or usual care strategy in adults (age ≥ 20 yr.) and to determine which components of these interventions optimized their impact on both depression and anxiety as well as health behaviour adherence such as diet, physical activity and medication adherence. Besides, this paper will also describe the methodology used and outline its main findings in terms of the quality and content of the reviews, the impact of interventions and will discuss the implications of these findings.

3. Methods

3.1. Search Strategy

The present review followed the framework of Arksey and O'Malley [19] for a scoping review. The preferred reporting items for Systematic Reviews and Meta-Analysis for Scoping Review (PRISMA-ScR) [20] criteria and guidelines were adhered while executing and reporting this review.

3.2. Stage 1: Review Aims and Research Questions

The present scoping review aimed to explore the impact of PPIs on well-being and health behaviour adherence for people with T2DM. This research question followed the suggestion by Arkey and O'Malley's [19] where emphasize was to start with a broad area before narrowing the search to determine what is already available. The authors, being experience in the field of PPIs, believe that there is a significant impact of PP on enhancing the adherence of health behaviour and improved clinical outcome *via* improving wellbeing and reducing stress and depression levels among people with T2DM. However, the existing meta-analysis is not specific in context to health behaviour adherence, and therefore this review helps describe the evidence for this PPI on adherence of health behaviour and distil key professional context, activities, and training protocols in the research of PP interventions. The following are the research questions guiding the scoping review

(1) What are the demographic characteristics of the population in which PP intervention was applied for T2DM?
(2) What theoretical basis has been used to design the PP intervention for T2DM?
(3) What are the different primary and secondary outcome measures used in the interventions for T2DM?
(4) What methods and approaches are used to deliver PP interventions for T2DM?
(5) What is the retention rate and acceptability of the intervention for T2DM?
(6) What are the educational background and prior experience of professionals delivering PP Intervention for T2DM?

3.3. Stage 2: Identifying Relevant Studies – Search Strategy

For this particular scoping review, the researcher executed

systematic searches on the following electronic database: Scopus, PubMed, PsycINFO, Embase, and Ovid Cochrane Library. Search items, summarised, included positive psychological constructs (A): optimism, hope, gratitude, vitality, meaning, subjective well-being, happiness, self-acceptance, tranquillity, contentment, personal growth, positive affect, character strengths, emotional well-being, and cheerfulness. Interventions focused on PP include counting your blessings, practicing kindness, loving-kindness, setting a personal goal, expressing gratitude, using personal strengths, positive psychology intervention, and optimism training. During the search strategy, no time restrictions were placed where all published articles up to December 15, 2019, taken into consideration. The search strings were adapted according to the database. In addition, four meta-analyses [21–24] and six review articles on PPIs [25–30] were also cross-checked for additional references.

3.3.1. Primary Outcome

The primary outcome was an improvement in the mean positive affect, optimism, and life satisfaction constructs were included. Other primary outcome included health behaviour adherence such as diet, exercise, long-term glycemic control by the percentage of glycated haemoglobin (HbA1c) and body mass index (BMI), self-management and medication adherence.

3.3.2. Secondary Outcome

The secondary outcomes included in the review were depression, anxiety and stress.

3.4. Stage 3: Selection of Studies

The eligible studies were screened for their titles in the first phase, followed by its abstract in the second phase and the full paper in the final phase. This review paper comprised of peer-reviewed studies that were published exclusively in English and followed the PICOS (Participants, Interventions, Comparators, Outcomes and Study Design) framework. The framework utilized to set up particular criterions for inclusion and exclusion. To be part of this review, the following criteria had to be met. i) adult participants (≥18 years old) ii) diagnosed with T2DM, ii) any intervention trial (RCT, and non-RCT such as quasi-experimental study, proof-of-concept trials) that evaluated the effectiveness of PP intervention structured such as to encourage subjective well-being and health behaviour adherence iii) effect of PP intervention developed in line with the theoretical tradition of PP (Sin & Lyubomirsky, 2009) and iv) utilized a RCT. Conference paper, abstracts, case studies, observational studies and case reports were excluded. We also excluded studies that addressed a) recent acute complications or hospitalisation, b) patients with life-threatening illness, c) gestational diabetes, d) studies that described patients with T2DM or insulin-dependent diabetes, e) interventions that were primarily focused on reminiscence, mindfulness and /or meditation, f) and not published in English language peer-reviewed journals.

3.5. Stage 4: Data Extraction

The first author (GR) performed the data extraction, which was then verified by the second author (RS). Any disagreements were resolved by consensus and through consultation with the last author (RR). The GR later appraised abstracts from the rest of the papers to ensure that all the identified papers matched the objectives of this current research and also identifying any additional papers that could be excluded from this review. Lastly, whatever papers remained after the elimination was completely reviewed by the researcher. Following identification and elimination of duplicate papers, the rest of the identified papers were extensively reviewed by the GR, and any articles that were not pertinent to the current research were removed. In case of missing data, study authors were contacted.

The following data was gathered: First Author, year of publication, country of origin, participant ethnicity, type of diabetes (Type 1 or II), study objective, primary outcome, intervention type and psychological component involved, control group, theoretical basis, study design, mean age and percentage of female participants, sample size (per condition), setting, interventionists, mode of delivery, delivery form (self-help, group-based, individual therapy), module addressed and components, program phase, retention and acceptability of the intervention, PP intervention duration, follow-up period, metabolic control, physical activity, medication, diet, self-management, self-efficacy, positive outcome, subject wellbeing, depression, anxiety, and stress. We extracted means and standard deviation at post-test.

3.6. Stage 5: Evidence Synthesis

According to the guidelines recommended by Arksey and O'Malley's framework [19], a 'descriptive-analytical' method, based on the narrative tradition, was performed. Tables and graphs were created to reflect the overall summary of studies included. The main outcome of our scoping review was to answer the broad primary research question.

3.7. Risk of Bias

According to the scoping review recommendations and the Joanna Briggs Institute manual [20, 31], the present review does not conduct an appraisal of the quality of included sources and an assessment of the risk of bias [32].

4. Meta-analysis Procedure

Based on Rosenthal [33] all statistical analyses were performed using "Review Manager (REVMAN) 5.3 Copenhagen" (The Nordic Cochrane Centre, 2014) to calculate the pooled MD (mean difference) as well as the corresponding 95% confidence interval (CI). The Q, I^2, and T^2 were calculated to assess the heterogeneity between studies. A P value <0.01 or I^2>50% indicated significant heterogeneity, and then, a random-effect model was used to pool the MDs.

Otherwise, a fixed-effect model was applied. T^2 provides the proportion of variability in the effect size [34]. A Z-test was used to determine the statistical significance of these pooled MDs. Funnel plot and Egger's test was used to assess the Publication bias. Separate meta-analyses were performed for Positive affect (PA), depression, BMI (Body Mass Index), HbA1c, and self-care. Since only two meta-analyses had all five variables filled, only those were considered into an account. In this meta-analysis, an adjusted estimate called *Hedges' g* which generates for each effect size was calculated based on its sample size as Cohen's d produces an overestimation for studies with small sample size [35, 36]. The ES was considered as large, moderate and small if the size were 0.56 to 1.2; 0.33 to 0.55; and 0 to 0.32 small [37]. et al., subgroup analyses were performed by type of diabetes or the evaluation criteria of depression and anxiety. For all analyses, the *P* value of <0.05 indicated statistical significance. Evidence of publication bias was assessed in the following ways. First, Orwin's [38] Fail-Safe *N*, Egger's regression test and Kendall's tau [39] were used to assess publication bias. Second, we created a funnel plot by plotting the overall mean effect size against study size. Finally, we applied the trim-and-fill method [40] where the procedure imputes the effect sizes of missing studies and produces an adjusted effect size.

5. Results

5.1. Search and Selection of Studies

The flow chart of literature search and study selection is represented in Figure 1. On the basis of a search of the selected electronic databases, a total of 888 potentially relevant citations were retrieved. After excluding duplicates and irrelevant articles, 82 potentially relevant articles remained. Among them, 67 citations were removed by scanning the title and abstracts: 17 non-original articles (reviews, letters or case reports), 29 articles were not directly relevant to diabetes or positive psychological intervention, 6 articles on adolescents or children and 15 non-RCTs were removed, according to the inclusion and exclusion criteria. After reading the full-text, 10 articles without available data were excluded. Finally, eleven studies [41–51] were included in this scoping review and meta-analysis. The characteristics of these included studies were listed in Table 1.

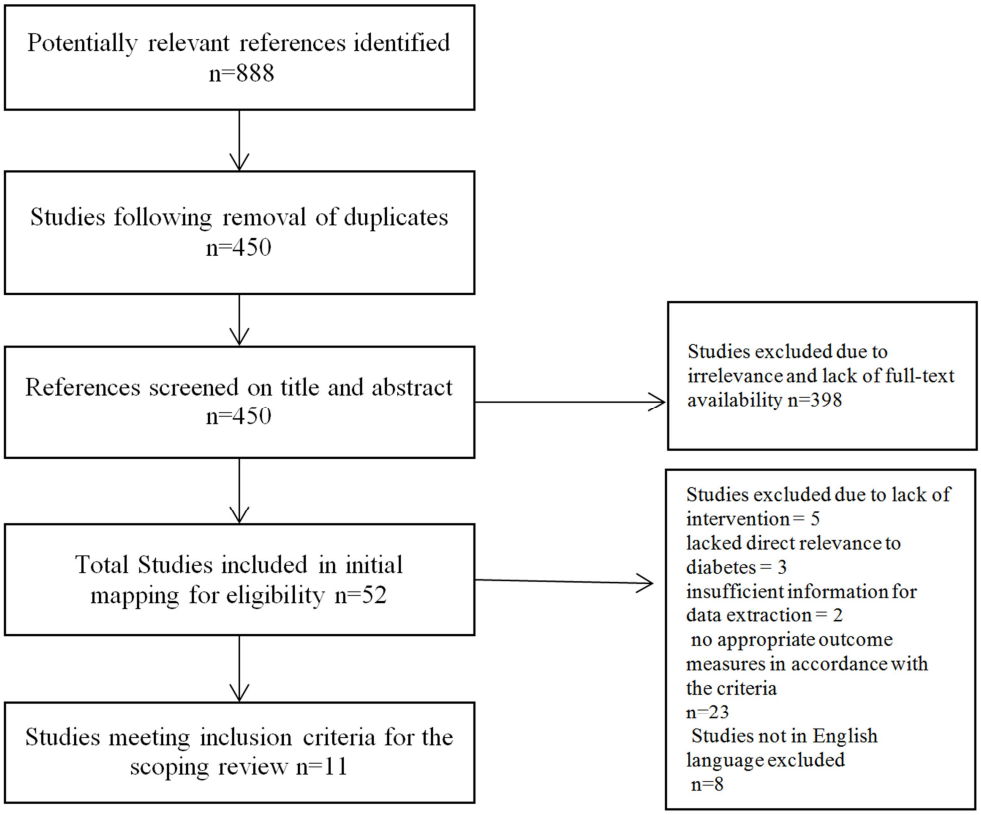

Figure 1. *Flow diagram of studies included in the study.*

Table 1. *Summary of Studies Reviewed.*

	First Author, year, Country	Control group	Theoretical basis	Study Design	Mean age & Gender	Sample Size
1	Bradshaw et al.,[55] (2007) USA	Control	Self-efficacy, locus of control, purpose in life and social support.	A Single-blinded Randomized Controlled Trial (RCT)	Male=8, Female=17 Age: 60.8 (SD: 10.92) Male=11	N_I=200 N=54, (physiological &

	First Author, year, Country	Control group	Theoretical basis	Study Design	Mean age & Gender	Sample Size
					Female=18,	psychosocial data)
2	Celano et al., [56] (2019) USA	(.)	(.)	A single-arm proof-of-concept study. Pre-post intervention	Age: 57.5 (SD: 11.02) 65% female (I): DM duration: 8.9 (1.7) Median age of 58.5 (11.5). Female 42%	N_I=25 N_C=29 N_I=10
3	Cohn et al., [58] (2014), USA	Control	Revised Stress and Coping Theory & the Broaden-and Build Theory of Positive emotion.	Intervention Study	Median age 54 yr. Female 50.9%	*N=49;* N_I=25; Nc=17
4	DuBois et al., [59] (2016) USA	Control	PP	A Pilot RCT	58.3% female Mean age 61.4 (7.0)	*N=15; n=12 (I) complete data and follow up*
5	Nishita et al., [60] (2012) USA	(.)	(.)	RCT	Female 62.6%, mean age: 48.5 (I) Mean age=47.59 Female=65.63% (C) Mean age=50.26 Female=56.45%	*N=190* N_I=128 Control group N=62
6	Nolan et al., [61] (2015) USA	(.)	(.)	RCT, a single session intervention.	Age 60+ with T2D 40% female Mean age 71.7 (7.4)	*N=81* *n=28 (positive reappraisal) n=27 -cognitive restructuring n=26, supportive counseling*
7	Pena-Purcell. et al., [62] (2011) USA	Control (wait list)	Self-regulation and social cognitive theory.	Non-RCT (Quasi Experimental repeated measures design)	N_I 59.4±9.9 M/F=28.4/71.6 N_C: 63.9±9.9 M/F=24.6/75.4	*N=* N_I=83 N_C=61
8	Steinhardt et al., [63] (2009) USA	None	(.)	Pre-post design pilot study / 1 group	Mean duration of diabetes: 72% female Mean age 62 (10.3)	*N*=65
9	Voseckova et al., [64] (2017) Czech Republic	Control	Roger's humanistic psychotherapy	Non-RCT	Mean duration of diabetes: 11 ± 6 years 61% female Mean age 69 (14)	N_I=18 N_C=22
10	Wu et al., [65] (2011). Taiwan	Control	Self-efficacy theory	Randomized Control Group pre-test/ post-test Design)	Mean duration of diabetes: 6.05 yrs. (I). (6.91 SD) Mean age: 64.83 (I); 64.05 (C), male=34.7;	*N*=145; N_I=72 N_C=73
11	Yalcin et al., [57] (2008) Turkey	Wait list	Emotional Intelligence Theory	Randomized Control Group	50% female (I) Mean age=54.3 (7.3) (C) Mean=51.2 (5.8)	N_I=18 N_C=18

Table 1. *Continued.*

	First Author, year, Country	Control group	Theoretical basis	Study Design	Mean age & Gender	Sample Size
1	Bradshaw et al.,[55] (2007) USA	Control	Self-efficacy, locus of control, purpose in life and social support.	A Single-blinded Randomized Controlled Trial (RCT)	Male=8, Female=17 Age: 60.8 (SD: 10.92) Male=11 Female=18, Age: 57.5 (SD: 11.02) 65% female (I):	N_I=200 N=54, (physiological & psychosocial data) N_I=25 N_C=29
2	Celano et al., [56] (2019) USA	(.)	(.)	A single-arm proof-of-concept study. Pre-post intervention	DM duration: 8.9 (1.7) Median age of 58.5 (11.5). Female 42%	N_I=10
3	Cohn et al., [58] (2014), USA	Control	Revised Stress and Coping Theory & the Broaden-and Build Theory of Positive emotion.	Intervention Study	Median age 54 yr. Female 50.9%	*N=49;* N_I=25; Nc=17
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	First Author, year, Country	Control group	Theoretical basis	Study Design	Mean age & Gender	Sample Size
5	Nishita et al., [60] (2012) USA	(.)	(.)	RCT	Female 62.6%, mean age: 48.5 (I) Mean age=47.59 Female=65.63% (C) Mean age=50.26 Female=56.45%	*N=190* N_I=128 Control group N=62
6	Nolan et al., [61] (2015) USA	(.)	(.)	RCT, a single session intervention.	Age 60+ with T2D 40% female Mean age 71.7 (7.4)	*N=81* *n=28 (positive reappraisal) n=27 -cognitive restructuring n=26, supportive counseling*
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10	Wu et al., [65] (2011). Taiwan	Control	Self-efficacy theory	Randomized Control Group pre-test/ post-test Design)	Mean duration of diabetes: 6.05 yrs. (I). (6.91 SD) Mean age: 64.83 (I); 64.05 (C), male=34.7;	*N*=145; N_I=72 N_C=73
11	Yalcin et al., [57] (2008) Turkey	Wait list	Emotional Intelligence Theory	Randomized Control Group	50% female (I) Mean age=54.3 (7.3) (C) Mean=51.2 (5.8)	N_I=18 N_C=18

5.2. Scoping Review of PP Intervention Among T2D

The characteristics of these included studies were listed in Table 1. A total of eleven studies involving 1594 patients with diabetes mellitus (including 797 patients in PP intervention group and 797 patients in the control group) were published from 2007 to 2019. Most samples comprised of a heterogeneous mix of male and female participants with a mean age ranged from 72 to 49 years. There were no significant differences in age and sex between groups in these included studies.

Three studies [41, 42, 45] included 100% Americans outpatients, one study [43] included Turkish adults, Wu [51] conducted a study from the Taiwanese, Steinhardt [49] conducted a study amongst African Americans, while Pena [48] in Spanish Speaking Hispanic or Latino Adults. The study by Nolan et al., [47] conducted amongst Australian adults, Nishita [46] had a mix of Asian, Hawaiian or Pacific Islanders while Cohn et al., [44] had a mix of Caucasians, African Americans and Asian or Asian Americans, and non-white Hispanics. In terms of study design, four were RCT or single group RCT, or a pilot RCT [45], while three [42, 49, 51] used proof of concept pre and post-intervention. Two studies [44, 50] had either intervention or nonrandomized trials. Three studies had self-efficacy [46, 48, 51], locus of control [41] as theoretical base while others applied revised stress and coping theory and the broaden and build theory of positive emotion [44], self-regulation and social cognitive theory [48], Rogers humanistic psychotherapy [50], and emotional intelligence theory [43] (Table 1).

The primary mental health outcome reported in the included studies are changes in EI levels and QoL [43], Self-efficacy [51], improve Self-care behaviour [45, 46, 48, 50, 51], improve knowledge (Nishita et al., 2013), active lifestyle [48] increasing subjective wellbeing [50], coping [49], reduce anxiety and depression [44, 47], improve physical activity adherence [42], improve psychosocial management and identify barriers [41], with many studies including more than one mental health measure. The most common positive outcomes reported include positive affect, optimism, self-efficacy and positive appraisal while negative outcome includes anxiety, depression, stress and negative affect.

Of the included studies, two studies focused on optimism and gratitude intervention [42, 45], one on positive emotion especially acts of kindness while other two (Steinhardt et al., 2009; [41] focused on resilience, and three studies [46, 48, 50], did focus on self-efficacy based intervention, one on positive reappraisal [47]. The duration of intervention varied from 1-week [47] to 8 months [50]. All studies had a control group except the study by Steinhardt [49] and Voscekova [50]. Single exposure duration ranged from 15 [42] to 120min [48, 49]. Frequency of exposure ranged from biweekly and to one single exposure with 50min duration. Majority of the programs were delivered in-person while two studies delivered through telephone [45, 51] and one online [44]. The format of the program was delivered individually in two studies [42, 47], while eight studies did have a group program [41, 43, 48–51], and others had self-help [44]. Majority of the programs were conducted in a clinical setting [41, 47, 49, 51] while two in Urban Medical Centre [42, 45] and one in

diabetes education centre [44] (Table 2).

The retention rate was reported in four studies [41] Celano et al., 2019; [44] Wu et al., 2011b), with 88.8% as highest rate at 6 months. An incentive for participants ranged from $20 AUS (Nowlan et al., 2016) to $100 [44]. The programs were delivered by diverse experts including psychologists [42, 47], research staff [45], trained life coach and pharmacist [46], registered nurse [50, 51] and dietician [48], dietary nurse [50] PhD Candidate (Steinhardt et al., 2009), medical doctor psychotherapists and social worker (Voseckova et al., 2017) (Table 3). The criteria for evaluating depression were CES-D (Centre for Epidemiological Studies scale for Depression), BDI (Beck Depression Inventory), MADRS (Montgomery–Asberg Depression Rating Scale), CGI (Clinical Global Impression) or/and PHQ-9 (PatientHealthQuestionnaire-9) in these studies. The basic values of these criteria were similar between PP and control groups in these included studies (Supplementary, Table 1).

Table 2. *Intervention Designs carried out in each of the studies.*

Author & Year	Duration of intervention	Control group (CG)	Single exposure duration	Freq. of exposure	Delivery Setting	Format (ind. Or group)	Setting
Bradshaw et al.,[55] (2007) USA	5-weeks	Control group: usual care	90-min	bi-weekly classes.	In-person	Group	Clinic
Celano et al., [56] (2019) USA	16-week	-	15-min (PP); 15 min (MI)	Weekly	Phone	Individual	Urban Medical Centre
Cohn et al., [58] (2014), USA	60-day	Control group: Reported emotions daily on website	-	5 times/week	Online	Self-help. (audio-visual)	Diabetes Education Centre.
DuBois et al., [59] (2016) USA	12-week	Control group: None	-		Telephone		Urban Medical Centre
Nishita et al., [60] (2012) USA	12-month	Control: no treatment	60 min	10 times	In-person	Group	Community Centre
Nolan et al., [61] (2015) USA	1-week delivered; Comparison group: Cognitive Restructuring	Control group: supportive counseling	50-minute	One time	In-person	Individual	Clinic
Pena-Purcell. et al., [62] (2011) USA	3-month,	Waitlist control	120 minutes	over 1.5-week	In-person	Group	community settings (eg, church and library)
Steinhardt et al., [63] (2009) USA	6-month,	No Control groups.	120 minutes (RI); 90 min/2wk (Self-management)	4 weekly plus 8 bi-weekly	In-person	Group	Clinical Setting
Voseckova et al., [64] (2017) Czech Republic	8-month – 8 group (23 clients/group)	Control group	-	session-14 to 21 d interval.	In-Person	Group	Community Centre
Wu et al., [65] (2011). Taiwan	6 month- in each group 10-15 participants	Care as usual or individual appointment 10-15 min, Nutritionists 10-15 min (control).	/60min each (I); 10-15 min (FU)	4-weekly session; 8 and 16 weeks (FU)	In-person (I) Telephone	Group	Clinical Setting
Yalcin et al., [57] (2008) Turkey	12-week	Control: participated just after the study group program came to an end.	90 min each	Every weekend.	In-person	Group	

Table 3. *Intervention Protocol and Training characteristics carried out in each of the studies.*

Author & Year	Focus of Intervention	Interventionist(s)	Module addressed/components	Program Phase	Retention and Acceptability of the Intervention
Bradshaw et al.,[55] (2007) USA	Efficacy of a resiliency training approach for diabetes (RTAD)	-	10-module, 15-hour educational/ experiential intervention. The psychosocial enrichment of the individual and the supportive relationship between the individual and his or her environment. Reinforcing the ADA, concept of resilience.	The context and intent for the modules was a resiliency approach to assist people with type 2 diabetes to initiate and develop self-directed behavior change.	At 3 months, the retention rate (I) 92% (C) 97% At 6 months, the retention rate (I) 88% (C) 86% Received a pedometer
Celano et al., [56] (2019) USA	Optimism, gratitude,	Psychologists	In-person visit #1, screening & visit #2, Provide treatment manual, outline the structure, and rationale of the intervention, and assign the first PP and MI exercises. Participants were given a pedometer to track their activity. Remainder of the	W1: Gratitude for positive events; W2: Expressing gratitude; W3: Capitalizing on positive events; W4: Using gratitude in daily life; W5: Remembering your past success; W6: identifying your personal strengths; W7: Using Perseverance; W8: Humor in everyday life; W9: Strengths in daily life; W10:	78% sessions completed. 80% completed 9/13 exercises and rated easy and useful.

Author & Year	Focus of Intervention	Interventionist(s)	Module addressed/components	Program Phase	Retention and Acceptability of the Intervention
			intervention was completed by phone. Set PA goals for each week, reviewed PP activities during weekly phone sessions.	Enjoyable and meaningful activities; W11: Performing acts of kindness; W12: The good life; W13: Focusing on meaning in life; W14: Planning for the future	
Cohn et al., [58] (2014), USA	Enhance positive emotion or adaptive coping.	-	8 Skills. 1st 1-2: Introducing week's skills. Rest of the weeks: "home practice" assignments consisting of simple practices and noticing positive events or tracking progress to attain goal. Daily visit to the website. New lessons available 7 day after beginning previous lesson. Automated daily reminders.	W1: Noticing & recalling positive events, savouring or capitalizing on positive events; W2: Mindfulness; W3: positive reappraisal; W4: Strength and goals; W5: Act of kindness	79% retention of pp controls; $1 for daily report completed; $20 completing the final questionnaire & Phone Interview; $20 completed study within 75 days with reports on 75% of all days.; Total amount $100.
DuBois et al., [59] (2016) USA	Optimism, gratitude,	Research staff	The intervention included 7 separate PP exercise, which were assigned by the interventionist, recorded in the treatment manual by the participant, and then reviewed together at weekly (for the first 4 weeks) or biweekly (for the remainder of the intervention) calls.	W1: Gratitude for positive events; W2: Personal Strengths; W3: Gratitude letter; W4: Enjoyable and meaningful activities; W5: Recalling past success; W6: 8-10: Acts of kindness or repeat an exercise.	Ease of completion: post exercise score 7.11 (2.66) Utility: 7.77 (2.07)
Nishita et al., [60] (2012) USA	*Self-efficacy:* Multicomponent intervention	Trained Life coach (bachelor's degree in social sciences) and pharmacist – 65 hours of training	Topics discussed are work, exercise, goals, and nutrition/healthy eating. Pharmacist counseling, Pharmacists generally met with a participant for 45 minutes; the most frequent topics of discussion were exercise and goals; and the most frequent activities performed were conducting assessments and providing education.	Model Behaviour: Established/maintained trust, remained non-judgmental, exhibited professionalism, focused on participant agenda, maintained coaching relationship, asked questions, used active listening strategies, addressed participant goals, practiced non advice giving, remained solution focused. The participant-driven nature of the program, which led participants to set appointments and direct the content of life coaching sessions, was also a distinguishing feature.	-
Nolan et al., [61] (2015) USA	Positive Reappraisal program	Registered Psychologists,	The positive reappraisal (PRA) and cognitive restructuring interventions (CRI) comprised five structured stages: validation, explanation, example, practice, and personal application,	Stage (S)1: discussion of the negatives of the participants diabetes (PRA & CRS); read through arthritis and breast cancer examples. S2: Explanation of positive reappraisal coping and restructuring coping. Discussion of the negative of the participants diabetes; S3: Example (arthritis) of positive reappraisal and cognitive restructuring. Open ended questions about the diabetes with reflective listening but no cognitive reappraisal or advice.; S4: Practice (breast cancer) of positive reappraisal and followed by cognitive restructuring.; S5: Personal application of positive reappraisal. Followed by cognitive restructuring.	75.3% of participants completed homework's. Received $20 (AUS) for completion of the study.
Pena-Purcell. et al., [62] (2011) USA	*Self-efficacy:* DSME program - reinforced concepts	A registered nurse and dietitian delivered.	A weekly video *novela* (soap opera) series was created to vehicle to deliver health message. Core constructs employed in the curriculum include self-efficacy, social modeling and behavioral capability such as understanding diabetes, SMBG, relationship	1. Five weekly 1.5 to 2-hour sessions'; 2. A review of the weekly homework activity; 3. Guided discussion on the video *novela* (soap opera) messages; 4. Experiential activities reinforcing dietary principals; 5. Multiple repetitions of key concepts occurring at every session.	Participants received a free glucose monitor, strips, and pedometer as incentive

Author & Year	Focus of Intervention	Interventionist(s)	Module addressed/components	Program Phase	Retention and Acceptability of the Intervention
			between carbohydrates intake and blood glucose level, PA, food measurement, physical activity, menu planning, diabetes complications, medications.		
Steinhardt et al., [63] (2009) USA	*Resilience Intervention* + diabetes self-management focus on nutrition education	PhD Candidate	DCP included four weekly class sessions devoted to resilience education and diabetes self-management, followed by eight biweekly support group meetings. Psychosocial process variables (resilience, coping strategies, diabetes empowerment), and proximal (perceived stress, depressive symptoms, diabetes self-management) and distal outcomes	W1: The resilience model, the stress response, problem focused coping strategies, emotion focused coping strategies. W2: The responsibility model, above the line/below line behaviour, circle of influence /circle of concern. Five step process to move above the line. W3: focusing on empowering interpretations, how our thinking affects our health, ABCDE thinking model. The origin of beliefs. W4: Creating meaningful connections, the healing power of love and intimacy. Self-leadership and the circle of influence. Features of psychological thriving.	All subjects received $100 for their participation, dispersed in increment of $20 throughout the study. An additional $25 was received for participation in a two-hour focus group to evaluate the acceptance of the DCP intervention.
Voseckova et al., [64] (2017) Czech Republic	Humanistic psychotherapy	Medical doctor psychotherapist, a clinical psychologist-psychotherapist, a social worker, and a dietary nurse.	intervention focused on strengthening self-concept, personal development, interpersonal relationships, gestalt effect and perceived self-efficacy	1) Patient motivation, and their co-responsibility for the treatment 2) Improving the diabetic informedness about the disease 3) practicing ability to manage psychological burden and stress 4) development and enforcement of health promoting behavioural patterns 5) deepening client self-reflection and positive self-concept 6) strengthening of patient's subjectively perceived self-efficacy.	-
Wu et al., [65] (2011). Taiwan	Self-efficacy enhancing Intervention program (SEEIP)	Registered Nurses	Viewed 10 minutes video, received a booklet entitled "diabetes self-care", efficacy enhancing counselling session, telephone follow up, DVD vicarious experience by showing a person with T2D carrying out self-care to prevent acute and chronic complications, booklet covered diet, PA, Blood glucose testing adherence to the medication regimen & footcare.	Goal setting sheet for diabetes self-care. self-efficacy enhancing skills, self-goal setting, peer support	88.8% of participants completed the intervention
Yalcin et al., [57] (2008) Turkey	Emotional Intelligence	Psychotherapy	Based on lived experience. Followed an eclectic approach that has an educational and time limited structure based on small group experience. Covered the area of being aware, identifying, perceptions, differentiating between emotions, being aware of methods of expressing emotions, understanding the relationship between emotions and thoughts, physical reactions and behaviour, managing emotions, displaying empathetic bonding with others and empathetic reactions to achieve empathetic listening skills, learning to expend motivational energies in the direction of a determined target, trusting speech, differentiating friendly	1st session: Skill related training information program; Role playing, and scenario based on real or friction-based experience and homework.; 2nd session: To improve the perceptions of individuals about their feelings along with exercises and practices.; 3rd and 4th session: To differentiate between emotions; 5th session: To focus on awareness of methods of how the emotions are expressed; 6th session: To manage the emotions; 7th and 8th sessions: To improve empathetic bonding abilities with others, displaying empathetic reactions, and attaining the skill of empathetic listening activities; 9th session: To acquire self-motivational ability; 10th and 11th sessions: To use emotions in daily life; 12th session: To share the group's feeling regarding the program	100% participation rate. Challenges in expressing positive emotions.

Author & Year	Focus of Intervention	Interventionist(s)	Module addressed/components	Program Phase	Retention and Acceptability of the Intervention
			behaviour and not. Includes relaxation training.		

*Parentheses indicate that classification was done by GR, RS as no model was mentioned.

5.3. Primary Outcome

5.3.1. Effects of Positive and Negative Affect

For Positive affect (PA), pooled analysis of three studies [42, 44, 49] (*n*=81) indicated significant improvement in the PA in the intervention compared to the baseline (Z=4.29, *p* <0.001) with no significant heterogeneity (χ^2=0.15, I^2=0%, Q: 0.00, *p*=0.93) (Table 4). This corresponds to an effect size of 0.585 (ranged from 0.076 to 0.884). Similar findings were observed in regards to intervention and control group, whereas pooled analysis of the four studies [42, 44, 47, 49] (*n*=107 participants) showed that PPI was effective in increasing positive affect (SEM=0.26, 95% CI: 0.06, 0.46, *p*<0.01; *Hedge's g*=0.585, 95% CI: -0.076-0.8839) (Table 6) with no significant heterogeneity (χ^2=3.15, I^2=5%, Q: 0.01, *p*=0.37). Effects on negative affect (NA) were reported in three studies (*n*=95 participants) and PPI was not effective in reducing NA (Table 5).

5.3.2. Effects on Optimism

The pooled analysis from two studies [42] Wu et al., 2011b) (*n*=112) showed that PPI was significantly was associated with an improvement in optimism (SEM=-1.56, 95% CI:-2.89, to -0.23, *Z=2.30, p*=0.02). The mean *Hedge's g* was -0.21 (95% CI: -0.7536, to 0.3263) (Table 6). which is considered a small ES. Heterogeneity was insignificant (χ^2=0.48; I^2=0%, *p*=0.49). (Table 4).

5.3.3. Effects on Positive Appraisal

Pooled analyses of two studies (Nowlan et al., 2016; Yalcin et al., 2008) (*n*=62) reported no significant mean difference in positive appraisal between pre and post-test (Z=1.63, *p*=0.10), which corresponds to an effect size of -2.455 (ranged from -3.1594 to -1.7999). Heterogeneity was significant (χ^2=86.28, I^2=99%, *p* <0.001). After removal of the outliers, the heterogeneity was low and there was a significant improvement in the positive appraisal (Z=4.92, *p*<0.001) (Table 4).

5.3.4. Effects on Self-efficacy

No significant mean difference in self-efficacy (3 studies [46, 48, 51], *n*=487) between pre and post-test (SEM: -19.45 95% CI: -43.86 to 4.96, Z=1.56, *p*=0.12). This corresponds to an effect size of -2.314 (ranged from -2.641 to -2.041) (Table 6). Heterogeneity was significant and high (χ^2=149.14; I^2=99%, *p* <0.001) (Table 4). Similarly, three studies (Peña-Purcell et al., 2011; Nishita et al., 2013; [51] (*n*=487 participants) analyzed the mean change of self-efficacy in the intervention and control group. The results showed a significant heterogeneity (χ^2=52.16, I^2=96%, *p*<0.001) and the pooled estimate (SMD: 5.25 95% CI: -9.30, 19.79, Z=0.71, *p*=0.48) indicated no significant mean difference in self-efficacy between the groups (Table 5).

5.3.5. Effects on Quality of Life

Effects on QoL were reported in four studies [43, 45, 46, 49] (*n*=342) and the pooled estimate (Z=1.08, *p*=0.28) indicated no significant improvement in the QoL between pre and post-test (*Hedge's g*=-0.773%, 95% CI: -1.2455 to -0.3003) (Table 6). Heterogeneity was highly significant (χ^2=286.95, I^2=99%, *p* <0.001) (Table 4).

5.3.6. Effects on HbA1c

Three studies [42, 46, 49] (*n*=218 participants) analyzed the mean change of HbA1C. The results showed there was a significant heterogeneity (χ^2=6.48, I^2=69%, *p*=0.04) among these included studies. The pooled estimate (Z=1.42, *p*=0.16) indicated that there is no significant mean difference in HbA1C between pre and post-test (*Hedge's g*=0.85, 95% CI: 0.273 to 1.450). (Table 4). Similar findings were observed when compared the PP and with a control as reported in five studies [41–43, 46, 49] (*n*=321). The pooled estimate (SMD=0.07, 95% CI: -0.25 to 0.39, Z=0.42, *p*=0.67) indicated no significant reduction in the mean HbA1c (*Hedge's g*=-0.0107, 95% CI: -0.5198 to 0.5075) (Table 6). A significant heterogeneity (χ^2=16.47, I^2=76%, *p*=0.002) was observed while the removal of the outliers did not improve the effect (Z=0.95, *p*=0.34) (Table 5).

5.3.7. Effects on BMI

Three studies [42, 46, 49] (*n*=218 participants) analyzed the mean change of BMI and the findings showed no significant heterogeneity (χ^2=0.10, I^2=0%, *p*=0.95). The pooled estimate (Z=6.08, *p* <0.001) indicated that there is a significant reduction in the mean BMI after PPI (*Hedge's g*=0.26, 95% CI: –0.2658 to 0.8376). (Table 4). Four studies [42, 43, 46, 49](*n*=254 participants) analyzed the mean change of BMI and the results showed no significant heterogeneity (χ^2=1.70, I^2=0%, *p*=0.64) (Table 5). The pooled estimate (MD=-0.69, 95% CI: -0.74, -0.64, Z=25.13, *p*<0.001) indicated that there is a significant reduction in the mean BMI among intervention groups than controls (*Hedge's g*=-0.5764, 95% CI: -1.1336 to 0.0192) (Table 6).

5.3.8. Effects on Dietary Adherence

Pooled analyses of two studies [42, 45] (*n*=112 participants) analyzed the effect of PP intervention on improvement in the dietary adherence score found significant heterogeneity (χ^2=2.76, I^2=64%, *p*=0.10) between studies. From the two studies, PPI (Z=1.31, *p*=0.19) was not effective in adhering dietary goals (*Hedge's g*=-0.52, 95% CI: -1.099 to 0.024) (Table 4). Similar findings were observed between intervention and control group where included studies showed high [41, 48](*n*=193 participants) heterogeneity (χ^2=33.20, I^2=97%, P<0.001) (Table 5) and no significant effect (*Hedge's*

g=0.622, 95% CI: 0.3111 to 0.9375) (Table 6).

Table 4. *Summary of Studies Pre and Post intervention.*

Study or Subgroup	Pre			Post				Mean Difference
	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
11.1.1 HbA1c								
Celano et al., 2018	8.87	1.77	12	8.48	1.54	12	1.50%	0.39 [-0.94,1.72]
Nishita et al., 2012	7.82	0.14	190	7.64	0.13	190	6.20%	0.18 [0.15,0.21]
Steinhardt et al., 2009	6.94	1.7	16	5.57	0.81	16	2.50%	1.37 [0.45,2.29]
Subtotal (95% CI)			218			218	10.20%	0.58 [-0.22,1.38]
Heterogenetity: Tau^2=0.33; Chi^2=6.48, df=2 (P=0.04); I^2=69%								
Test for overall effect Z=1.42 (P=0.16)								
11.1.2 BMI								
Celano et al., 2018	37.3	6.1	12	37	6.8	12	0.10%	0.30 [-4.87,5.47]
Nishita et al., 2012	33.06	0.3	190	32.87	0.31	190	6.20%	0.19 [0.13,0.25]
Steinhardt et al., 2009	32.83	5.36	16	32.08	4.94	16	0.30%	0.75 [-2.82,4.32]
Subtotal (95% CI)			218			218	6.60%	0.19 [0.13,0.25]
Heterogenetity: Tau^2=0.00; Chi^2=0.10, df=2 (P=0.95); I^2=0%								
Test for overall effect Z=6.08 (P<0.00001)								
11.1.3 Dietary Adherence								
Celano et al., 2018	2.5	1.4	12	4.1	2	12	1.49%	-1.60 [-2.98,-0.22]
DuBois et al., 2016	4.17	2.46	100	4.5	1.63	100	3.90%	-0.33 [-0.91,0.25]
Subtotal (95% CI)			112			112	5.30%	-0.80 [-2.01,0.40]
Heterogenetity: Tau^2=0.51; Chi^2=2.76, df=1 (P=0.10); I^2=64%								
Test for overall effect Z=1.31 (P=0.19)								
11.1.4 Diabetes Self-care								
Celano et al., 2018	2	0.7	12	3.8	1.2	12	3.00%	-1.80 [-2.59,-1.01]
DuBois et al., 2016	3.61	0.95	100	4.25	0.9	100	5.60%	-0.64 [-0.90,-0.38]
Pena-Purcell et al 2011	40.48	26.2	139	66.67	16.7	139	0.10%	-26.19 [-31.36, -21.02]
Steinhardt et al., 2009	3.25	0.12	16	3.98	0.08	16	6.20%	-0.73 [-0.80,-0.66]
Wu et al., 2011	46.15	15.24	158	55.06	16.01	158	0.30%	-8.91 [-12.36,-5.46]
Subtotal (95% CI)			425			425	15.10%	-2.59 [-3.67,-1.50]
Heterogenetity: Tau^2=0.98; Chi^2=122.50, df=4 (P<0.00001); I^2=97%								
Test for overall effect Z=4.68 (P<0.00001)								
11.1.5 Self reported PA								
Celano et al., 2018	225.7	41.35	12	309.9	48.66	12	0.00%	-84.20 [-120.33,-48.07]
DuBois et al., 2016	1.29	1.94	100	2.88	1.58	100	4.40%	-1.59 [-2.08,-1.10]
Steinhardt et al., 2009	518.9	41.4	16	633.1	59.9	16	0.00%	-114.20 [-149.88,-78.52]
Subtotal (95% CI)			128			128	4.40%	-65.17 [-144.74,14.41]
Heterogenetity: Tau^2=4726.51; Chi^2=58.33, df=2 (P<0.00001); I^2=97%								
Test for overall effect Z=1.61 (P=0.11)								
11.1.6 Positive effects								
Celano et al., 2018	37.2	5.1	12	37.4	4.6	12	0.20%	-0.20 [-4.09,3.69]
Cohn et al., 2014	4.68	1.48	53	4.76	1.43	53	4.00%	-0.08 [-0.63,0.47]
Steinhardt et al., 2009	3.87	0.12	16	4.06	0.13	16	6.10%	-0.19 [-0.28, -0.10]
Subtotal (95% CI)			81			81	10.40%	-0.19 [-0.27,-0.10]
Heterogenetity: Tau^2=0.00; Chi^2=0.15, df=4 (P=0.93); I^2=0%								
Test for overall effect Z=4.29 (P<0.0001)								
11.1.7 Optimism								
Celano et al., 2018	19	5	12	19.4	3.7	12	0.30%	-0.40 [-3.92,3.12]
DuBois et al., 2016	20.91	5.82	100	22.66	4.45	100	1.30%	-1.75 [-3.19,-0.31]
Subtotal (95% CI)			112			112	1.60%	-1.56 [-2.89,-0.23]
Heterogenetity: Tau^2=0.00; Chi^2=0.48, df=1 (P=0.49); I^2=0%								
Test for overall effect Z=2.30 (P=0.02)								
11.1.8 Anxiety								
Celano et al., 2018	5.8	3.6	12	6.6	4.4	12	0.30%	-0.80 [-4.02,2.42]
DuBois et al., 2016	7.25	4.07	100	5.67	3.3	100	2.20%	1.58 [0.55,2.61]
Nowlan et al., 2015	6.58	5.93	26	5.65	6.71	26	0.30%	0.93 [-2.51,4.37]
Subtotal (95% CI)			138			138	2.80%	1.33 [0.39,2.27]
Heterogenetity: Tau^2=0.00; Chi^2=1.96, df=2 (P=0.37); I^2=0%								
Test for overall effect Z=2.77 (P=0.006)								
11.1.9 Depression								
Celano et al., 2018	3.1	7.4	12	2.6	1.8	12	0.20%	0.50 [-3.81,4.81]
Cohn et al., 2014	20.9	11.5	53	1.7	9.58	53	0.20%	19.20 [15.17,23.23]
DuBois et al., 2016	6.08	3.09	100	5	2.7	100	2.90%	1.08 [0.28,1.88]
Subtotal (95% CI)			165			165	3.30%	6.85 [-3.88,17.58
Heterogenetity: Tau^2=86.87; Chi^2=75.03, df=2 (P<0.00001); I^2=97%								
Test for overall effect Z=1.25 (P=0.21)								

11.1.10 Self-efficacy								
Nishita et al., 2012	3.77	0.06	190	4.05	0.05	100	6.20%	-0.28 [-29, -027]
Pena-Purcell et al., 2011	56.25	28.1	139	88.75	21.3	139	0.10%	-32.50 [-38.36, -26.64]
Wu et al., 2011	131.79	44.52	158	157.89	34.68	158	0.00%	-26.10 [-34.90,-17.30]
Subtotal (95% CI)			487			397	6.40%	-19.45 [-43.86,4.96]
Heterogenetity: Tau^2=455.78; Chi^2=149.14, df=2 (P<0.00001); I^2=99%								
Test for overall effect Z=1.56 (P=0.12)								
11.1.11 QOL								
DuBois et al., 2016	28.5	4.4	100	26.55	3.78	100	1.90%	1.95 [0.81, 3.09]
Nishita et al., 2012	14.39	0.19	190	14.91	0.17	190	6.20%	-0.52 [-0.56, -0.48]
Steinhardt et al., 2009	2.28	0.11	16	2.13	0.13	16	6.10%	0.15 [0.07, 0.23]
Yalcin et al., 2008	56.56	7.3	36	68.16	4.4	36	0.40%	-11.60 [-14.38,-8.82]
Subtotal (95% CI)			342			342	14.70%	-0.37 [-1.04,0.30]
Heterogenetity: Tau^2=0.30; Chi^2=286.95, df=3 (P<0.00001); I^2=99%								
Test for overall effect Z=1.08 (P=0.28)								
11.1.12 Health Behaviour Adherence								
Celano et al., 2018	2.5	1.4	12	4.1	2	12	1.40%	-1.60 [-2.98, -0.22]
DuBois et al., 2016	11.5	3.5	100	12.67	2.28	100	2.80%	-1.17 [-1.99, -0.35]
Yalcin et al., 2008	53.34	10.34	36	69.5	3.19	36	0.30%	-16.16 [-19.69, -12.63]
Subtotal (95% CI)			148			148	4.50%	-5.85 [-10.86,-0.83]
Heterogenetity: Tau^2=18.43; Chi^2=65.73, df=2 (P<0.00001); I^2=97%								
Test for overall effect Z=2.28 (P=0.02)								
11.1.13 Stress								
Cohn et al., 2014	2.09	0.58	53	1.5	0.69	53	5.60%	0.59 [0.35,0.83]
DuBois et al., 2016	2.42	0.92	100	2.2	0.79	100	5.70%	0.22 [-0.02,0.46]
Steinhardt et al., 2009	15.56	1.33	16	14.1	1.14	16	2.70%	1.46 [0.60, 2.32]
Subtotal (95% CI)			169			169	14.00%	0.59 [0.14, 1.03]
Heterogenetity: Tau^2=0.11; Chi^2=10.18, df=3 (P=0.006); I^2=80%								
Test for overall effect Z=2.57 (P=0.01)								
11.1.14 Positive Appraisal								
Nowlan et al., 2015	10.39	4.78	26	16.82	4.64	26	0.50%	-6.43 [-8.99,-3.87]
Yalcin et al., 2008	97.77	8.98	36	124.44	5.37	36	0.30%	-26.67 [-30.09,-23.25]
Subtotal (95% CI)			62			62	0.80%	-16.52 [-36.35, 3.32]
Heterogenetity: Tau^2=202.45; Chi^2=86.28, df=1 (P<0.00001); I^2=99%								
Test for overall effect Z=1.63 (P=0.10)								
Total (95% CI)			2805			2715	100.0%	-0.39 [-0.58, -0.20]
Heterogenetity: Tau^2=0.15; Chi^2=2633.72, df=41 (P<0.00001); I^2=98%								
Test for overall effect Z=4.09 (P<0.0001)								
Test for Subgroup differences: Chi^2=110.01, df=13 (P< 0.00001), I^2=88.2%								

Table 5. *Summary of Studies PP intervention vs control.*

Study or Sugroup	**PP Intervention**			**Control**				**Mean Difference**
	Mean	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random,95% CI**
1.1.1 Depression								
Celano et al 2018	3.1	7.4	12	2.6	1.8	12	0.20%	050 [-3.81, 4.81]
Cohn et al., 2014	17.1	15.4	53	17.7	14.7	53	0.10%	-0.60 [-6.33, 5.13]
Nowlan et al. 2015	3.46	2.98	26	2.38	2.73	26	1.1.%	1.08 [-0.47, 2.63]
Steinhardt et al 2009	12.61	1.33	16	13.97	14.3	16	0.10%	-1.36 [-8.40, 5.68]
Subtotal (95% CI)			107			107	1.40%	0.83 [-0.56, 2.21]
Heterogeneity: Tau^Z=0.00; Chi^Z=0.73, df=3 (p=0.87); I^Z=0%								
Test for overall effect: Z=1.17 (P=0.24)								
1.1.2 Anxiety								
Celano et al 2018	5.8	3.6	12	6.6	4.4	12	0.30%	-0.80 [-4.02, 2.42]
Nowlan et al. 2015	6.58	5.93	26	5.65	6.71	26	0.20%	0.93 [-2.51, 4.37]
Subtotal (95% CI)			38			38	0.50%	0.01 [-2.34,2.36]
Heterogeneity: Tau^Z=0.00; Chi^Z=0.52, df=1 (p=0.47); I^Z=0%								
Test for overall effect: Z=1.17 (P=1.00)								
1.1.3 Positive effects								
Celano et al 2018	37.2	5.1	12	37.4	4.6	12	0.20%	-0.20 [-4.09, 3.61]
Cohn et al., 2014	5.13	1.94	53	4.64	2.13	53	3.10%	0.49 [-0.29, 1.27]
Nowlan et al. 2015	14.42	3.42	26	15.7	3.27	26	0.80%	-1.28 [-3.10, 0.54]
Steinhardt et al 2009	2.21	0.1	16	1.94	0.11	16	8.20%	0.27 [0.20, 0.34]
Subtotal (95% CI)			107			107	12.30%	0.26 [0.06, 0.46]
Heterogeneity: Tau^Z=0.00; Chi^Z=3.15, df=3 (p=0.37); I^Z=5%								
Test for overall effect: Z=2.57 (P=0.01)								
1.1.4 Negative effects								
Cohn et al., 2014	2.69	1.25	53	2.39	0.86	53	5.70%	0.30 [0.11, 0.71]

Nowlan et al. 2015	14.42	3.42	26	15.7	3.27	26	0.80%	1.50 [-0.29, 3.29]
Steinhardt et al 2009	2.21	0.1	16	1.94	0.11	16	8.20%	0.13 [0.05, 0.21]
Subtotal (95% CI)			107			107	12.30%	0.19 [-0.04, 0.43]
Heterogeneity: Tau^2=0.02; Chi^2=2.87, df=2 (p=0.24); I^2=30%								
Test for overall effect: Z=1.60 (P=0.11)								
1.1.5 HbA1C								
Bradshaw et al 2007	6.7	1.16	67	6.9	1.14	67	5.80%	-0.20 [-0.59, 0.19]
Celano et al 2018	8.87	1.77	12	8.48	1.54	12	1.40%	0.39 [-0.94, 1.72]
Nishita et al.,2012	7.64	0.13	190	7.82	0.14	190	8.30%	-0.18 [-0.21, -0.15]
Steinhardt et al 2009	6.94	1.7	16	5.57	0.81	16	2.50%	1.37 [0.45, 2.29]
Yalcin et al., 2008	7.86	0.31	36	7.73	0.77	36	6.90%	0.13 [-0.14, 0.40]
Subtotal (95% CI)			321			321	0.07%	0.07 [-0.25, 0.39]
Heterogeneity: Tau^2=0.07; Chi^2=16.47, df=4 (p=0.002); I^2=76%								
Test for overall effect: Z=0.42 (P=0.67)								
1.1.6 Self -efficancy								
Nishita et al.,2012	4.05	0.05	190	3.92	0.08	190	8.30%	0.13 [0.12, 0.14]
Pena-Purcell et al., 2011	56.25	28.1	139	66.7	22.5	139	0.10%	-10.45 [-16.13, -4.47]
Wu et al., 2008	157.89	34.89	158	130.32	41.95	158	0.00%	27.57 [19.08, 36.06]
Subtotal (95% CI)			487			487	8.40%	5.25 [-9.30, 19.79]
Heterogeneity: Tau^2=156; Chi^2=52.16, df=2 (p<0.00001); I^2=96%								
Test for overall effect: Z=0.71 (P=0.48)								
1.1.7 Healthful eating pattern								
Bradshaw et al 2007	1.3	0.47	54	1.1	0.314	54	7.80%	0.20 [0.05, 0.35]
Pena-Purcell et al., 2011	3	4	139	0	4	139	2.40%	3.00 [2.06, -4.47]
Subtotal (95% CI)			193			193	10.20%	1.56 [-1.18, 4.30]
Heterogeneity: Tau^2=3.80; Chi^2=33.20.16, df=1 (p<0.00001); I^2=97%								
Test for overall effect: Z=1.11 (P=0.26)								
1.1.8 BMI								
Celano et al 2018	37.3	6.1	12	37	6.8	12	0.10%	0.30 [-4.87, 5.47]
Nishita et al.,2012	32.37	0.23	190	33.06	0.3	190	8.30%	-0.69 [-0.74, -0.64]
Steinhardt et al 2009	32.83	5.36	16	32.08	4.94	16	0.20%	0.75 [-2.82, 4.32]
Yalcin et al., 2008	29.92	5.31	36	29.51	4.31	36	0.60%	0.41 [-1.82, 2.64]
Subtotal (95% CI)			254			254	12.30%	-0.69 [-0.74, -0.64]
Heterogeneity: Tau^2=0.00; Chi^2=1.70, df=3 (p=0.64); I^2=0%								
Test for overall effect: Z=25.13 (P<0.00001)								
1.1.9 Exercise								
Bradshaw et al 2007	2.67	1.51	54	2.32	1.3	54	4.60%	0.34 [-0.18, 0.88]
Nowlan et al. 2015	2	4	26	0	3.5	26	0.70%	2.00 [-0.04, 4.04]
Pena-Purcell et al., 2011	3	6	139	0	45	139	1.40%	3.00 [1.79, 4.30]
Steinhardt et al 2009	32.83	5.36	16	32.08	4.94	16	0.20%	0.75 [-2.82, 4.32]
Subtotal (95% CI)			235			235	7.00%	1.56 [-0.11, 3.23]
Heterogeneity: Tau^2=2.04; Chi^2=15.11, df=3 (p<0.0002); I^2=80%								
Test for overall effect: Z=1.83 (P=0.07)								
1.1.10 Self-care								
Celano et al 2018	2	0.7	12	3.8	1.2	12	3.00%	-1.80 [-2.59, -1.01]
Steinhardt et al 2009	3.98	0.08	16	3.82	0.11	16	8.20%	0.16 [0.09, 0.23]
Wu et al., 2008	55.06	16.01	158	46.71	14.28	158	0.30%	8.35 [5.00, 11.70]
Subtotal (95% CI)			186			186	11.50%	1.19 [-1.11, 3.49]
Heterogeneity: Tau^2=3.44; Chi^2=46.81, df=2 (p<0.00001); I^2=98%								
Test for overall effect: Z=1.01 (P<0.31)								
Total (95% CI)			2023			2023	100.00%	0.20 [0.03, 0.37]

Heterogeneity: Tau^2=0.09; Chi^2=1372.86, df=33 (p<0.00001); I^2=98%
Test for overall effect: Z=2.30 (P<0.02)
Test for subgroup difference: ChiZ=155.18. df=9 (P<0.00001). IZ94.2%

Table 6. *Main effects.*

Outcome measures	n	N	Hedge'g (95% CI)	Heterogeneity	Test for overall effect
Post-test					
HbA1C	218	N_e=321, N_c=321	0.8532 (0.2734-1.4503)	Q=6.48, df=2, T^2=0.33 (p=0.04), I^2=69%	Z=1.42, (p=0.16)
BMI	218	N_e=254, N_c=254	0.2694 (-0.2958, 0.8376)	Q=0.10, df=2, T^2=0.00 (p=0.95), I^2=0%	Z=6.08 (p<0.001)
Dietary Adherence	112	N_e=112, Nc=112	-0.5262 (-1.0992, -0.0237)	Q=2.76, df=1, T^2=0.51 (p=0.10), I^2=64%	Z=1.31 (p=0.19)
Self-Care	425	N_e=186, Nc=186	-2.2387 (-3.0158, -1.5516)	Q=122.50, df=4, T^2=0.98 (p<0.001), I^2=97%	Z=4.68 (p<0.001)
Self-reported physical activity	128	N_e=128, Nc=128	-1.6193 (-2.3684, -0.9346)	Q=58.33, df=2, T^2=4726.51, (p<0.001), I^2=97%	Z=1.161 (p=0.11)
Positive affect	81	N_e=107, Nc=107	0.5815 (-0.0760,0.8839)	Q=0.15, df=2, T^2=0.00, (p=0.93), I^2=0%	Z=4.29 (p<0.001)
Optimism	112	N_e=112, Nc=112	-0.2122 (-0.7536, 0.3263)	Q=0.48, df=1, T^2=0.00, (p=0.49), I^2=0%	Z=2.30 (p=0.02)
Anxiety	138	N_e=38, Nc=38	0.1258 (-0.4172, 0.6674)	Q=1.96, df=2, T^2=0.00, (p=0.37), I^2=0%	Z=2.77 (p=0.006)
Depression	165	N_e=107, Nc=107	0.7538 (0.2470, 1.2694)	Q=75.03, df=2, T^2=86.87, (p<0.001), I^2=97%	Z=1.25 (p=0.21)
Self-efficacy	487	N_e=487, Nc=487	-2.314 (-2.641, -2.041)	Q=149.14, df=2, T^2=455.78, (p<0.001), I^2=99%	Z=1.56 (p=0.12)
Quality of Life	342	N_e=342, Nc=342	-0.7737 (-1.2455, -0.3003)	Q=286.95, df=3, T^2=0.30, (p<0.001), I^2=99%	Z=1.08 (p=0.28)
Health behaviour Adherence	148	N_e=148, Nc=148	-1.1265 (-1.7083, -0.5722)	Q=65.77, df=2, T^2=18.44, (p<0.001), I^2=97%	Z=2.28 (p=0.02)
Stress	169	N_e=169, Nc=169	0.7745 (0.3057, 1.2612)	Q=10.18, df=2, T^2=0.11, (p=0.006), I^2=80%	Z=2.57 (p=0.01)
Positive Appraisal	62	N_e=62, Nc=62	-2.4553 (-3.1594, -1.7999)	Q=86.28, df=1, T^2=202.45, (p<0.001), I^2=99%	Z=1.63 (p=0.10)
PP intervention VS Control					
Depression	107	N_e=107, N_c=107	0.1254 (-0.4796, 0.7346)	Q=0.84, df=3, T^2=0.00, (p=0.84), I^2=0%	Z=1.33, (p=0.18)
Anxiety	38	N_e=38, N_c=38	-0.0237 (-0.6987, 0.6480)	Q=0.52, df=1, T^2=0.00, (p=0.47), I^2=0%	Z=0.01 (p=1.00)
Positive affect	107	N_e=107, N_c=107	0.5815 (-0.0760, 0.8839)	Q=3.15, df=3, T^2=0.01, (p=0.37), I^2=5%	Z=2.57 (p=0.01)
Negative affect	95	N_e=95, N_c=95	0.6245 (0.0711, 1.1960)	Q=2.87, df=2, T^2=0.02, (p=0.24), I^2=30%	Z=1.60 (p=0.11)
HbA1C	321	N_e=321, N_c=321	-0.0107 (-0.5198, 0.5075)	Q=16.47, df=4, T^2=0.07, (p=0.002), I^2=76%	Z=0.42 (p=0.67)
Self-efficacy	487	N_e=487, N_c=487	0.7762 (0.5411, 1.0136)	Q=52.16, df=2, T^2=156.18, (p<0.001), I^2=96%	Z=0.71 (p=0.48)
Healthful eating pattern	193	N_e=193, N_c=193	0.6224 (0.3111, 0.9375)	Q=33.20, df=1, T^2=3.80, p<0.001, I^2=97%	Z=1.11 (p=0.26)
BMI	254	N_e=254, N_c=254	-0.5764 (-1.1336, -0.0192)	Q=1.70, df=3, T^2=0.00, p=0.64, I^2=0%	Z=25.13 (p<0.001)
Exercise	235	N_e=235, N_c=235	0.3636 (-0.1003, 0.8325)	Q=15.11, df=3, T^2=2.04, p=0.002, I^2=80%	Z=1.83 (p=0.07)
Self-care	186	N_e=186, N_c=186	0.1339 (-0.5378, 0.7948)	Q=46.81, df=2, T^2=3.44, p<0.001, I^2=96%	Z=1.01 (p=0.31)

5.3.9. Effects on Self-care

As shown in the Table 4, the pooled analysis from five studies [42, 45, 48, 49](n=425 participants) showed that PPI was significantly associated with an improvement in the self-care (*Hedge's g*=-2.239, 95% CI: -3.0158 to -1.5516) (Table 6) with a significant heterogeneity (χ^2=122.50, I^2=97%, p <0.001). (Table 4). However, such an effect was not observed [42, 49, 51] (n=186 participants) when compared with intervention and control group (Z=1.01, p=0.31) (Table 5).

5.3.10. Effects on Self-reported Physical Activity

Three studies [42, 45, 49] (n=128) analyzed the mean change of self-reported PAT and no significant mean difference was observed between pre and post-test (Z=1.61, p=0.11). (Table 4). A significant heterogeneity (χ^2=58.33, I^2=97%, p <0.001) was observed. Although not significant, moderate effect of PPI lead to participation in the physical activity compared to controls in the pooled analyses of four studies [41, 47–49] (n=235) (Z=1.83, p=0.07) (Table 5). This corresponds to an effect size of 0.3636 in absolute units (ranged from -0.1003 to 0.833). Heterogeneity was significant (χ^2=15.11, I^2=80%, p<0.001).

Overall, pooled analyses of three studies [42, 43, 45] (n=148) on the effect of PPI on health behaviour adherence showed a significant heterogeneity (χ^2=65.77, I^2=97%, p <0.001) (Table 4). The pooled estimate (Z=2.28, p=0.02) indicated that there is a significant mean difference in health behaviour adherence between pre and post-test (*Hedge's g*=-1.1265 95% CI: -1.7083 to -0.5722) (Table 6).

5.4. Secondary Outcome

5.4.1. Effects on Anxiety

Three studies [42, 45, 47] (n=38) analyzed the mean change of anxiety at post-intervention while the pooled estimate (MD=1.33, 95% CI: 0.39, 2.27, Z=2.77, p=0.006) indicated that there is a significant mean difference in anxiety score between pre and post-test. (Table 4) (*Hedge's g*=0.12, 95% CI: -0.4172 to 0.6674) (Table 6). No significant heterogeneity (χ^2=1.96, I^2=0%, p=0.37) was observed. On the other hand, two studies [42, 47] (n=38 participants) that compared intervention with a control group showed no significant mean difference (MD=0.01, 95% CI: -2.34 to 2.36, Z=0.01, p=1.00) in anxiety score and heterogeneity was insignificant (χ^2=0.52, I^2=0%, p=0.47) (Table 5).

5.4.2. Effects on Depression

Effects on depression were reported in three studies [42, 44, 45] (n=165). The pooled estimate (Z=1.25, p=0.21) (Table 4) indicated that there is no significant mean difference in depression between pre and post-test (*Hedge's g*=0.75%, 95% CI: 0.247 to 1.269) (Table 6). Heterogeneity was significant (χ^2=75.03, I^2=97%, p <0.001). Similarly, the mean change of

depression score between PP intervention and control groups (n=107 participants) also insignificant (MD=0.83, 95% CI: -0.56, 2.21, p=0.24) (Table 5).

5.4.3. Effects of Stress

Three studies [42, 45, 49] (n=169 participants) analyzed the mean change of stress after pre-test immediately. The results showed there was a significant heterogeneity (χ^2=10.18, I^2=80%, p <0.001) among these included studies. The pooled estimate (MD=0.59, 95% CI: 0.14, 1.03, Z=2.57, p=0.01) (Table 4) indicated that there is a significant mean difference in stress between pre and post-test (*Hedge's g*=0.77, 95% CI: 0.3057 to 1.2612) (Table 6).

5.5. Subgroup Analyses

The subgroup analyses were carried out to examine the difference in the delivery setting (individual versus group intervention), intervention delivered by nurses versus physicians or psychologists, male versus female, age <60 years old versus age ≥60 years old. However, due to the nature of studies, subgroup analyses were carried out to only two primary outcomes, i.e., health behaviour adherence and individual group. Two studies [42, 47] (n=38 participants) analyzed the mean change of individual group after PP intervention and control group immediately. The results showed there was no significant heterogeneity (χ^2=0.06, I^2=0%, p=0.80) among these included studies (*Hedge's g*=-0.245, 95% CI: -3.1594 to -1.7999). The pooled estimate (MD=1.01, (-0.45, 2.47), Z=1.36, p=0.17) showed that there is difference between pre and post-test. Two studies [42, 45] (n=112 participants) analyzed the mean change of health behaviour adherence after pre-test immediately. The results showed there was no significant heterogeneity (χ^2=0.28, I^2=0%, p=0.60>0.05) among these included studies. The pooled estimate (MD=-1.28, (-1.99, -0.58), Z=3.57, p=0.004) indicated that there is a significant mean difference in stress between pre and post-test (*Hedge's g*=- 0.64 95% CI: -1.2191 to -0.0940) (Table 6).

6. Discussion

To our knowledge, this is the first meta-analysis examining the effects of multicomponent PP interventions on well-being and health behaviour adherence amongst patients with T2DM. Our findings indicate that PPIs have a small but significant effect on well-being, especially positive affect and optimism at post-intervention. In addition, a small but significant effect size was found for health behaviour adherence, body mass index and self-care at post-intervention. Effect sizes for anxiety and stress were also significant. These findings show that PPIs have a potential not only to improve well-being but also help for self-care and health behaviour adherence and reduction in anxiety and stress. However, our meta-analyses did not show any effect on other well-being measures such as positive appraisal, self-efficacy, QoL, nor on HbA1c, or health behaviour adherence measures such as diet and physical activity adherence, and depression score in both at post-intervention or in comparison with controls.

The previous meta-analysis did report a significant substantially larger effect sizes of PPIs on subjective, psychological wellbeing, depression [52] and anxiety [52]. However, in contrast, the present meta-analysis did not find any association with depression. This may be perhaps due to the inclusion of the low-quality studies and possibly the use of a wide variety of tools to measure depression. Although we attempted to identify eight hundred and eighty-eight titles which met our initial search strategy but only eleven studies met our inclusion criteria, focusing specifically on enhancing well-being and health behaviour adherence with T2D. Majority of the studies that excluded during the title and abstract screening were studies that focused on a treatment approach for diagnosed depression among T2D. This suggests that to date, research has overwhelmingly emphasized alleviating depressive symptoms rather than enhancing wellbeing. Still, our analysis allowed us to hone on the key elements of preventative approaches, namely PP intervention incorporating diabetes self-management, problem-solving and resilience-focused approaches.

Positive psychological interventions have several advantages compared to other treatment programs. Firstly, exercises within positive psychological interventions tend to be shorter and could be finished independently. Secondly, as opposed to other treatments that are applied to patients with clinical depression, PP interventions are used instead of increased positive psychological wellbeing across the different population. Thirdly, this does not require the substantial provider training, specifically targets positive and optimism constructs, thereby linked to superior adherence and outcomes in T2DM, and there is no need for an in-person session. Fourthly, positive psychological interventions in a specific focus on behaviours and positive traits (for instance, optimism and positive effects) that have been linked with an increase in participation within health behaviours and superior medical outcomes [53, 54]. Finally, positive psychological interventions exercises are validated, which target particular positive constructs other than self-efficacy or optimism which is associated with outcomes that are advantageous [55, 56].

Yet there have not been many studies that extensively compared the effectiveness of an extensive range of PPIs on improving the subjective well-being and health behaviour adherence amongst patients with T2DM, especially from Western perspective. The western perspective would be a starting point to identify concepts, theories and methodological basis. This in turn would enable researchers from non-western countries such as India to develop culturally based constructs and intervention by mapping from Upanishads, Bhagavad Gita and examining historical, religious and sociological texts in conjunction with the scientific literature. Our strength of meta-analyses lay in the fact that the analysis comprised of evaluating the findings from diverse studies which allowed aggregation of information resulting in a superior statistical power with a strong point estimate. This is in stark contrast to any analysis that would be executed on the basis of a single stand-alone study. However, the findings should be interpreted within the scope of a few limitations. Firstly, the quality of the

studies was not high, given the scope of this review. Secondly, evidence was not strong enough due to the small sample size. More studies with larger sample size should be performed to verify these results. Thirdly, most of the studies conducted the completers-only analysis, as opposed to intention-to-treat analysis, which in turn could have resulted in seriously biased results [57]. Fourthly, the significant heterogeneity among studies was still present, due to the mixed nature of the intervention (e.g. two studies that focused on resilience plus nutrition state, one study on emotional intelligence, self-efficacy (2 studies) and activation state). Despite strict inclusion criteria applied, different types of PP interventions are clubbed together and hence resulted in a high level of heterogeneity.

In this meta-analysis, there was little variation in regard to the intervention module, and program phase and most of the studies did not report on adherence. Studies had reported quite low adherence in self-help interventions [58] Therefore, it does not provide firm indications on how to improve its effectiveness. Although the timeline for outcome measurement was objectively defined (i.e., 6 months), due to the variability in the choice of the instrument across studies, which in turn could lead differences in terms of effects. The future meta-analysis should be carried out to assess the robustness of the results based on tools of measurement, different measures of effect size (risk ratio and odds ratio), and different statistical models (fixed-effect and random effect models). Further, in the present meta-analysis, a subgroup-analysis was not carried out on specific interventions type due to a small number of studies and too diverse studies. Future studies need more RCT to draw a firmer conclusion.

6.1. Conclusion

In conclusion, this scoping review and meta-analysis provide evidence that PPIs are effective in improving well-being and health behaviour adherence among patients with T2DM. Further, the review also demonstrates that PP intervention can be effective in the reduction of anxiety and stress symptoms. Practitioners can customize their treatment strategy based on the client needs and preferences in conjunction with other evidence-based interventions that enhance well-being such as mindfulness intervention [59], behavioural activation [60], reminiscence [61], acceptance and commitment therapy [62] and forgiveness interventions [63]. From the perspective of public health, PP interventions can be used as a preventive approach and non-stigmatized tool in two ways, such as promoting mental health through health internet portals and leaflets distribution. Secondly, PP can be part of the first step in a stepped care approach, which starts with low intensity at the same time low, or no costs empirically-based intervention [64, 65] that boost total well-being. In case of failure in the first step, participants can be referred to specialized care for more intensive treatment. However, given that study quality was not assessed (e.g. using GRADE or a similar tool), and variation in study design, the effectiveness of these results needs to be interpreted cautiously due to the nature of publication bias and also accounting the limitations discussed above.

6.2. Recommendations for Further Research

Given that PP interventions are still evolving, there is a need for more high-quality and well-conducted studies across the different clinical population, in different age groups (e.g. older adults) with a different set of intervention formats customized based on culture. Majority of the studies have been conducted amongst the western population, and not many have been carried out in non-western or Asian population where more than one-half of the patients with diabetes in the world live. Only countable studies had focused on PP while majority delivered the program in conjunction with problem-based preventive interventions multi-component models; therefore, it's still not clear whether the impact PP on the outcome is due to multicomponent. In future, more studies need to be conducted by adapting the existing culture (e.g. See Martinez et al., [66]). Lastly, diabetes poses a huge economic burden to the society and to an individual patient; therefore, future studies need to account cost-effectiveness of conducting such interventions aiming to establish the society and public impact.

Declarations of Interest

The authors declare that they have no competing interest.

CreDit Author Statement

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