Appendix 5 Meta-analyses and Forest plots

The effectiveness of interventions was assessed through meta-analyses[1] which present data on the statistical significance and effect size of any changes in loneliness from pre to post intervention. Effect sizes from individual studies were also pooled at the theme and sub-theme- level to show the overall effects of intervention type on loneliness alleviation. For studies that used a control group, a secondary meta-analysis was conducted by theme. Here, overall effect sizes show the difference in loneliness changes over time between the intervention and control groups. These generally represent the most robust estimates of loneliness impacts identified in the review.

What is a Forest plot and what does it mean?

A forest plot is a visual way to summarise the meta-analysis results. The effect size (green square) is the *standardised mean difference,* which shows the change in loneliness score from pre to post intervention for each individual study.

The *confidence intervals* (black horizontal lines) are a measure of how certain we are about each effect. Finally, the *pooled effect size* (black diamond) is an overall estimate of the intervention effect based on all the studies included in the meta-analysis.

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[1] Meta-analysis is a statistical technique used to combine the results of two or more studies. Meta-analysis generates an overall statistic that summarises the effectiveness of an intervention. More information can be found here https://training.cochrane.org/handbook/current/chapter-10.

1. Social Support-based interventions

Figure 1. Forest plot demonstrating the effect of **social support-based interventions** on change in loneliness from pre to post intervention

Reference	Pre-intervention			Post-intervention			Standardised Mean Difference	95% CI
	N	Mean	SD	N	Mean	SD		
Haslam et al., 2019	66	25.13	3.11	46	21.51	1.82	-1.35	[-1.77; -0.93]
Quinn, 2021	17	35.39	9.18	17	26.28	7.01	-1.09	[-1.82; -0.36]
Foster et al., 2020	2250	7.20	1.77	2250	5.38	1.80	-1.02	[-1.08; -0.96]
Roberts and Windle, 2019	114	3.43	1.94	114	1.83	1.83	-0.85	[-1.12; -0.57]
Coll-Planas et al., 2017	37	4.55	2.05	26	2.84	2.33	-0.78	[-1.30; -0.26]
Juris et al., 2022 (older adult mentees)	7	5.60	2.20	7	4.10	1.30	-0.78	[-1.88; 0.32]
Massie & Ahmad, 2019	51	4.50	2.16	51	2.80	2.41	-0.74	[-1.14; -0.34]
Bostick and Anderson, 2009	49	2.24	0.78	49	1.67	0.77	-0.73	[-1.14; -0.32]
Ramamonjiarivelo et al., 2022	22	73.65	5.59	22	68.30	9.41	-0.68	[-1.29; -0.07]
Lowthian et al., 2018	39	5.76	1.84	34	4.59	1.62	-0.66	[-1.14; -0.19]
Kahlon et al., 2021	107	6.50	2.11	107	5.20	2.11	-0.61	[-0.89; -0.34]
Stewart et al., 2011	58	38.59	6.75	58	34.39	6.86	-0.61	[-0.99; -0.24]
Kahlon et al., 2021	120	6.50	2.21	107	5.23	2.04	-0.59	[-0.86; -0.33]
Jones et al., 2021	16	2.22	0.42	16	1.99	0.45	-0.52	[-1.22; 0.19]
Renaisi, 2016	62	1.92	1.10	35	1.40	1.30	-0.44	[-0.86; -0.02]
Lim et al., 2020	12	52.58	9.94	10	48.10	10.37	-0.43	[-1.28; 0.43]
Larsson et al., 2016	15	45.53	7.41	14	42.43	7.44	-0.41	[-1.14; 0.33]
McDaid et al., 2021	121	9.30	4.43	121	7.55	4.41	-0.39	[-0.65; -0.14]
Theurer et al., 2021 (older adult mentees)	43	12.77	4.36	43	11.19	4.22	-0.36	[-0.79; 0.06]
Broer et al., 2011	186	5.81	3.21	186	4.85	3.18	-0.30	[-0.50; -0.10]
Theurer et al., 2021 (older adult mentors)	46	10.63	3.95	27	9.41	4.24	-0.30	[-0.78; 0.18]
Fields J. et al., 2021	27	6.81	2.04	27	6.23	2.01	-0.28	[-0.82; 0.25]
Gadbois et al., 2022	21	6.00	2.20	18	5.44	2.01	-0.26	[-0.89; 0.37]
Lai et al., 2020	30	3.27	1.41	30	2.64	3.75	-0.22	[-0.73; 0.29]
Bouwman et al., 2017	131	4.06	1.55	75	3.71	1.89	-0.21	[-0.49; 0.08]
Ohta et al., 2022	77	4.25	1.34	77	4.05	1.21	-0.16	[-0.47; 0.16]
Moonen et al., 2022	47	39.11	2.06	47	38.83	1.98	-0.14	[-0.54; 0.27]
Moore & Preston, 2015	400	7.32	1.70	251	7.11	1.87	-0.12	[-0.28; 0.04]
Antunes et al., 2022	36	68.23	22.67	36	65.77	23.28	-0.11	[-0.57; 0.36]
Costello et al., 2022	232	44.78	10.54	232	43.69	10.94	-0.10	[-0.28; 0.08]
Mattanah et al., 2010	82	1.64	0.44	65	1.60	0.46	-0.09	[-0.41; 0.24]
Kellezi et al., 2019	19	2.42	1.13	19	2.35	1.00	-0.06	[-0.70; 0.57]
Burchett et al., 2022	26	4.30	3.14	26	4.20	2.48	-0.03	[-0.58; 0.51]
Kramer et al., 2022	32	2.47	1.78	32	2.44	1.92	-0.02	[-0.51; 0.47]
Sandu et al., 2021	141	4.16	1.41	84	4.15	1.41	-0.00	[-0.27; 0.27]
Hernández-Ascanio, et al., 2022	63	6.51	3.62	43	6.50	3.50	-0.00	[-0.39; 0.38]
Nguyen et al., 2022	124	5.50	1.70	124	5.50	1.80	0.00	[-0.25; 0.25]
Larsen et al., 2019	962	2.24	0.79	809	2.25	0.77	0.01	[-0.08; 0.11]
Lorente-Martínez et al., 2021	34	32.29	5.13	34	32.41	7.02	0.02	[-0.46; 0.49]
Larsen et al., 2019	781	2.21	0.79	670	2.30	0.79	0.11	[0.01; 0.22]
Juris et al., 2022 (student mentors)	30	5.00	1.50	18	5.20	1.70	0.12	[-0.46; 0.71]
Llewellyn et al., 2020	59	6.60	3.14	7	7.10	2.48	0.16	[-0.62; 0.94]
The Mental Health Foundation, 2018	13	2.25	2.16	13	3.08	2.41	0.35	[-0.42; 1.13]

Overall effect — **-0.34 [-0.45; -0.22]**

Heterogeneity: I^2 = 94%, p < 0.01

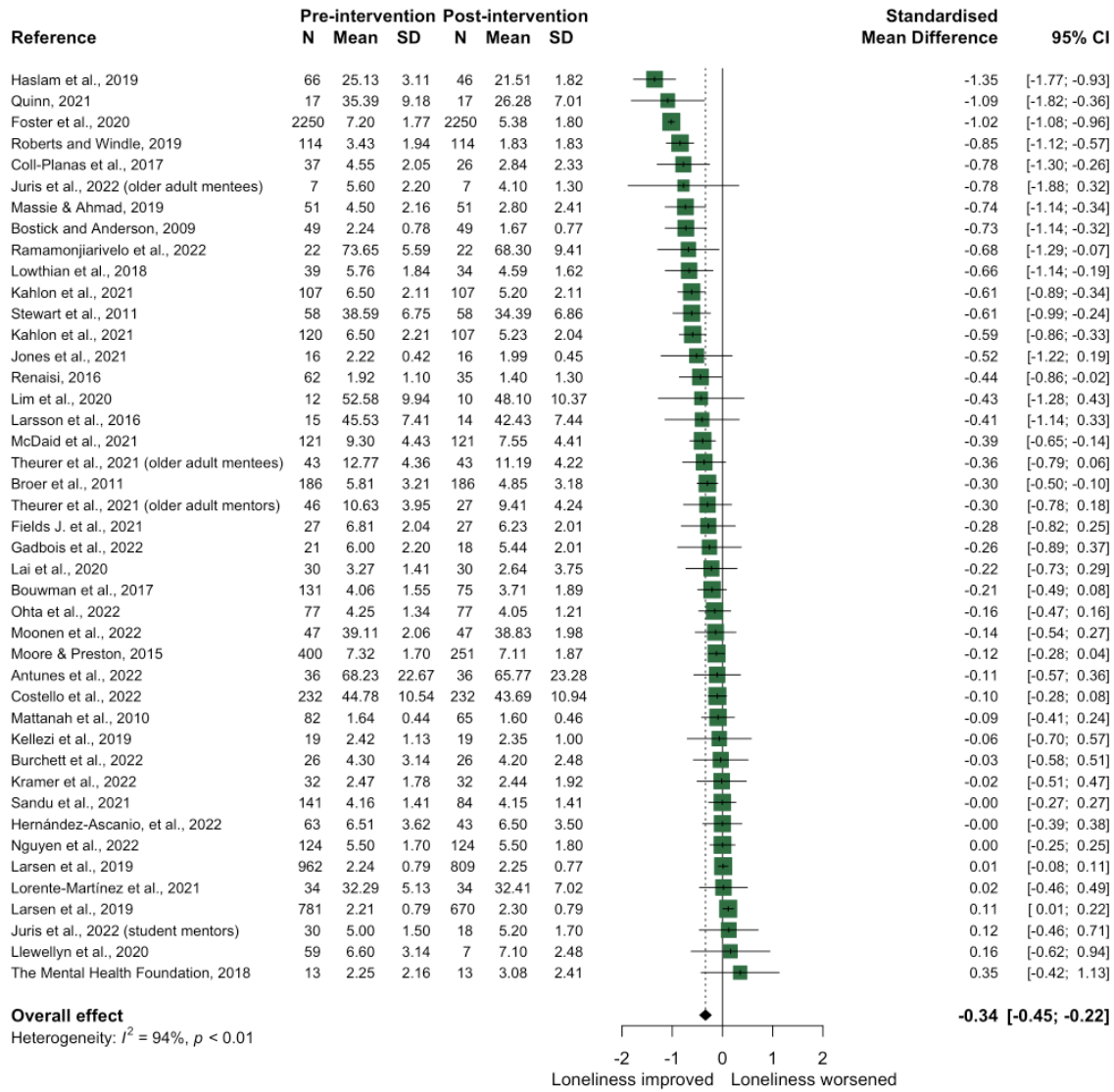Loneliness improved   Loneliness worsened

Figure 2. Forest plot demonstrating the effect of **social support-based** interventions by **subtheme** on change in loneliness from pre to post-intervention
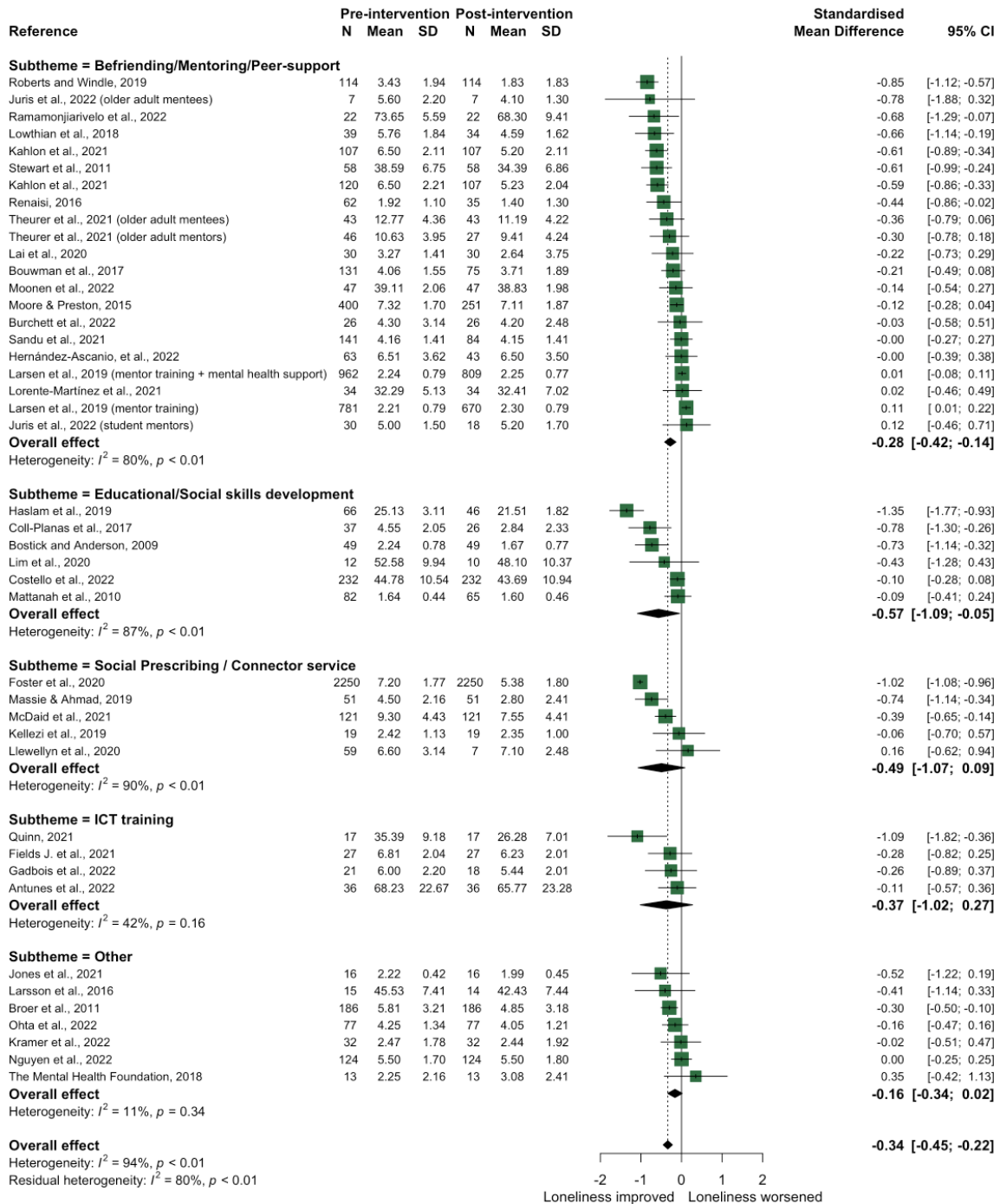
Reference	Pre-intervention			Post-intervention			Standardised Mean Difference	95% CI
	N	Mean	SD	N	Mean	SD		
Subtheme = Befriending/Mentoring/Peer-support								
Roberts and Windle, 2019	114	3.43	1.94	114	1.83	1.83	-0.85	[-1.12; -0.57]
Juris et al., 2022 (older adult mentees)	7	5.60	2.20	7	4.10	1.30	-0.78	[-1.88; 0.32]
Ramamonjiarivelo et al., 2022	22	73.65	5.59	22	68.30	9.41	-0.68	[-1.29; -0.07]
Lowthian et al., 2018	39	5.76	1.84	34	4.59	1.62	-0.66	[-1.14; -0.19]
Kahlon et al., 2021	107	6.50	2.11	107	5.20	2.11	-0.61	[-0.89; -0.34]
Stewart et al., 2011	58	38.59	6.75	58	34.39	6.86	-0.61	[-0.99; -0.24]
Kahlon et al., 2021	120	6.50	2.21	107	5.23	2.04	-0.59	[-0.86; -0.33]
Renaisi, 2016	62	1.92	1.10	35	1.40	1.30	-0.44	[-0.86; -0.02]
Theurer et al., 2021 (older adult mentees)	43	12.77	4.36	43	11.19	4.22	-0.36	[-0.79; 0.06]
Theurer et al., 2021 (older adult mentors)	46	10.63	3.95	27	9.41	4.24	-0.30	[-0.78; 0.18]
Lai et al., 2020	30	3.27	1.41	30	2.64	3.75	-0.22	[-0.73; 0.29]
Bouwman et al., 2017	131	4.06	1.55	75	3.71	1.89	-0.21	[-0.49; 0.08]
Moonen et al., 2022	47	39.11	2.06	47	38.83	1.98	-0.14	[-0.54; 0.27]
Moore & Preston, 2015	400	7.32	1.70	251	7.11	1.87	-0.12	[-0.28; 0.04]
Burchett et al., 2022	26	4.30	3.14	26	4.20	2.48	-0.03	[-0.58; 0.51]
Sandu et al., 2021	141	4.16	1.41	84	4.15	1.41	-0.00	[-0.27; 0.27]
Hernández-Ascanio, et al., 2022	63	6.51	3.62	43	6.50	3.50	-0.00	[-0.39; 0.38]
Larsen et al., 2019 (mentor training + mental health support)	962	2.24	0.79	809	2.25	0.77	0.01	[-0.08; 0.11]
Lorente-Martínez et al., 2021	34	32.29	5.13	34	32.41	7.02	0.02	[-0.46; 0.49]
Larsen et al., 2019 (mentor training)	781	2.21	0.79	670	2.30	0.79	0.11	[0.01; 0.22]
Juris et al., 2022 (student mentors)	30	5.00	1.50	18	5.20	1.70	0.12	[-0.46; 0.71]
Overall effect							**-0.28**	**[-0.42; -0.14]**
Heterogeneity: $I^2 = 80\%$, $p < 0.01$								
Subtheme = Educational/Social skills development								
Haslam et al., 2019	66	25.13	3.11	46	21.51	1.82	-1.35	[-1.77; -0.93]
Coll-Planas et al., 2017	37	4.55	2.05	26	2.84	2.33	-0.78	[-1.30; -0.26]
Bostick and Anderson, 2009	49	2.24	0.78	49	1.67	0.77	-0.73	[-1.14; -0.32]
Lim et al., 2020	12	52.58	9.94	10	48.10	10.37	-0.43	[-1.28; 0.42]
Costello et al., 2022	232	44.78	10.54	232	43.69	10.94	-0.10	[-0.28; 0.08]
Mattanah et al., 2010	82	1.64	0.44	65	1.60	0.46	-0.09	[-0.41; 0.24]
Overall effect							**-0.57**	**[-1.09; -0.05]**
Heterogeneity: $I^2 = 87\%$, $p < 0.01$								
Subtheme = Social Prescribing / Connector service								
Foster et al., 2020	2250	7.20	1.77	2250	5.38	1.80	-1.02	[-1.08; -0.96]
Massie & Ahmad, 2019	51	4.50	2.16	51	2.80	2.41	-0.74	[-1.14; -0.34]
McDaid et al., 2021	121	9.30	4.43	121	7.55	4.41	-0.39	[-0.65; -0.14]
Kellezi et al., 2019	19	2.42	1.13	19	2.35	1.00	-0.06	[-0.70; 0.57]
Llewellyn et al., 2020	59	6.60	3.14	7	7.10	2.48	0.16	[-0.62; 0.94]
Overall effect							**-0.49**	**[-1.07; 0.09]**
Heterogeneity: $I^2 = 90\%$, $p < 0.01$								
Subtheme = ICT training								
Quinn, 2021	17	35.39	9.18	17	26.28	7.01	-1.09	[-1.82; -0.36]
Fields J. et al., 2021	27	6.81	2.04	27	6.23	2.01	-0.28	[-0.82; 0.25]
Gadbois et al., 2022	21	6.00	2.20	18	5.44	2.01	-0.26	[-0.89; 0.37]
Antunes et al., 2022	36	68.23	22.67	36	65.77	23.28	-0.11	[-0.57; 0.36]
Overall effect							**-0.37**	**[-1.02; 0.27]**
Heterogeneity: $I^2 = 42\%$, $p = 0.16$								
Subtheme = Other								
Jones et al., 2021	16	2.22	0.42	16	1.99	0.45	-0.52	[-1.22; 0.19]
Larsson et al., 2016	15	45.53	7.41	14	42.43	7.44	-0.41	[-1.14; 0.33]
Broer et al., 2011	186	5.81	3.21	186	4.85	3.18	-0.30	[-0.50; -0.10]
Ohta et al., 2022	77	4.25	1.34	77	4.05	1.21	-0.16	[-0.47; 0.16]
Kramer et al., 2022	32	2.47	1.78	32	2.44	1.92	-0.02	[-0.51; 0.47]
Nguyen et al., 2022	124	5.50	1.70	124	5.50	1.80	0.00	[-0.25; 0.25]
The Mental Health Foundation, 2018	13	2.25	2.16	13	3.08	2.41	0.35	[-0.42; 1.13]
Overall effect							**-0.16**	**[-0.34; 0.02]**
Heterogeneity: $I^2 = 11\%$, $p = 0.34$								
Overall effect							**-0.34**	**[-0.45; -0.22]**
Heterogeneity: $I^2 = 94\%$, $p < 0.01$								
Residual heterogeneity: $I^2 = 80\%$, $p < 0.01$								

Forest plot axis: -2 -1 0 1 2

Loneliness improved   Loneliness worsened

Figure 3. Forest plot demonstrating differences in change in loneliness from pre to post intervention between **intervention and control group** in **social support-based** interventions
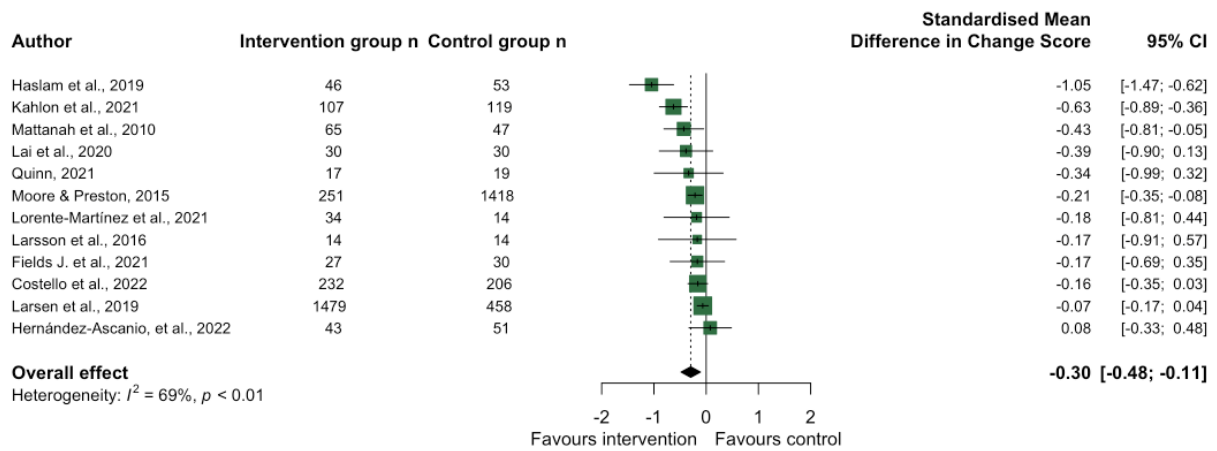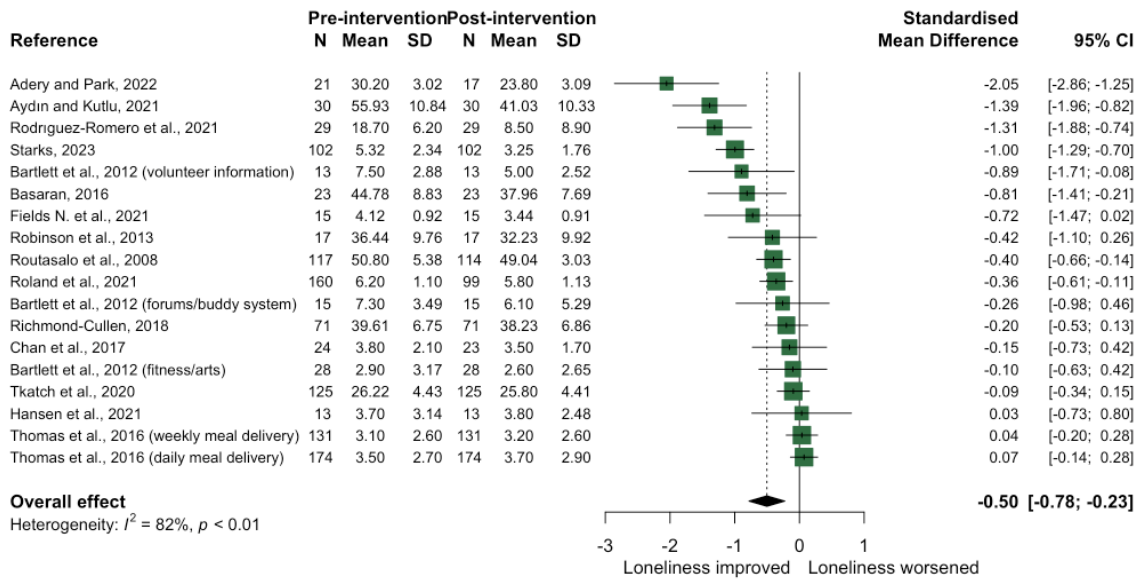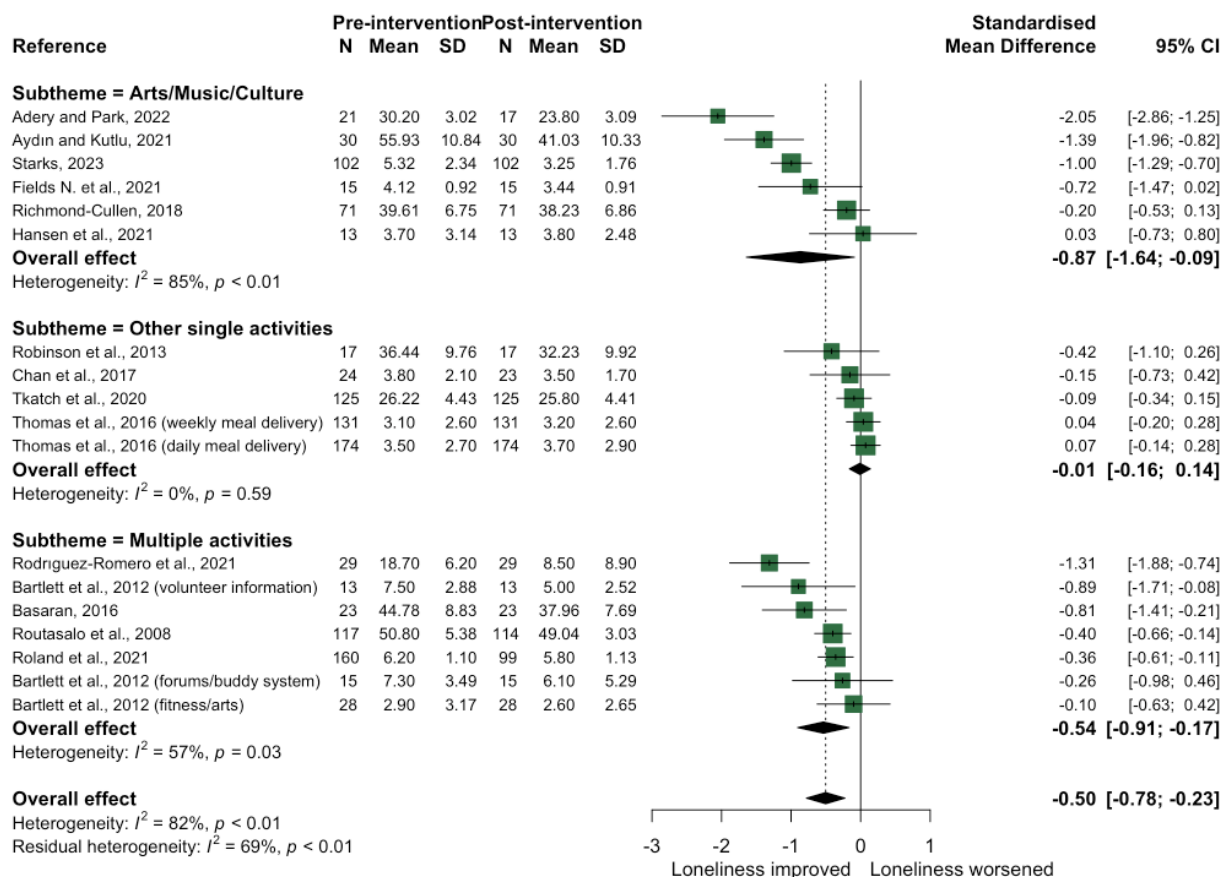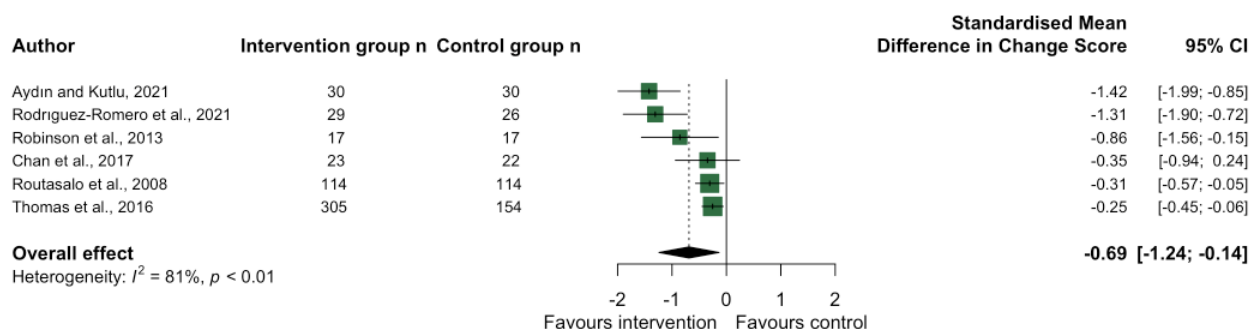
Author	Intervention group n	Control group n	Standardised Mean Difference in Change Score	95% CI
Haslam et al., 2019	46	53	-1.05	[-1.47; -0.62]
Kahlon et al., 2021	107	119	-0.63	[-0.89; -0.36]
Mattanah et al., 2010	65	47	-0.43	[-0.81; -0.05]
Lai et al., 2020	30	30	-0.39	[-0.90; 0.13]
Quinn, 2021	17	19	-0.34	[-0.99; 0.32]
Moore & Preston, 2015	251	1418	-0.21	[-0.35; -0.08]
Lorente-Martínez et al., 2021	34	14	-0.18	[-0.81; 0.44]
Larsson et al., 2016	14	14	-0.17	[-0.91; 0.57]
Fields J. et al., 2021	27	30	-0.17	[-0.69; 0.35]
Costello et al., 2022	232	206	-0.16	[-0.35; 0.03]
Larsen et al., 2019	1479	458	-0.07	[-0.17; 0.04]
Hernández-Ascanio, et al., 2022	43	51	0.08	[-0.33; 0.48]
Overall effect			**-0.30**	**[-0.48; -0.11]**

Heterogeneity: I^2 = 69%, $p < 0.01$

-2 -1 0 1 2
Favours intervention   Favours control

Figure 4. Forest plot demonstrating the effect of **social interaction-based interventions** on change in loneliness from pre to post intervention

Reference	Pre-intervention N	Mean	SD	Post-intervention N	Mean	SD	Standardised Mean Difference	95% CI
Adery and Park, 2022	21	30.20	3.02	17	23.80	3.09	-2.05	[-2.86; -1.25]
Aydın and Kutlu, 2021	30	55.93	10.84	30	41.03	10.33	-1.39	[-1.96; -0.82]
Rodrıguez-Romero et al., 2021	29	18.70	6.20	29	8.50	8.90	-1.31	[-1.88; -0.74]
Starks, 2023	102	5.32	2.34	102	3.25	1.76	-1.00	[-1.29; -0.70]
Bartlett et al., 2012 (volunteer information)	13	7.50	2.88	13	5.00	2.52	-0.89	[-1.71; -0.08]
Basaran, 2016	23	44.78	8.83	23	37.96	7.69	-0.81	[-1.41; -0.21]
Fields N. et al., 2021	15	4.12	0.92	15	3.44	0.91	-0.72	[-1.47; 0.02]
Robinson et al., 2013	17	36.44	9.76	17	32.23	9.92	-0.42	[-1.10; 0.26]
Routasalo et al., 2008	117	50.80	5.38	114	49.04	3.03	-0.40	[-0.66; -0.14]
Roland et al., 2021	160	6.20	1.10	99	5.80	1.13	-0.36	[-0.61; -0.11]
Bartlett et al., 2012 (forums/buddy system)	15	7.30	3.49	15	6.10	5.29	-0.26	[-0.98; 0.46]
Richmond-Cullen, 2018	71	39.61	6.75	71	38.23	6.86	-0.20	[-0.53; 0.13]
Chan et al., 2017	24	3.80	2.10	23	3.50	1.70	-0.15	[-0.73; 0.42]
Bartlett et al., 2012 (fitness/arts)	28	2.90	3.17	28	2.60	2.65	-0.10	[-0.63; 0.42]
Tkatch et al., 2020	125	26.22	4.43	125	25.80	4.41	-0.09	[-0.34; 0.15]
Hansen et al., 2021	13	3.70	3.14	13	3.80	2.48	0.03	[-0.73; 0.80]
Thomas et al., 2016 (weekly meal delivery)	131	3.10	2.60	131	3.20	2.60	0.04	[-0.20; 0.28]
Thomas et al., 2016 (daily meal delivery)	174	3.50	2.70	174	3.70	2.90	0.07	[-0.14; 0.28]
Overall effect							**-0.50**	**[-0.78; -0.23]**

Heterogeneity: I^2 = 82%, $p < 0.01$

-3 -2 -1 0 1
Loneliness improved   Loneliness worsened

Figure 5. Forest plot demonstrating the effect of **social interaction-based interventions** by **subtheme** on change in loneliness from pre to post intervention

Reference	Pre-intervention			Post-intervention			Standardised Mean Difference	95% CI
	N	Mean	SD	N	Mean	SD		
Subtheme = Arts/Music/Culture								
Adery and Park, 2022	21	30.20	3.02	17	23.80	3.09	-2.05	[-2.86; -1.25]
Aydın and Kutlu, 2021	30	55.93	10.84	30	41.03	10.33	-1.39	[-1.96; -0.82]
Starks, 2023	102	5.32	2.34	102	3.25	1.76	-1.00	[-1.29; -0.70]
Fields N. et al., 2021	15	4.12	0.92	15	3.44	0.91	-0.72	[-1.47; 0.02]
Richmond-Cullen, 2018	71	39.61	6.75	71	38.23	6.86	-0.20	[-0.53; 0.13]
Hansen et al., 2021	13	3.70	3.14	13	3.80	2.48	0.03	[-0.73; 0.80]
Overall effect							**-0.87**	**[-1.64; -0.09]**
Heterogeneity: $I^2 = 85\%$, $p < 0.01$								
Subtheme = Other single activities								
Robinson et al., 2013	17	36.44	9.76	17	32.23	9.92	-0.42	[-1.10; 0.26]
Chan et al., 2017	24	3.80	2.10	23	3.50	1.70	-0.15	[-0.73; 0.42]
Tkatch et al., 2020	125	26.22	4.43	125	25.80	4.41	-0.09	[-0.34; 0.15]
Thomas et al., 2016 (weekly meal delivery)	131	3.10	2.60	131	3.20	2.60	0.04	[-0.20; 0.28]
Thomas et al., 2016 (daily meal delivery)	174	3.50	2.70	174	3.70	2.90	0.07	[-0.14; 0.28]
Overall effect							**-0.01**	**[-0.16; 0.14]**
Heterogeneity: $I^2 = 0\%$, $p = 0.59$								
Subtheme = Multiple activities								
Rodrıguez-Romero et al., 2021	29	18.70	6.20	29	8.50	8.90	-1.31	[-1.88; -0.74]
Bartlett et al., 2012 (volunteer information)	13	7.50	2.88	13	5.00	2.52	-0.89	[-1.71; -0.08]
Basaran, 2016	23	44.78	8.83	23	37.96	7.69	-0.81	[-1.41; -0.21]
Routasalo et al., 2008	117	50.80	5.38	114	49.04	3.03	-0.40	[-0.66; -0.14]
Roland et al., 2021	160	6.20	1.10	99	5.80	1.13	-0.36	[-0.61; -0.11]
Bartlett et al., 2012 (forums/buddy system)	15	7.30	3.49	15	6.10	5.29	-0.26	[-0.98; 0.46]
Bartlett et al., 2012 (fitness/arts)	28	2.90	3.17	28	2.60	2.65	-0.10	[-0.63; 0.42]
Overall effect							**-0.54**	**[-0.91; -0.17]**
Heterogeneity: $I^2 = 57\%$, $p = 0.03$								
Overall effect							**-0.50**	**[-0.78; -0.23]**
Heterogeneity: $I^2 = 82\%$, $p < 0.01$								
Residual heterogeneity: $I^2 = 69\%$, $p < 0.01$								

Loneliness improved   Loneliness worsened

Figure 6. Forest plot demonstrating differences in change in loneliness from pre to post intervention between **intervention and control group** in **social interaction-based** interventions

Author	Intervention group n	Control group n	Standardised Mean Difference in Change Score	95% CI
Aydın and Kutlu, 2021	30	30	-1.42	[-1.99; -0.85]
Rodrıguez-Romero et al., 2021	29	26	-1.31	[-1.90; -0.72]
Robinson et al., 2013	17	17	-0.86	[-1.56; -0.15]
Chan et al., 2017	23	22	-0.35	[-0.94; 0.24]
Routasalo et al., 2008	114	114	-0.31	[-0.57; -0.05]
Thomas et al., 2016	305	154	-0.25	[-0.45; -0.06]
Overall effect			**-0.69**	**[-1.24; -0.14]**
Heterogeneity: $I^2 = 81\%$, $p < 0.01$				

Favours intervention   Favours control

3. Psychological interventions

Figure 7. Forest plot demonstrating the effect of **psychological interventions** by **subtheme** on change in loneliness from pre to post intervention
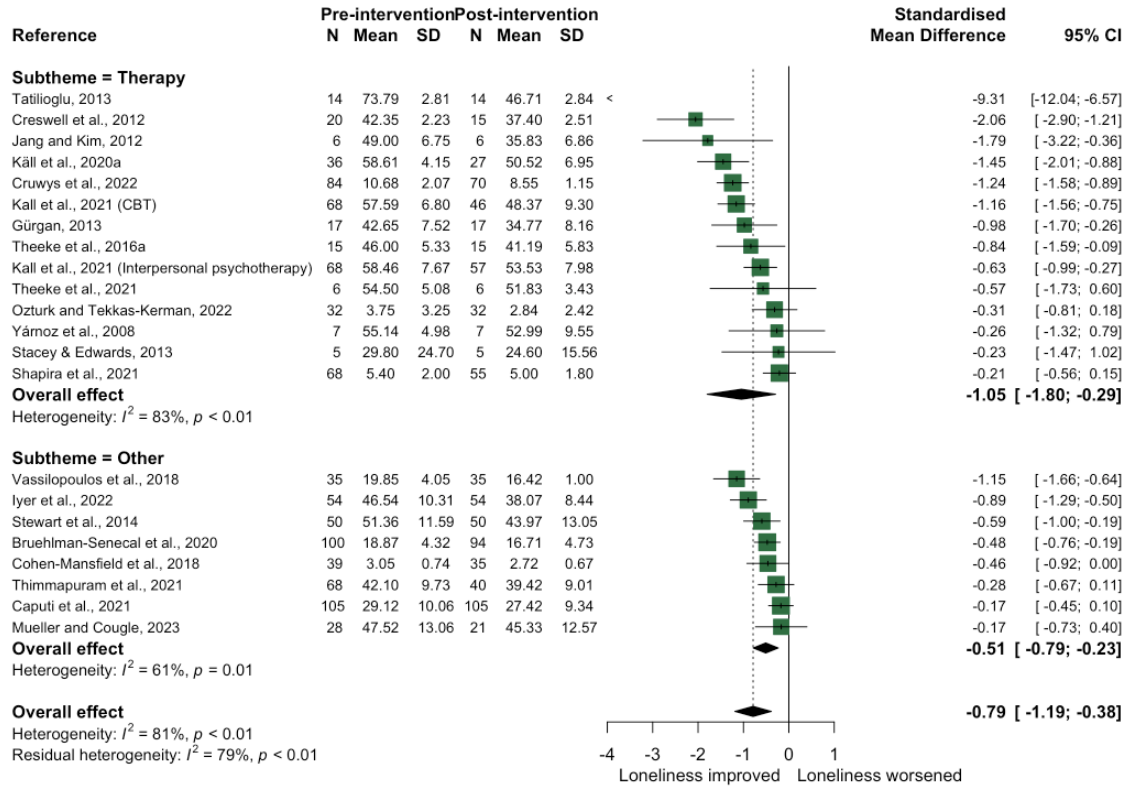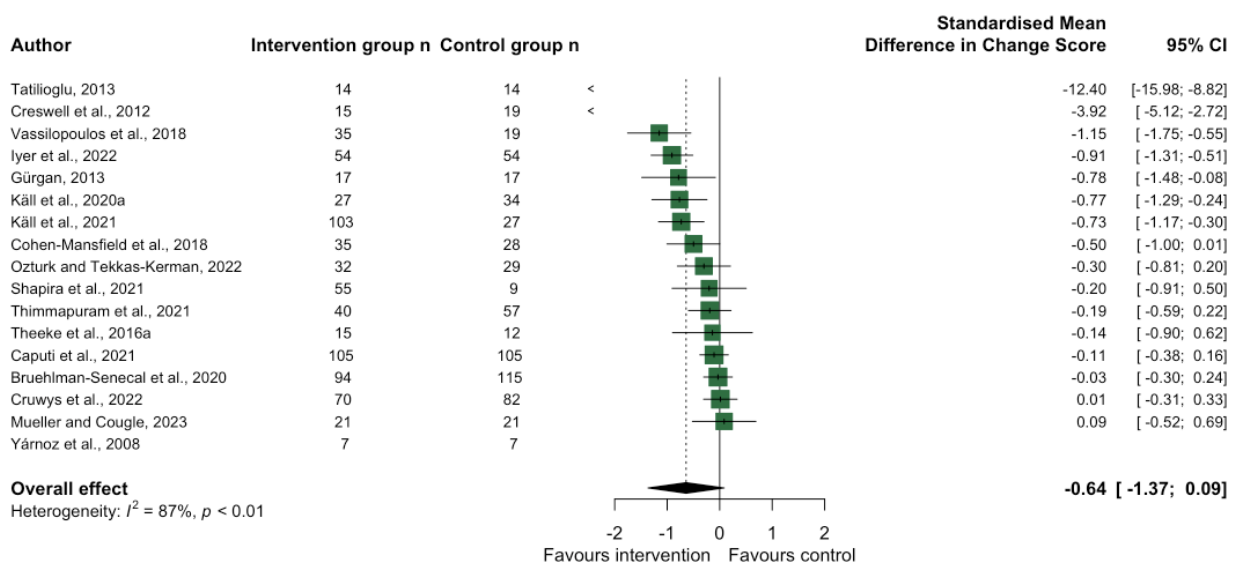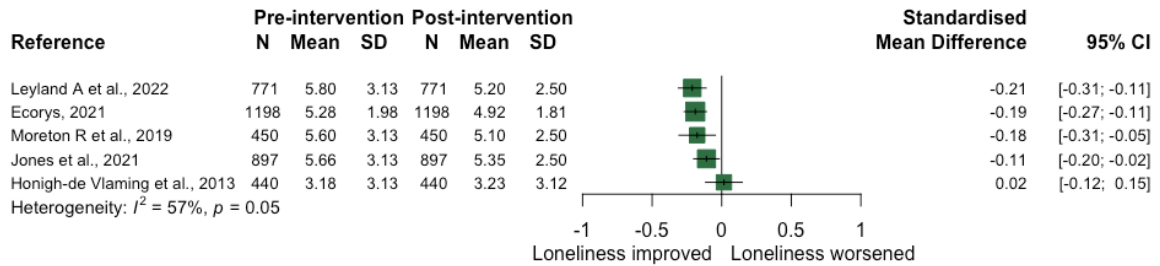

Figure 8. Forest plot demonstrating differences in change in loneliness from pre to post intervention between **intervention and control group** in **psychological interventions**
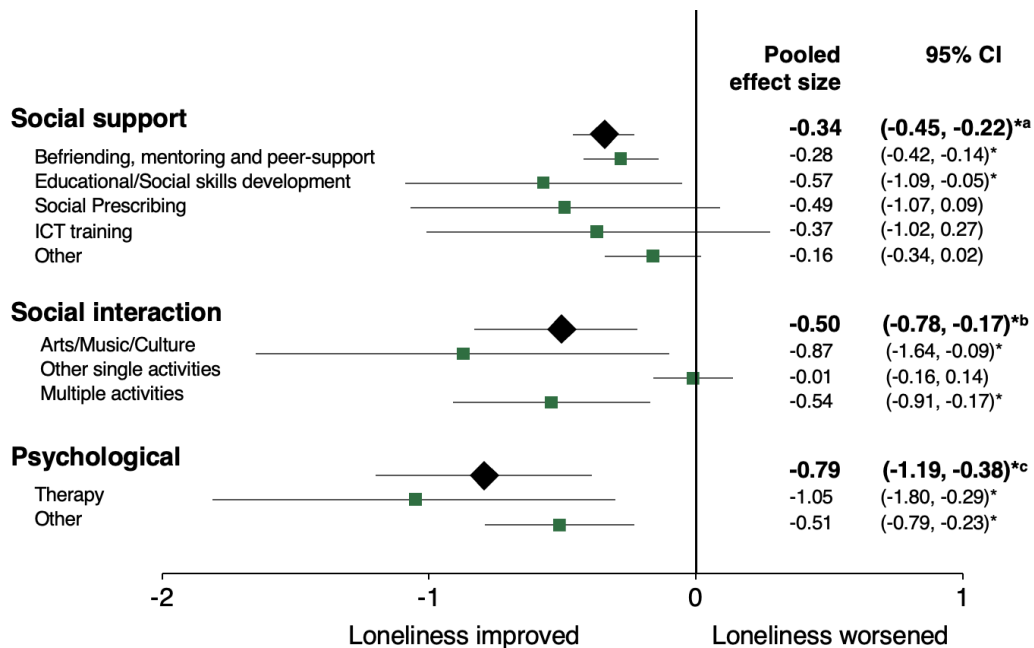
4. Multiple-themed interventions

Figure 9. Forest plot demonstrating individual effects of 'Multiple-themed' interventions on change in loneliness from pre to post intervention

Reference	Pre-intervention			Post-intervention			Standardised Mean Difference	95% CI
	N	Mean	SD	N	Mean	SD		
Leyland A et al., 2022	771	5.80	3.13	771	5.20	2.50	-0.21	[-0.31; -0.11]
Ecorys, 2021	1198	5.28	1.98	1198	4.92	1.81	-0.19	[-0.27; -0.11]
Moreton R et al., 2019	450	5.60	3.13	450	5.10	2.50	-0.18	[-0.31; -0.05]
Jones et al., 2021	897	5.66	3.13	897	5.35	2.50	-0.11	[-0.20; -0.02]
Honigh-de Vlaming et al., 2013	440	3.18	3.13	440	3.23	3.12	0.02	[-0.12; 0.15]

Heterogeneity: I^2 = 57%, p = 0.05

-1 -0.5 0 0.5 1
Loneliness improved   Loneliness worsened

5. Findings from controlled studies

Figure 10. Forest plot demonstrating pooled effects by core intervention theme and subtheme on change in loneliness between **intervention and control group** from pre to post intervention

	Pooled effect size	95% CI
Social support	**-0.34**	**(-0.45, -0.22)*a**
Befriending, mentoring and peer-support	-0.28	(-0.42, -0.14)*
Educational/Social skills development	-0.57	(-1.09, -0.05)*
Social Prescribing	-0.49	(-1.07, 0.09)
ICT training	-0.37	(-1.02, 0.27)
Other	-0.16	(-0.34, 0.02)
Social interaction	**-0.50**	**(-0.78, -0.17)*b**
Arts/Music/Culture	-0.87	(-1.64, -0.09)*
Other single activities	-0.01	(-0.16, 0.14)
Multiple activities	-0.54	(-0.91, -0.17)*
Psychological	**-0.79**	**(-1.19, -0.38)*c**
Therapy	-1.05	(-1.80, -0.29)*
Other	-0.51	(-0.79, -0.23)*

-2   -1   0   1
Loneliness improved   Loneliness worsened

a Social Support pooled effect size for loneliness change in control vs intervention groups: -0.30 (-0.48, -0.11)*
b Social Interaction pooled effect size for loneliness change in control vs intervention groups: -0.69 (-1.24, -0.14)*
c Psychological pooled effect size for loneliness change in control vs intervention groups: -0.64 (-1.37, 0.09)

6. Funnel Plot

Figure 11. Funnel plot to assess publication bias in included studies from A. pre-post intervention changes in intervention group and B. differences in pre-post loneliness scores between control and intervention groups.