The Best Approaches and Doses of Exercise for Improving Sleep Quality: A Network Meta-Analysis and Dose-Response Relationship Study

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Appendix 1 Table of Study Characteristics

Study	country	N,Sex (male/female)	Mean Age(SD/Range)	Interventions	Intervention duration (weeks)	Frequency	Time /session	Exact dose	Dose	Residual dose	Outcomes measured
Steriani2007[1]	USA	164(0/164)	42-58 years	AE YOGA	16	3、2	60/90	AE:1296 YOGA:414	AE:1200 YOGA:300	AE:96 YOGA:114	PSQI
Min-Jung2018[2]	Korea	63(4/59)	77.6±5.69years	YOGA	12	2	35	231	300	69	PSQI
Kerry2012[3]	Canada	117(69/48)	<50 years=38 ≥50years=79	AE	12	3	15-20 40-45	756	900	144	PSQI
Evan2006[4]	Australia	44(20/24)	31±4years	AE+RT	24	3	50	723	600	123	PSQI
Brian2007[5]	USA	84(30/54)	69.2±9.26years	TC AE+RT	12	3	60	TC:1080 AE+RT:900	TC:1200 AE+RT:900	TC:120 AE+RT:0	PSQI
Seong2015[6]	Korea	24(NA)	75.20±6.25years	AE	8	3	50	1320	1200	120	PSQI
Shahrian2019[7]	Iran	36(0/36)	60-70years	AE	8	3	50	600	600	0	PSQI
Filiz2023[8]	Turkey	44(40/4)	44.36±8.56years	YOGA	12	3	60	414	300	114	PSQI ESS
Desplan2014[9]	France	22(NA)	35-70years	AE+RT	4	6	120	2250	1500	750	PSQI ESS
Corjena2014[10]	USA	36(0/36)	72years	YOGA	8	1	60	138	300	112	PSQI
Wang2020[11]	Hungary	32(10/22)	24.87±4.91years	AE	4	7	/	1764	1500	264	PSQI
Laura2014[12]	Ireland	78(38/50)	59 ±12years	AE+RT	12	3\5	60	1500	1500	0	PSQI
Ferreira2012[13]	Brazil	44(0/44)	50-60years	YOGA	16	2	60	276	300	24	ISI
Wang2021[14]	Hungary	54(NA)	24.28±4.55years	AE	12	7	/	1176	1200	24	PSQI
Siu2022[15]	China	281(66/215)	55.91±9.37years	QG	8	3	60	693	600	93	PSQI
Zhou2022[16]	China	83(26/57)	79.46±4.82years	AE RT AE+RT	12	3	50	AE: 405 RT: 540 AE+RT:450	AE: 300 RT: 600 AE+RT:300	AE: 105 RT: 60 AE+RT:150	PSQI
Ruth2011[17]	USA	28(17/11)	69.3±11.0years	TC	12	3	60	1080	1200	120	PSQI
Viswanathan2021[18]	India	300(196/104)	52.8±7.0years	YOGA	12	5	50	575	600	25	PSQI
Haleh2023[19]	Iran	32(12/20)	43.7years	AE+RT	12	3\3	75	1120.5	1200	79.5	PSQI
Shu2012[20]	China	70(0/70)	45years	QG	12	7	30	693	600	93	PSQI

Manh2012[21]	Germany	96(48/48)	68.9±5.1years	TC	24	2	60	396	300	96	PSQI
[22]Kuei-Min2010	China	55(NA)	65years	YOGA	24	3	70	483	600	117	PSQI
Lucas[23]	Spain	69(33/36)	53.4±5.0years	AE+RT AE	12	/	/	AE+RT:1197 HIIT:540	AE+RT:1200 HIIT:600	AE+RT:3 HIIT:60	PSQI
Pourhabib2018[24]	Iran	60(60/0)	60-74years	AE+RT	12	3	60	630	600	30	PSQI
Gulhan2018[25]	Turkey	50(NA)	30-65years	TCQ	12	3	60	630	600	30	PSQI ESS
Karen2016[26]	USA	75(51/24)	21.1±3.5years	TC	10	2	60	1089	1200	111	PSQI
CAI2014[27]	China	19(0/19)	59.33±1.13years	AE	10	2	80	1752	1500	252	PSQI
Julienne2011[28]	USA	31(0/31)	54.4±5.7years	YOGA	12	2	90	414	300	114	PSQI
Gayatri2020[29]	India	60(0/60)	50.70±2.95years	AE RT	4	3	25	AE: 375 RT:262.5	AE: 300 RT:300	AE: 75 RT:37.5	PSQI
Ahmadinezhad2017[30]	Iran	108(0/108)	40-60years	Pilates	6	3	60	504	600	96	PSQI
Ghafoureh2018[31]	Iran	62(0/62)	20-45years	YOGA	10	3	60	414	300	114	PSQI
Maryam2020[32]	Iran	67(0/67)	18-26years	AE	8	3	60	792	900	108	PSQI
Wenchao2010[33]	Japan	34(NA)	aged 50 years	TC	12	1	50	165	300	145	PSQI
Saba2016[34]	Iran	46(46/0)	age >60 years	AE	8	3	30	405	300	105	PSQI
Michael2008[35]	USA	112(41/71)	59-86years	TC	16	3	40	396	300	96	PSQI
Barbara2014[36]	USA	246(0/246)	40-62years	AE	12	3	50	675	600	75	PSQI ISI
Siu2021[37]	China	320(64/256)	68.0±8.2years	AE+RT TC	12	3	60	AE+RT:900 TC:1080	AE+RT:900 TC:1200	AE+RT:900 TC:120	PSQI
Holger2016[38]	Germany	54(33/21)	68.26±9.69years	YOGA	10	1	90	207	300	93	PSQI
Tseng2020[39]	China	40(7/33)	62.2±7.4years	AE	12	3	50	690	600	90	PSQI
Rshikesan2017[40]	India	80(80/0)	40.03±8.74years	YOGA	14	5	90	1035	900	135	PSQI
Song2022[41]	China	40(0/40)	64.15±8.56years	TC	12	3	60	1080	1200	120	PSQI
Sat2021[42]	USA	44(NA)	25-59years	YOGA	8	7	45	724.5	600	124.5	PSQI
Yesim2011[43]	Turkey	20(20/0)	54.40±6.57years	AE	12	3	90	1809	1500	309	PSQI
Christopher2011[44]	USA	43(24/19)	46.9±1.2years	AE+RT	12	4	50	1125	1200	75	PSQI
Beifang2019[45]	China	139(34/105)	71.1±6.3years	Baduanjin	24	5	45	742.5	600	142.5	PSQI
Michael2014[46]	USA	123(35/88)	64.4±6.1years	TC	16	3	40	396	300	96	PSQI

Zheng2015[47]	China	198(65/133)	20.6±1.1years	TC	12	5	60	990	900	90	PSQI
Sean2021[48]	Ireland	20(0/20)	57±7.5years	AE	8	5	30	945	900	45	PSQI
Hady2020[49]	Egypt	30(NA)	47.79±7.28years	AE	12	3	40	1104	1200	96	PSQI
Glauber2018[50]	Brazil	125(15/110)	69.9±6.7years	AE+RT	12	3	40	636	600	36	ESS
Christopher2022[51]	USA	43(24/19)	47.6±1.3years	AE+RT	12	4	50	1125	1200	75	ESS
Feng2010[52]	China	71(17/54)	51.80±12.13years	AE	12	3	40	600	600	0	PSQI
Yasemin2019	Turkey	60(37/23)	65 years and over	AE	8	2	40	320	300	20	PSQI
Carolina2019[53]	Brazil	28(NA)	44.5±2.2years	RT	16	3	60	918	900	18	PSQI ISI
IULIANA2015[54]	UK	41(11/30)	59.80±9.46years	AE	24	5	30	825	900	75	ISI
Nalin1997[55]	USA	28(11/17)	70.0±1.6years	RT	10	3	60	1134	1200	66	PSQI
Azam2023[56]	Iran	67(0/67)	20.75±1.27years	Pilates	6	3	60	504	600	104	PSQI
Morteza2017[57]	Iran	31(0/31)	aged 60 years and above	AE	8	3	60	756	900	144	PSQI
Ruth2014[58]	USA	145(77/68)	69.9±10.0years	TC	12	3	60	1080	1200	120	PSQI
CARLA2016[59]	Brazil	22(16/6)	64.6±8.4years	RT	12	2	60	420	300	120	PSQI
María2022[60]	Spain	117(0/117)	69.73±6.44years	QG	12	2	60	396	300	96	PSQI
Helton2022[61]	Brazil	28(NA)	74.64±7.13years	RT	12	3	60	990	900	90	PSQI ESS
Helen2011[62]	USA	73(28/45)	69.1±7.0years	TC	10	1	120	396	300	96	PSQI
Abby2015[63]	USA	43(14/29)	62.4±6.4years	AE	16	4	50	1084	1200	116	PSQI
Lina2020[64]	China	111(43/68)	68.37±5.27years	AE	12	3	60	882	900	18	PSQI
Kuei2009[65]	China	128(NA)	69.20 ±6.23 years	YOGA	24	3	70	483	600	117	PSQI
Haleh2017[66]	Turkey	80(0/80)	48.99±9.42years	AE	24	3	50	1095	1200	105	PSQI
Mei2012[67]	China	55(19/36)	71.75±8.13years	Baduanjin	12	3	30	297	300	3	PSQI
María2016[68]	Spain	67(0/67)	69.07±4.4years	AE	8	3	50	450	600	150	PSQI
Fuzhong2004[69]	USA	118(22/96)	75.30±7.8years	TC	24	3	60	1080	1200	120	PSQI ESS
José2021[70]	Spain	73(17/56)	68.49±5.18years	AE	12	2	45	594	600	6	PSQI
Lü2017[71]	China	46(0/46)	64.61±3.40years	TC	24	3	60	594	600	6	PSQI
Song2019[72]	China	120(90/30)	75.78±6.28years	AE	16	3	60	720	600	120	PSQI
Pauline2023[73]	Switzerland	24(0/24)	46.4±5.67years	AE	12	3	80	1498.5	1500	1.5	ISI

Karen2013[74]	USA	410(17/393)	54.1±10.33	YOGA	4	2	75	345	300	45	PSQI
Curi2018[75]	Brazil	61(0/61)	63.75±0.08	Pilates	16	2	60	336	300	36	PSQI
Kathryn2010[76]	USA	17(1/16)	62±4.5years	AE	16	4	30	660	600	60	PSQI ESS
Huang2023[77]	China	89(89/0)	36.85±8.72 years	AE QG	12	4	60	AE：912 QG： 792	AE:900 QG:900	AE: 12 QG:108	PSQI
Abby2008[78]	USA	66(22/44)	61.86±6.33years	AE	48	3	70	1050	900	150	PSQI
Farzaneh2013[79]	Iran	80(0/80)	24.4±3.6years	Pilates	8	5	30	420	300	120	PSQI
Agustín2019[80]	Spain	110(0/110)	69.15±8.94 years	Pilates	12	2	60	336	300	36	PSQI
Fang2015[81]	China	120(0/120)	35.13±10.98years	YOGA	24	3	50-60	379.5	300	79.5	PSQI
Song2024[82]	USA	89(68/21)	75.97±6.31years	AE	16	3	60	774	900	26	PSQI
Rakesh2021[83]	Saudi Arabia	24(24/0)	19.78±1.05years	AE	12	2	50	800	900	100	PSQI
JENNIFER2012[84]	USA	126(77/49)	60.2±10.6years	AE	36	5	30	600	600	0	PSQI
Hariprasad2013[85]	India	120(48/72)	75.74±6.46years	YOGA	24	7	60	966	900	66	PSQI

AE: Aerobic Exercise; RT: Resistance Training; AE+RT: Combined Aerobic and Resistance Training; TCS: Traditional Chinese Sports; CON: Control Group.

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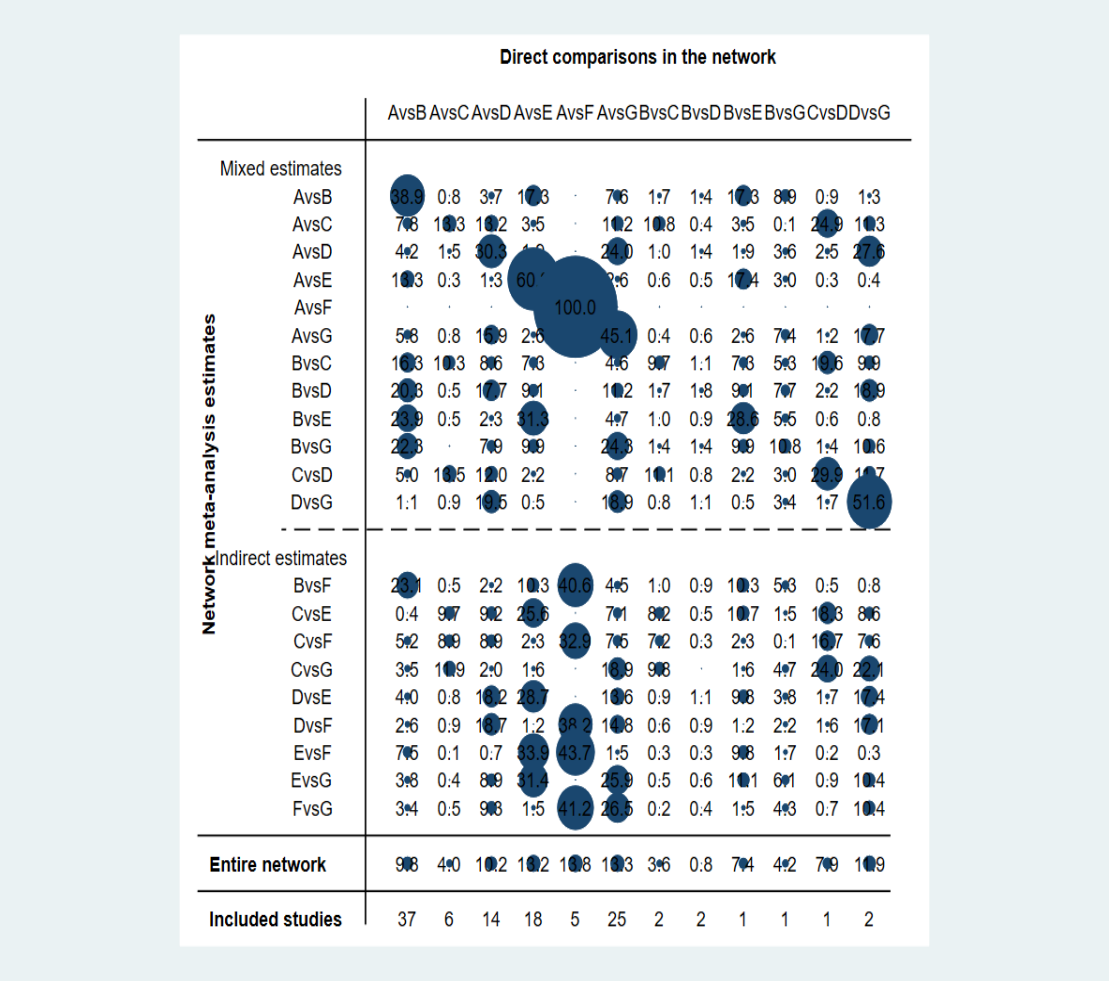
Appendix 2 Risk of Bias Assessment Based on the Cochrane Handbook

Study	Allocation generation	Concealment of allocation	blinding of participants and personnel	Blinding of outcome assessment	incomplete outcome data	Selective reporting	Other bias	Risk category
Steriani2007	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Min-Jung2018	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Kerry2012	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Evan2006	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Brian2007	LOW	Unclear	High	Unclear	LOW	LOW	LOW	Moderate
Seong2015	LOW	LOW	Unclear	Unclear	Unclear	LOW	Unclear	Moderate
Shahrian2019	LOW	LOW	High	Unclear	LOW	LOW	LOW	Moderate
Filiz2023	LOW	LOW	High	High	LOW	LOW	LOW	High
Desplan2014	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Corjena2014	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Wang2020	LOW	LOW	High	LOW	High	LOW	LOW	High
Laura2014	LOW	LOW	High	Unclear	LOW	LOW	High	High
Ferreira2012	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Wang2021	LOW	Unclear	High	LOW	LOW	LOW	High	High
Siu2022	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Zhou2022	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Ruth2011	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Viswanathan2021	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Haleh2023	LOW	Unclear	High	Unclear	LOW	LOW	LOW	Moderate
Shu2012	LOW	High	High	Unclear	LOW	LOW	LOW	High
Manh2012	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Kuei-Min2010	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Lucas	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Pourhabib2018	LOW	LOW	Unclear	Unclear	Unclear	LOW	LOW	LOW
Gulhan2018	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Karen2016	LOW	LOW	High	LOW	High	LOW	LOW	High
CAI2014	LOW	Unclear	Unclear	Unclear	LOW	LOW	LOW	LOW
Julienne2011	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Gayatri2020	LOW	Unclear	Unclear	Unclear	LOW	LOW	Unclear	Moderate
Ahmadinezhad2017	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Ghafoureh2018	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Maryam2020	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Wenchao2010	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Saba2016	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Michael2008	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW

Barbara2014	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Siu2021	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Holger2016	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Tseng2020	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Rshikesan2017	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Song2022	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Sat2021	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Yesim2011	LOW	LOW	High	Unclear	LOW	LOW	LOW	Moderate
Christopher2011	LOW	LOW	High	Unclear	LOW	LOW	LOW	Moderate
Beifang2019	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Michael2014	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Zheng2015	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Sean2021	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Hady2020	LOW	Unclear	Unclear	Unclear	LOW	LOW	LOW	LOW
Glauber2018	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Christopher2022	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Feng2010	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Yasemin2019	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Carolina2019	LOW	High	Unclear	Unclear	LOW	LOW	LOW	Moderate
IULIANA2015	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Nalin1997	LOW	Unclear	Unclear	Unclear	Unclear	LOW	LOW	Moderate
Azam2023	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Morteza2017	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Ruth2014	LOW	LOW	High	Unclear	LOW	LOW	LOW	Moderate
CARLA2016	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
María2022	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Helton2022	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Helen2011	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Abby2015	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Lina2020	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Kuei2009	LOW	LOW	High	Unclear	LOW	LOW	LOW	Moderate
Haleh2017	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Mei2012	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
María2016	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Fuzhong2004	LOW	LOW	Unclear	Unclear	High	LOW	LOW	Moderate
José2021	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Lü2017	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Song2019	LOW	LOW	High	LOW	LOW	LOW	LOW	Moderate
Pauline2023	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Karen2013	LOW	LOW	Unclear	LOW	High	LOW	LOW	Moderate

Curi2018	LOW	Unclear	Unclear	Unclear	LOW	LOW	LOW	LOW
Kathryn2010	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Huang2023	LOW	Unclear	Unclear	Unclear	LOW	LOW	LOW	LOW
Abby2008	LOW	LOW	Unclear	LOW	LOW	LOW	LOW	LOW
Farzaneh2013	LOW	Unclear	Unclear	Unclear	LOW	LOW	LOW	LOW
Agustín2019	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Fang2015	LOW	LOW	High	Unclear	LOW	LOW	LOW	Moderate
Song2024	LOW	LOW	High	Unclear	LOW	LOW	LOW	Moderate
Rakesh2021	LOW	Unclear	Unclear	Unclear	LOW	LOW	LOW	LOW
JENNIFER2012	LOW	LOW	Unclear	Unclear	LOW	LOW	LOW	LOW
Hariprasad2013	LOW	Unclear	Unclear	Unclear	LOW	LOW	LOW	LOW

Appendix 3 Contribution of Direct and Indirect Comparisons to the Network Meta-Analysis (NMA) and the Number of Studies in Each Direct Comparison on Sleep Quality Index



A-CON (Control Group), B-AE (Aerobic Exercise), C-RT (Resistance Training), D-AE+RT (Combined Aerobic and Resistance Training), E-YOGA , F-Pilates ,G-TCS (Traditional Chinese Sports)

Appendix 4 Inconsistency Testing for Sleep Quality Outcome Measures, Including Loop Inconsistency Testing, Inconsistency Model, and Node-Splitting Analysis Results

In the loop inconsistency test, only the "AE-RT-AE+RT" loop showed inconsistency (P = 0.000 < 0.05), while the consistency results for other loops were satisfactory (P > 0.05), as shown in Table 1

Table 1 Loop Inconsistency Testing

Loop	IF	seIF	z_value	p_value	CI_95	Loop_Heterog_tau2
AE-RT-AE+RT	2.137	0.55	3.883	0.000	(1.06,3.21)	0.000
CON-RT-AE+RT	1.777	0.925	1.92	0.055	(0.00,3.59)	0.294
CON-AE-TCS	1.717	1.015	1.692	0.091	(0.00,3.71)	0.458
CON-AE-AE+RT	0.961	0.847	1.135	0.256	(0.00,2.62)	0.514
CON-AE-RT	0.59	1.038	0.568	0.57	(0.00,2.63)	0.648
CON-AE+RT-TCS	0.424	0.559	0.759	0.448	(0.00,1.52)	0.318
AE-AE+RT-TCS	0.31	0.919	0.337	0.736	(0.00,2.11)	0.201
CON-AE-YOGA	0.168	0.95	0.177	0.859	(0.00,2.03)	0.43

The inconsistency model analysis showed P = 0.318 > 0.05, indicating good consistency among the included studies, allowing the use of a consistency model for analysis. See Table 2 for details

Table 2 Inconsistency Model

Inconsistency model	
chi2	13.73
Prob >chi2	0.318

The node-splitting analysis results showed that only A-B (CON-AE) and C-D (RT-AE+RT) direct comparisons had P < 0.05, while other results demonstrated good consistency (P > 0.05). See Table 3 for details.

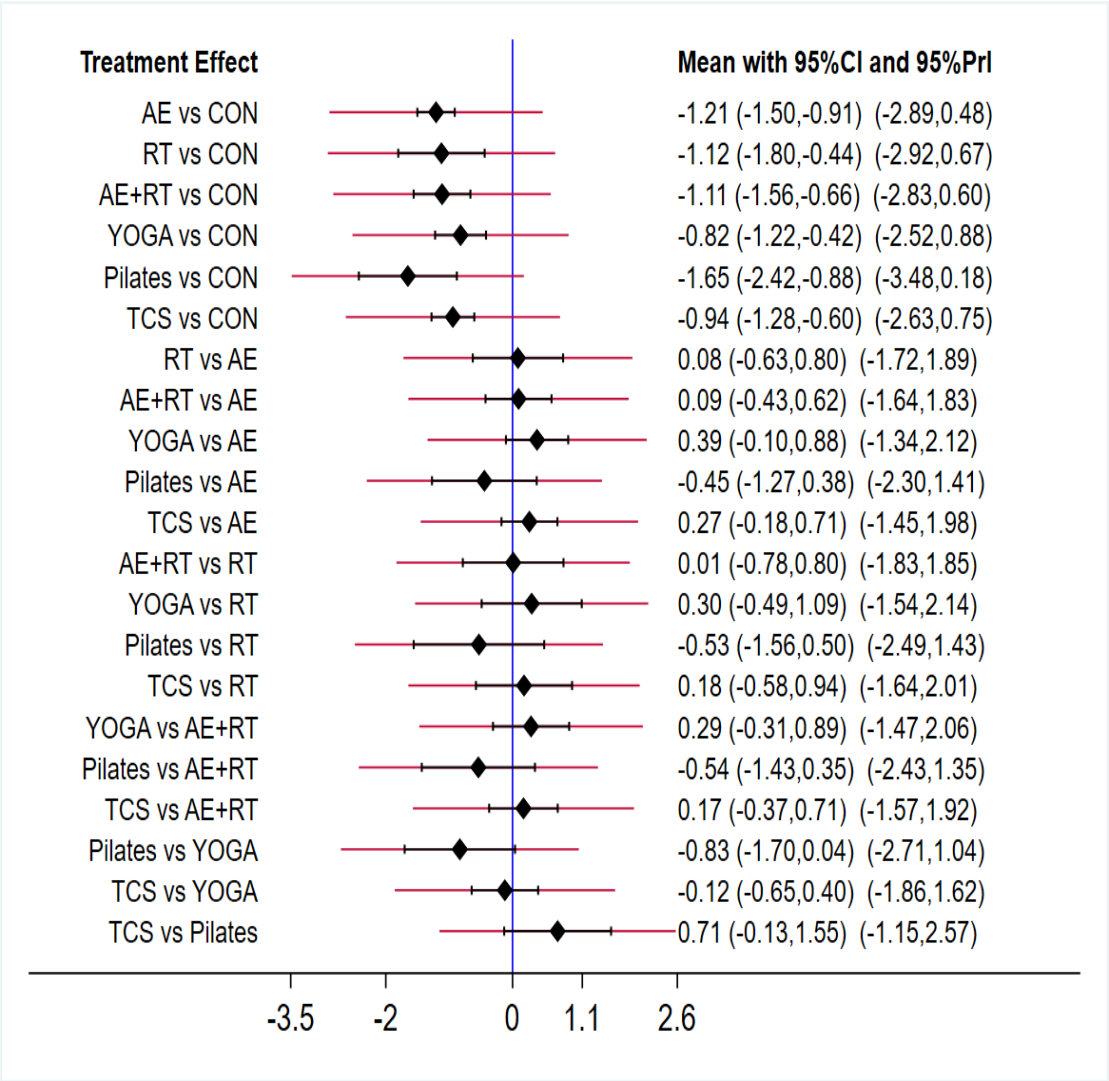
Table 3 Node-Splitting Analysis Results

Side	Direct		Indirect		Difference		
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	P>z
A B	-1.27692	0.1519864	0.05986	0.6123494	-1.336783	0.6309552	0.034
A C	-1.09333	0.3962569	-1.23183	0.7536992	0.1385045	0.853903	0.871
A D *	-1.07095	0.2411071	-1.53665	0.7681124	0.465701	0.8054462	0.563
A E *	-0.80338	0.2083176	-1.71052	1.521208	0.9071445	1.53571	0.555
A G *	-0.87798	0.1722332	-2.70983	0.9189154	1.831853	0.9347413	0.05
B C	-0.42784	0.6294491	0.34185	0.4453823	-0.7696939	0.7715354	0.318
B D	-0.75929	0.6392697	0.2689	0.2910326	-1.028193	0.702056	0.143
B E	0.278836	0.8592057	0.39916	0.2641462	-0.1203199	0.898893	0.894

B G	-1.33035	0.8643378	0.37311	0.2295319	-1.703454	0.8942351	0.057
C D	-1.6211	0.8987034	0.4121	0.4467761	-2.033198	1.00586	0.043
D G	-0.25515	0.610974	0.28201	0.310476	-0.5371656	0.6854255	0.433

A-CON (Control Group), B-AE (Aerobic Exercise), C-RT (Resistance Training), D-AE+RT (Combined Aerobic and Resistance Training), G-TCS (Traditional Chinese Sports)

Appendix 5 Forest Plot of Pairwise Comparison Results for the Sleep Quality Index



Appendix 6 Sensitivity Analysis of the Network Meta-Analysis

Network meta-analyses were conducted after excluding studies with high risk of bias, small sample sizes (N < 30), and short intervention durations (⩽4 weeks). The results showed no significant changes, indicating good sensitivity and stable outcomes. See Figures 1, 2 and 3 for details.

League Table for Sensitivity Analysis

Excluding Studies with High Risk of Bias

AE						
-0.13 (-0.83,0.57)	RT					
-0.09 (-0.62,0.44)	0.04 (-0.75,0.82)	AE+RT				
-0.48 (-0.99,0.02)	-0.35 (-1.14,0.43)	-0.39 (-1.00,0.22)	YOGA			
0.39 (-0.42,1.20)	0.51 (-0.49,1.52)	0.48 (-0.40,1.36)	0.87 (0.01,1.73)	Pilates		
-0.40 (-0.85,0.05)	-0.27 (-1.02,0.48)	-0.31 (-0.85,0.24)	0.09 (-0.45,0.62)	-0.78 (-1.61,0.04)	TCS	
-1.26 (-1.56,-0.96)	**-1.13 (-1.80,-0.47)**	**-1.17 (-1.62,-0.72)**	**-0.78 (-1.19,-0.37)**	**-1.65 (-2.40,-0.89)**	**-0.86 (-1.21,-0.52)**	CON

Excluding Studies with Small Sample Sizes (N<30)

AE						
0.15 (-0.87,1.18)	RT					
0.02 (-0.49,0.53)	-0.13 (-1.22,0.95)	AE+RT				
-0.21 (-0.68,0.25)	-0.36 (-1.46,0.73)	-0.23 (-0.80,0.34)	YOGA			
0.62 (-0.15,1.38)	0.47 (-0.79,1.72)	0.60 (-0.23,1.43)	0.83 (0.03,1.63)	Pilates		
-0.08 (-0.50,0.35)	-0.23 (-1.30,0.85)	-0.09 (-0.61,0.42)	0.14 (-0.35,0.62)	-0.69 (-1.47,0.08)	TCS	
-1.02 (-1.32,-0.73)	**-1.17 (-2.21,-0.14)**	**-1.04 (-1.48,-0.60)**	**-0.81 (-1.18,-0.44)**	**-1.64 (-2.35,-0.93)**	**-0.95 (-1.26,-0.63)**	CON

Excluding Studies with Intervention Duration of Four Weeks or Less

AE						
-0.33 (-1.12,0.47)	RT					
-0.20 (-0.75,0.36)	0.13 (-0.74,0.99)	AE+RT				
-0.41 (-0.92,0.11)	-0.08 (-0.94,0.78)	-0.21 (-0.85,0.43)	YOGA			
0.40 (-0.44,1.24)	0.73 (-0.36,1.81)	0.60 (-0.32,1.52)	0.81 (-0.08,1.70)	Pilates		
-0.31 (-0.77,0.14)	0.01 (-0.81,0.83)	-0.12 (-0.68,0.45)	0.09 (-0.45,0.63)	-0.71 (-1.57,0.14)	TCS	
-1.25 (-1.56,-0.95)	**-0.93 (-1.68,-0.18)**	**-1.06 (-1.54,-0.57)**	**-0.85 (-1.27,-0.43)**	**-1.65 (-2.44,-0.87)**	**-0.94 (-1.28,-0.60)**	CON

SUCRA Sensitivity Analysis

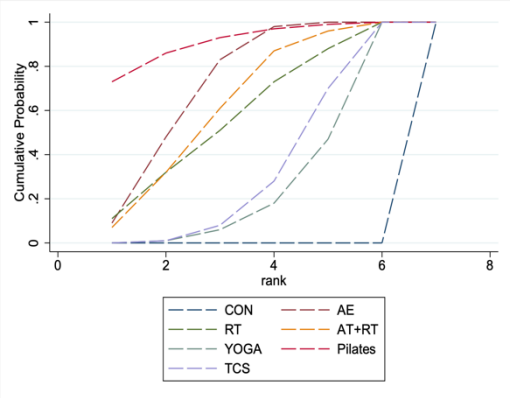


Figure 1: Excluding Studies with High Risk of Bias

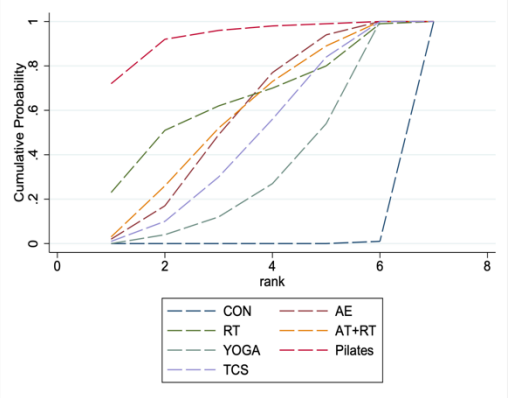


Figure 2: Excluding Studies with Small Sample Sizes

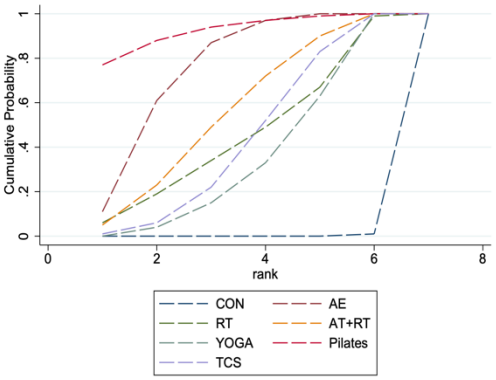
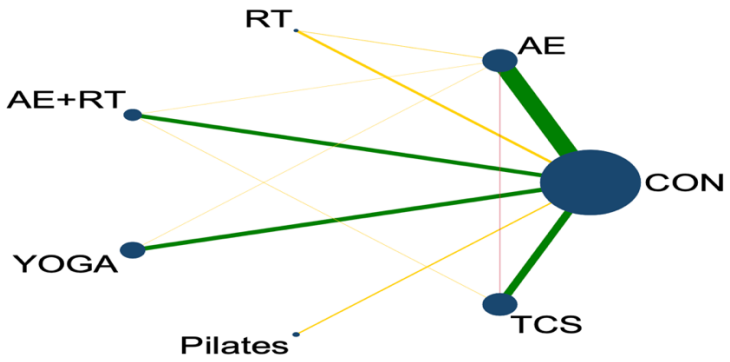


Figure 3: Excluding Studies with Intervention Duration of Four Weeks or Less

Appendix 7 GRADE Evidence Quality Assessment for the Sleep Quality Index

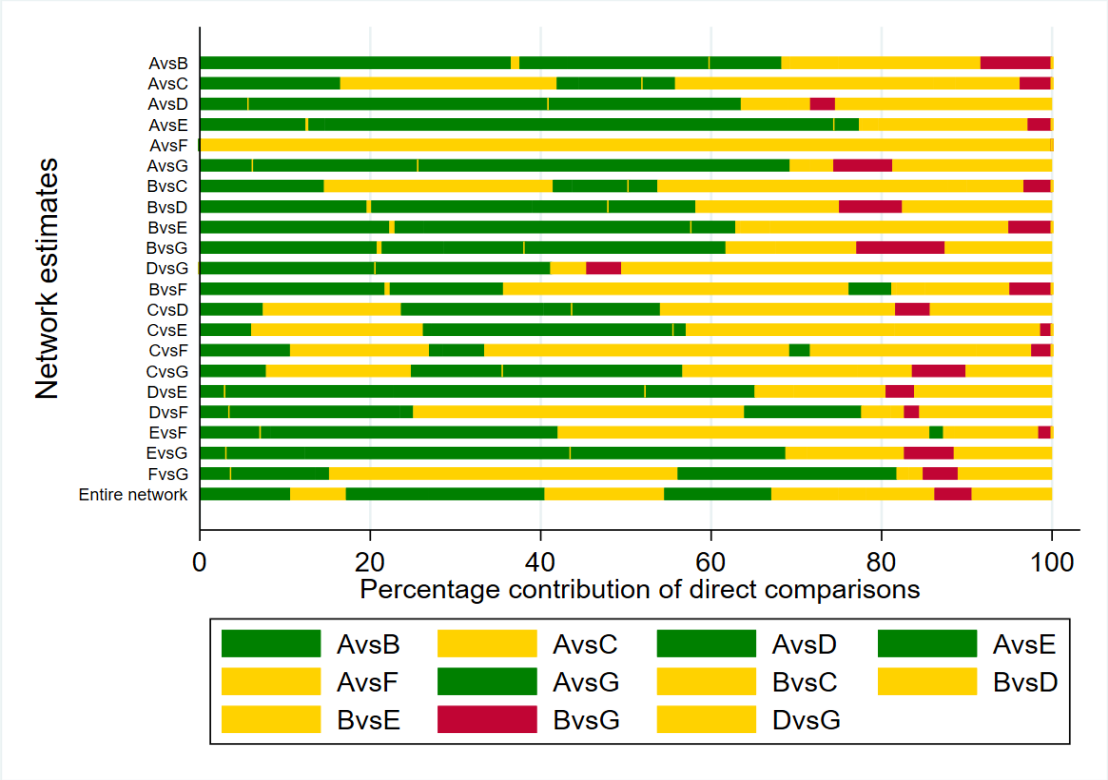
1. Summary of study limitations of the included studies.

The colours of the line indicate the summative ROB assessment of each comparison based on ROB assessment of each included studies (low ROB comparison [green], moderate ROB comparison [yellow] and high ROB comparison [red]).



2. Contribution of ROB comparisons to each network estimate.

Based on the above assessment of ROB for each comparison and the contributions of direct and indirect comparisons to all network estimates, the following bar graphs show the percentage of low, moderate and high ROB contributions for each network estimate.。



A-CON (Control Group), B-AE (Aerobic Exercise), C-RT (Resistance Training), D-AE+RT (Combined Aerobic and Resistance Training), E-YOGA , F-Pilates ,G-TCS (Traditional Chinese Sports)

3. Table of reasons for downgrading.

(1) Study limitations

Based on all the above information, we GRADEd each network estimate according to the following criteria. (1) Study limitations Low risk (green)/unclear risk (yellow)/high risk (red) of each direct comparison was given a weight of 0/1/-2, respectively. And then the risk value of each comparison and SUCRA probability sorting result were calculated according to the contribution to ROB comparisons to each network estimate. It would be downgraded by one level when the risk value is between -1.5 and -0.6 (indicated by “Study limitations”) and two level when the risk value is less than -1.6 (indicated by “Study limitations^{2}”).

(2) Indirectness

Indirectness was assessed by evaluating whether the study population, intervention type, and outcomes were directly relevant to the objectives of this meta-analysis.

(3) Inconsistency:

Heterogeneity and inconsistency were assessed in this study. Heterogeneity in direct comparisons was evaluated using pairwise forest plots (Appendix 5) by checking whether the

prediction interval crossed the line of no effect. If the prediction interval crossed the line of no effect (red solid line intersects the blue solid line), it was deemed highly heterogeneous (labeled as "Heterogeneity"). Inconsistency between direct and indirect comparisons was evaluated using loop-specific heterogeneity estimates and node-splitting analyses (labeled as "Inconsistency"). The stability of SUCRA probability rankings was assessed based on overall inconsistency.

(4) Imprecision

Imprecision was assessed based on the adequacy of sample size, with studies having a total sample size below 400 being downgraded by one level. The total sample size in this study was 7276, exceeding the threshold of 400; thus, no downgrading was applied. Imprecision in the ranking results was evaluated based on the differences between ranking values. If the differences in ranking values among treatments were small, indicating poor stability, the corresponding intervention was downgraded by one level.

(5) Publication Bias

Publication bias was detected using funnel plots in the network meta-analysis (Figure 5 in the main text).

Table 4 GRADE Assessment Results for Primary Sleep Quality Outcomes

Comparison	**Nature of the evidence**	**Confidence**	**Downgrading due to**
CON vs AE	**Mixed**	**Very low**	Heterogeneity,Inconsistency,Publication bias
CON vs RT		**Low**	Study limitations，Heterogeneity
CON vs AE+RT		**Moderate**	Heterogeneity
CON vs YOGA		**Moderate**	Heterogeneity
CON VS Pilates		**Low**	Heterogeneity, Study limitations
CON vs TCS		**Moderate**	Heterogeneity
AE vs RT		**Low**	Study limitations, Inconsistency
AE vs AE+RT		**Moderate**	Inconsistency
AE vs YOGA		**Moderate**	Publication bias
AE vs TCS		**Moderate**	Publication bias
AE+RT vs TCS		**Moderate**	Study limitations
AE vs Pilates	**Indirect**	**Moderate**	Indirectness
RT vs AE+RT		**Low**	Indirectness, Inconsistency
RT vs YOGA		**Moderate**	Indirectness
RT vs Pilates		**Moderate**	Indirectness
RT vs TCS		**Moderate**	Indirectness
AE+RT vs YOGA		**Moderate**	Indirectness
AE+RT vs Pilates		**Low**	Indirectness, Publication bias
YOGA vs Pilates		**Moderate**	Indirectness
YOGA vs TCS		**Moderate**	Indirectness

Pilates vs TCS	**Moderate**	Indirectness
Ranking of treatments	**Moderate**	Study limitations

Appendix 8 Key Assumptions of Dose-Response Network Meta-Analysis

1 Network Connectivity

Connectivity is a key assumption in NMA that, if considered insufficient (i.e., due to lack of direct comparisons), may lead to low statistical power and misleading results [86]. Our study assessed network connectivity at the motor and dose levels and did not find any evidence of network unconnectedness (Figure 4 and Figure 5)。

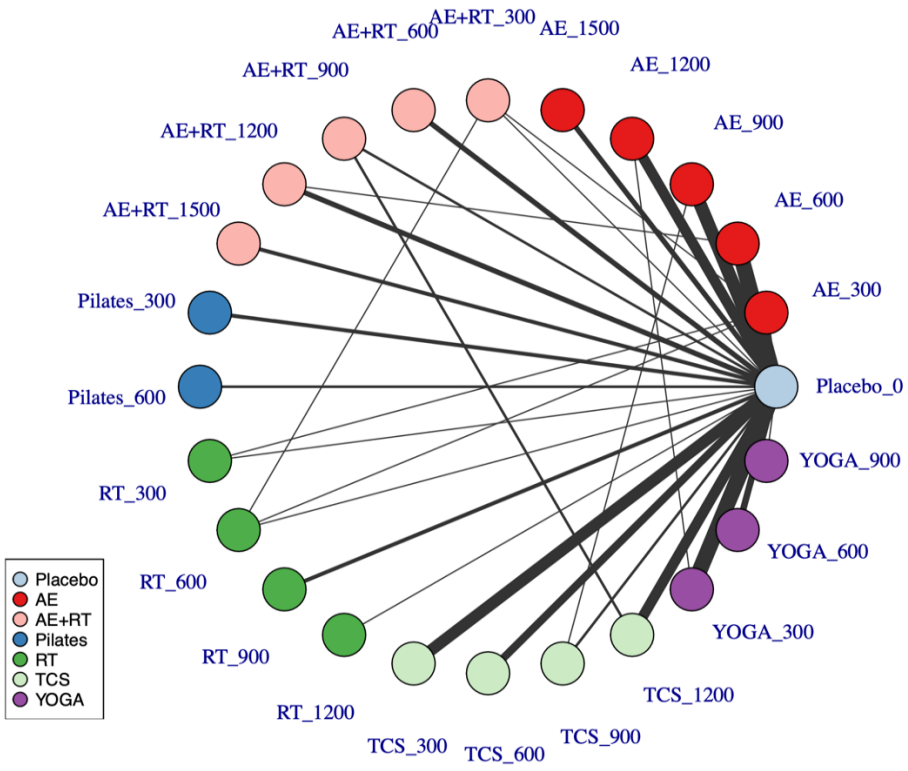


Figure 4 Treatment-level network. The first value indicates the specific intervention and the second one is the corresponding dose of that intervention.

CON (Control Group), AE (Aerobic Exercise), RT (Resistance Training), AE+RT (Combined Aerobic and Resistance Training), TCS (Traditional Chinese Sports)

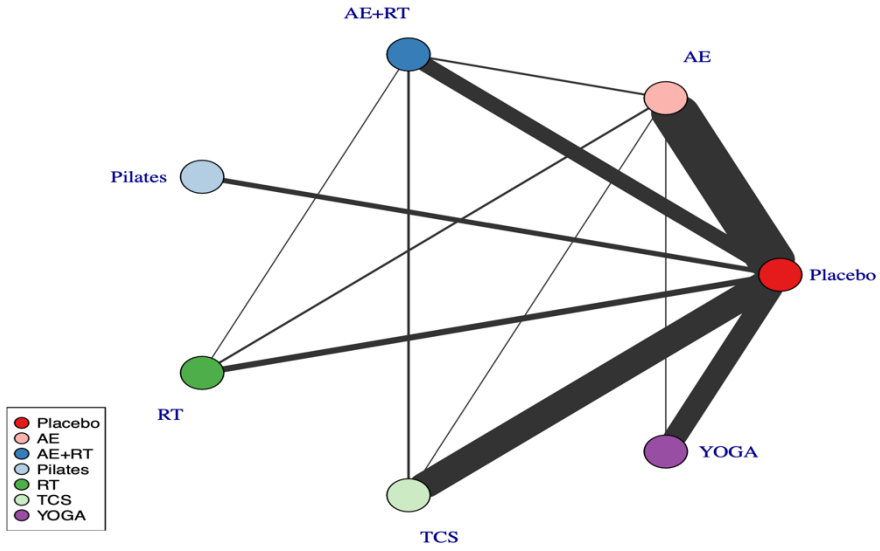


Figure 5 CON (Control Group), AE (Aerobic Exercise), RT (Resistance Training), AE+RT (Combined Aerobic and Resistance Training), TCS (Traditional Chinese Sports)

2、Data consistency

We performed a consistency analysis of the data by comparing the consistency of the network (i.e., network effect size) with the unrelated mean effects (UME) model (i.e., pairwise effect sizes). In practice, we checked whether the bias, the number of estimated parameters in the network, and the Deviance Information Criterion (DIC) metric were similar for both models, indicating a good fit[87]. The comparison of these parameters showed a good agreement between the different models (Table 5).。

Table 5 Consistent and UME models fit comparison.

Model	**pD**	**Deviance**	**DIC**	**SD**
Consistent	215.2	209.43	409.3	1.157
UME	212	209.81	408.6	1.152

3、Network transitivity

NMAs are based on the assumption of indirect/mixed comparisons, which implies that estimates of treatment effects from direct and indirect evidence are consistent but with the usual variation of meta-analyses under a random effects model [88]. This assumption is equivalent to heterogeneity in a "standard" meta-analysis [89]. Following a previous proposal [90], anomalies were assessed at a deeper network level (i.e., at the treatment level). We assessed

the span by the MBNMA node-splitting method. This method splits the contribution of a specific treatment contrast into direct and indirect evidence and compares them [91]. Similar effects indicate good span. Table 6 and Figure 6 presents the results for transitivity in this meta-analysis.

Table 6 Node-splitting analysis of consistency

Comparison	p-value	Median	2.50%	97.50%
RT_300 vs AE_300	0.192			
-> direct		-1.031	-3.416	1.521
-> indirect		0.199	-0.184	0.582
-> MBNMA		0.177	-0.209	0.552
YOGA_900 vs Placebo_0	0.521			
-> direct		-0.674	-3.159	1.819
-> indirect		-1.767	-3.064	-0.49
-> MBNMA		-1.528	-2.667	-0.349
YOGA_600 vs Placebo_0	0.744			
-> direct		-0.847	-1.958	0.261
-> indirect		-1.21	-2.295	-0.126
-> MBNMA		-1.019	-1.778	-0.232
YOGA_300 vs Placebo_0	0.426			
-> direct		-0.818	-1.532	-0.091
-> indirect		-0.357	-0.805	0.108
-> MBNMA		-0.509	-0.889	-0.116
TCS_1200 vs Placebo_0	0.127			
-> direct		-0.671	-1.498	0.171
-> indirect		-2.355	-3.69	-1.038
-> MBNMA		-1.199	-1.986	-0.482
TCS_900 vs Placebo_0	0.536			
-> direct		-0.945	-2.548	0.705
-> indirect		-0.855	-1.428	-0.297
-> MBNMA		-0.899	-1.489	-0.362
TCS_600 vs Placebo_0	0.233			
-> direct		-1.26	-2.263	-0.27
-> indirect		-0.502	-0.879	-0.113
-> MBNMA		-0.6	-0.993	-0.241
TCS_300 vs Placebo_0	0.16			
-> direct		-0.902	-1.699	-0.078
-> indirect		-0.271	-0.457	-0.081
-> MBNMA		-0.3	-0.496	-0.121
RT_1200 vs Placebo_0	0.798			

-> direct		-0.964	-3.555	1.517
-> indirect		-1.154	-2.947	0.604
-> MBNMA		-1.116	-2.608	0.297
RT_900 vs Placebo_0	0.65			
-> direct		-0.493	-1.984	1.016
-> indirect		-1.221	-2.766	0.338
-> MBNMA		-0.837	-1.956	0.223
RT_600 vs Placebo_0	0.44			
-> direct		-1.436	-3.609	0.656
-> indirect		-0.609	-1.371	0.166
-> MBNMA		-0.558	-1.304	0.149
Pilates_600 vs Placebo_0	0.663			
-> direct		-2.839	-4.603	-1.11
-> indirect		-2.011	-4.938	0.91
-> MBNMA		-2.569	-4.111	-1.136
Pilates_300 vs Placebo_0	0.653			
-> direct		-0.984	-2.405	0.436
-> indirect		-1.423	-2.352	-0.529
-> MBNMA		-1.284	-2.055	-0.568
AE+RT_1500 vs Placebo_0	0.738			
-> direct		-1.162	-2.642	0.362
-> indirect		-1.604	-2.827	-0.365
-> MBNMA		-1.429	-2.399	-0.502
AE+RT_1200 vs Placebo_0	0.858			
-> direct		-1.053	-2.238	0.137
-> indirect		-1.185	-2.173	-0.241
-> MBNMA		-1.143	-1.919	-0.401
AE+RT_900 vs Placebo_0	0.493			
-> direct		-0.526	-2.29	1.119
-> indirect		-0.884	-1.478	-0.292
-> MBNMA		-0.857	-1.439	-0.301
AE+RT_600 vs Placebo_0	0.437			
-> direct		-0.921	-2.228	0.308
-> indirect		-0.541	-0.927	-0.134
-> MBNMA		-0.572	-0.959	-0.201
AE+RT_300 vs Placebo_0	0.012			
-> direct		-3.123	-5.332	-0.923
-> indirect		-0.268	-0.443	-0.091

-> MBNMA		-0.286	-0.48	-0.1
AE_1500 vs Placebo_0	0.616			
-> direct		-1.936	-3.266	-0.665
-> indirect		-2.39	-3.148	-1.632
-> MBNMA		-2.278	-2.953	-1.619
AE_1200 vs Placebo_0	0.254			
-> direct		-1.227	-2.1	-0.358
-> indirect		-2.106	-2.751	-1.461
-> MBNMA		-1.823	-2.362	-1.296
AE_900 vs Placebo_0	0.43			
-> direct		-1.709	-2.51	-0.907
-> indirect		-1.249	-1.706	-0.801
-> MBNMA		-1.367	-1.772	-0.972
AE_600 vs Placebo_0	0.089			
-> direct		-1.633	-2.345	-0.944
-> indirect		-0.803	-1.067	-0.529
-> MBNMA		-0.911	-1.181	-0.648

The first value represents the specific intervention, and the second value indicates the dose corresponding to the intervention with its CrI (credible interval).

AE: Aerobic Exercise; RT: Resistance Training; AE+RT: Combined Aerobic and Resistance Training; YOGA: Yoga; Pilates: Pilates; TCS: Traditional Chinese Sports; CON: Control Group.

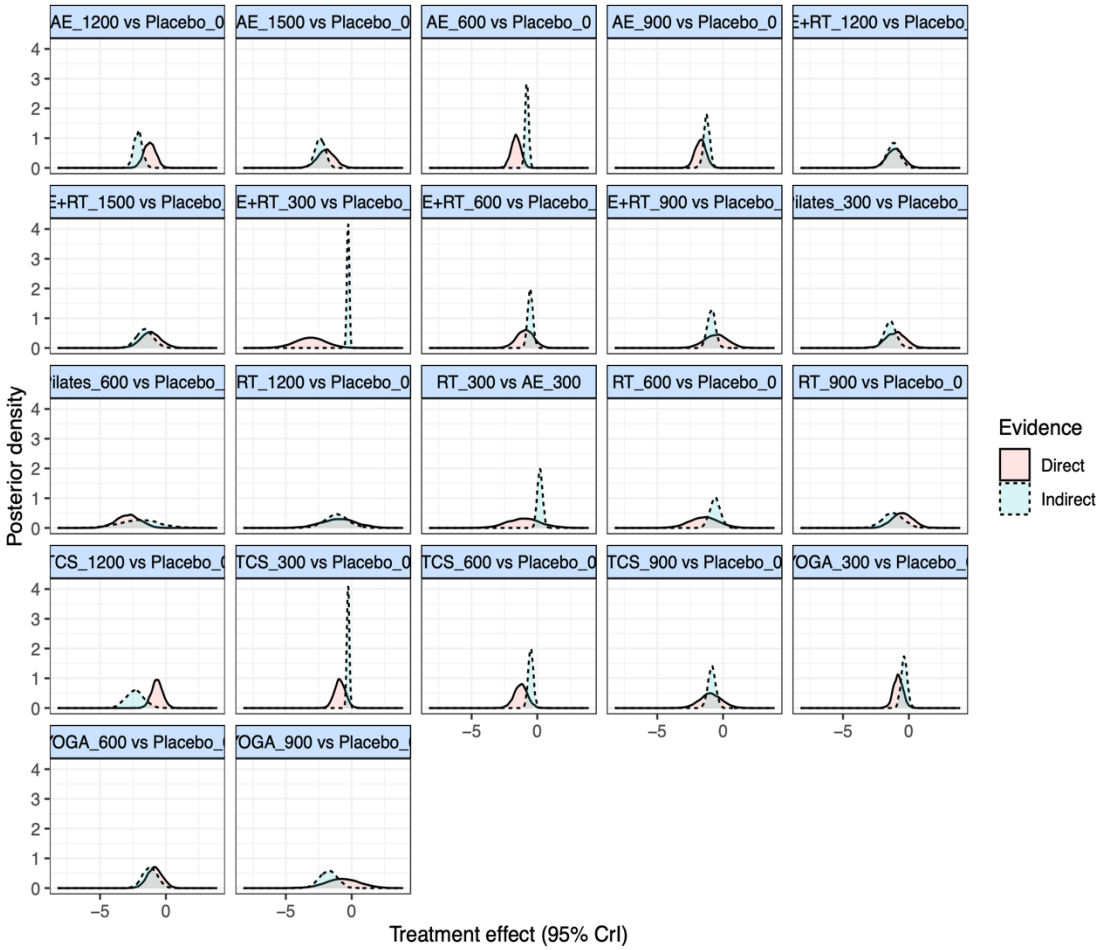


Figure 6. Node-splitting analysis (density plot). The value of title is the corresponding dose of that agent. CrI (credible interval) CON (Control Group), AE (Aerobic Exercise), RT (Resistance Training), AE+RT (Combined Aerobic and Resistance Training), TCS (Traditional Chinese Sports)

Appendix 9 Model Selection for Dose-Response Analysis

1、Non-linear functions and models fit comparison

A meta-analysis (i.e., a "split" NMA) of the different doses of physical activity as separate and unrelated treatments were performed. This step helps determine which function is more appropriate for the data and should be used in a model-based network meta-analysis (MBNMA) [92]. Figure 7 and Figure 8 show the different responses of each dose to overall and different types of exercise, respectively (MD).

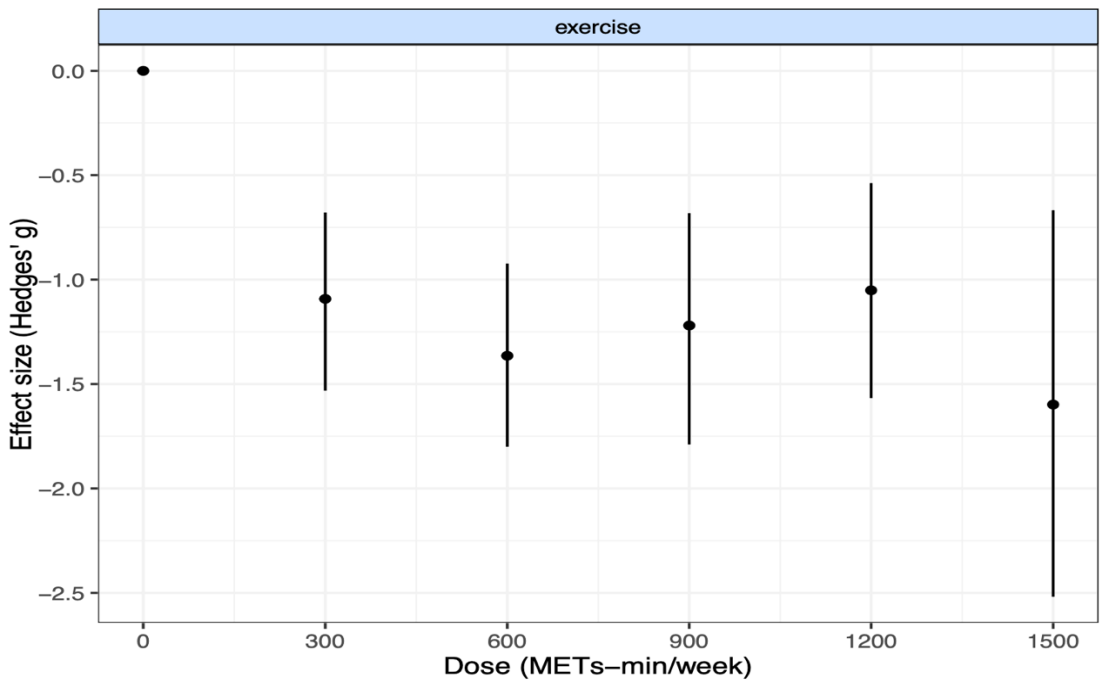


Figure 7. “Split” NMA of overall exercise.

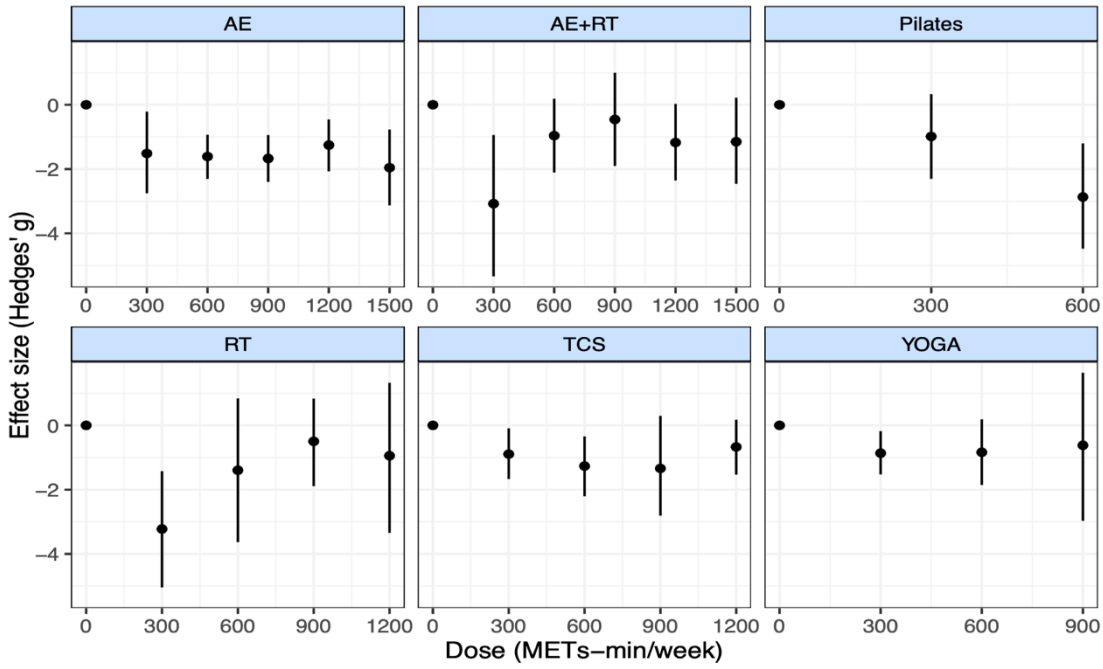


Figure 8. “Split” NMA of different exercise agents.

CON (Control Group), AE (Aerobic Exercise), RT (Resistance Training), AE+RT (Combined Aerobic and Resistance Training), TCS (Traditional Chinese Sports)

1、Models selection

For our data, quadratic model shows the best fit and were therefore used in subsequent analyses.

Table 7 Models fit comparison

Model	DIC	SD	Deviance	pD
Emax (common treatment effects)	407.7	1.16 (0.98, 1.37)	209.48	214.9
Emax (random treatment effects)	1638.9	NA	1532.97	108.3
Restricted cubic spline (common treatment effects; 3 knots)	1533.8	NA	1414.64	126.1
Restricted cubic spline (random treatment effects; 3 knots)	407.5	1.149(0.98, 1.35)	209.74	205.9
Quadratic (2nd degree polynomial, common treatment effects)	1678.5	NA	1568.192	113.0

Quadratic (2nd degree polynomial, random treatment effects)	407.1	1.19(1.02, 1.39)	209.29	216.6
Non-parametric monotonically up (common treatment effects)	3285.85	NA	3384.5	142.1

In addition to the model fit index, a deviation plot showing the contribution of each data point to the residuals can also help to confirm the robustness of the model selection. The contribution of each data point to the posterior mean bias should be around 1, which indicates a good model fit 10. Deviation plots for overall (Figure 9) treatment effects (Figure 10) confirm the robustness of our model selection (i.e., deviations <1.5 except for a few data points in the overall exercise and RE at 600 METs-min, which are all below a contribution of 1.5).

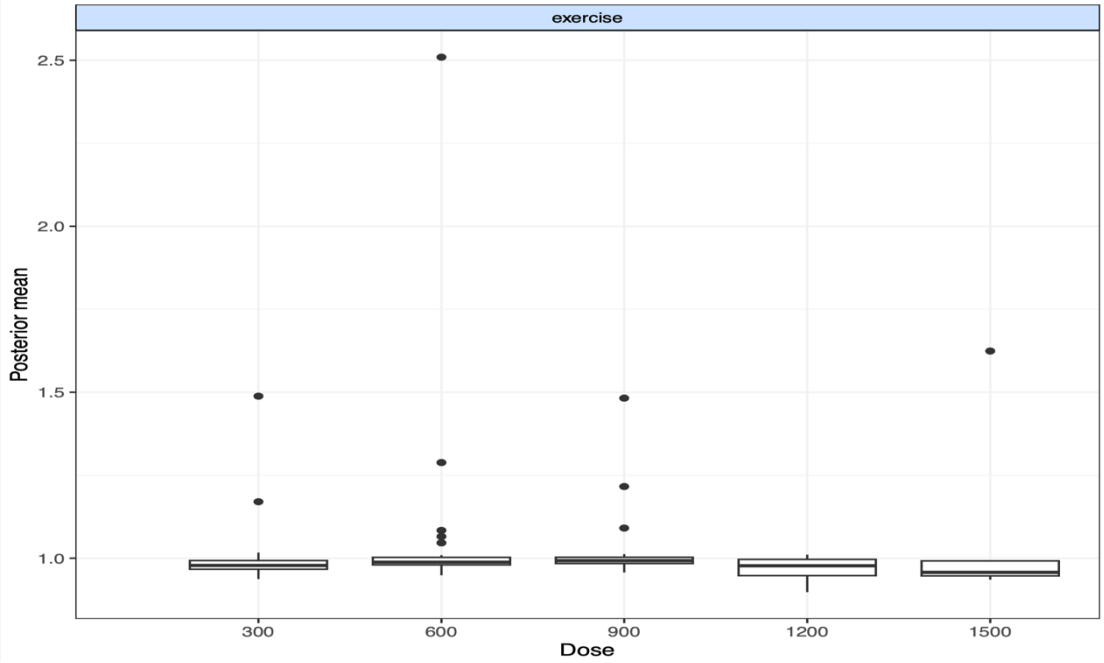


Figure 9. Deviance plot at overall exercise

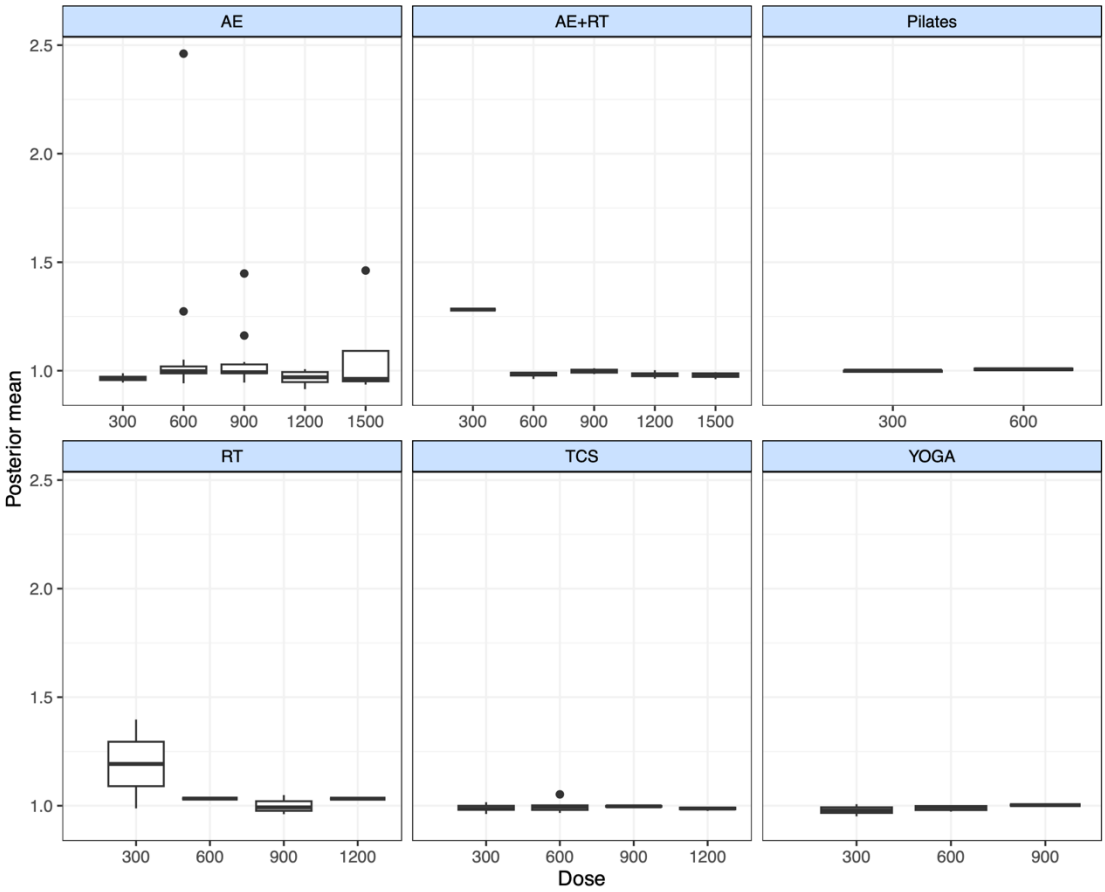


Figure 10. Deviance plots at treatment-level.

CON (Control Group), AE (Aerobic Exercise), RT (Resistance Training), AE+RT (Combined Aerobic and Resistance Training), TCS (Traditional Chinese Sports)

In addition, we also plotted the fit further to assess the degree of fit of the model. The fit values are plotted as connecting lines, and the observations in the original dataset are plotted as points. These plots can determine if the model fits the data well for different exercises and doses of the dose-response function[93].

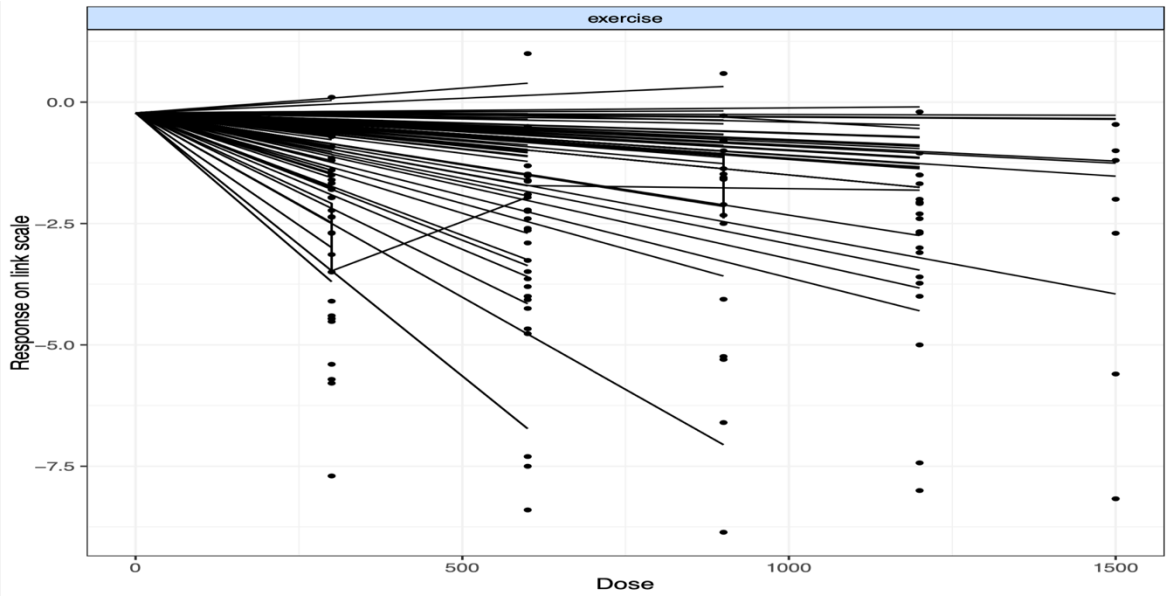


Figure 11. Fit plots at overall exercise level.

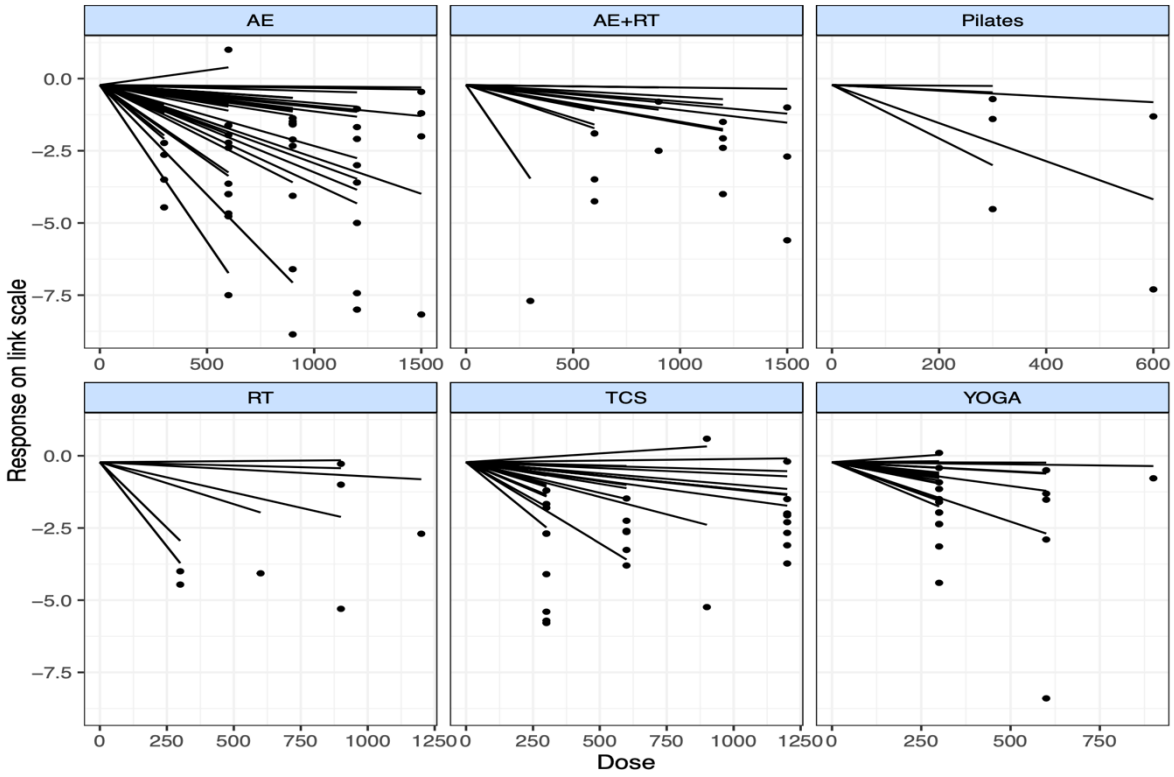


Figure 12. Fit plots at agent-level.

CON (Control Group), AE (Aerobic Exercise), RT (Resistance Training), AE+RT (Combined Aerobic and Resistance Training), TCS (Traditional Chinese Sports)

Appendix 10 Dose-Response Relationship

1、Dose-Response Relationship Between Exercise Dose and Sleep Quality

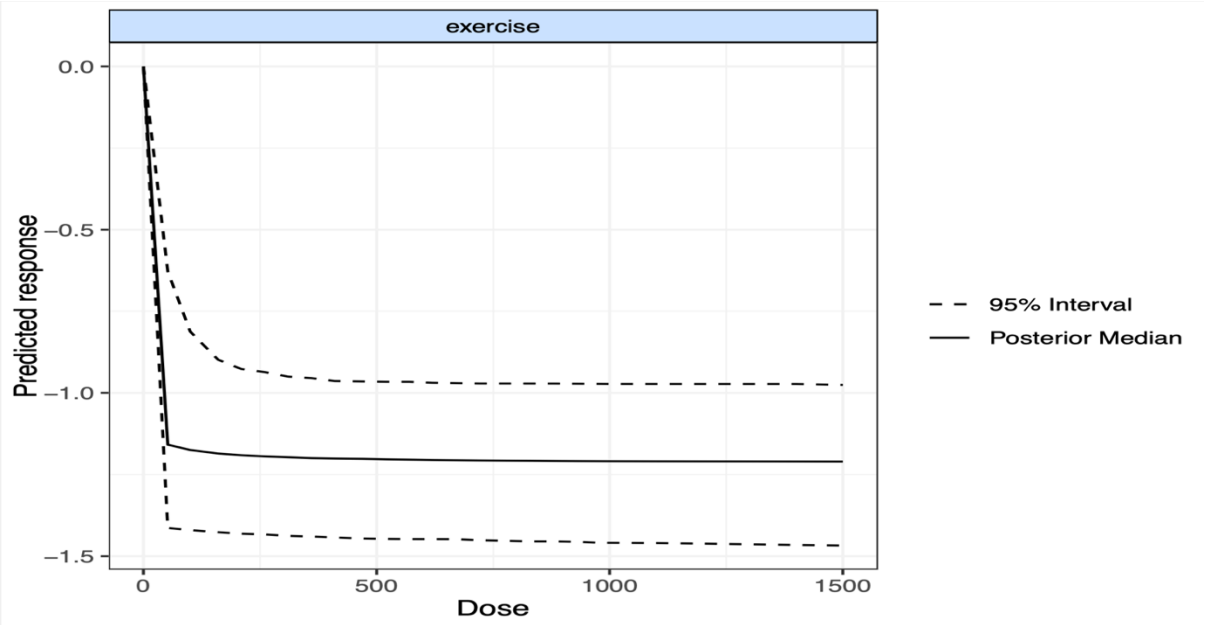


Figure 13 Dose-Response Relationship Between Exercise Dose and Sleep Quality

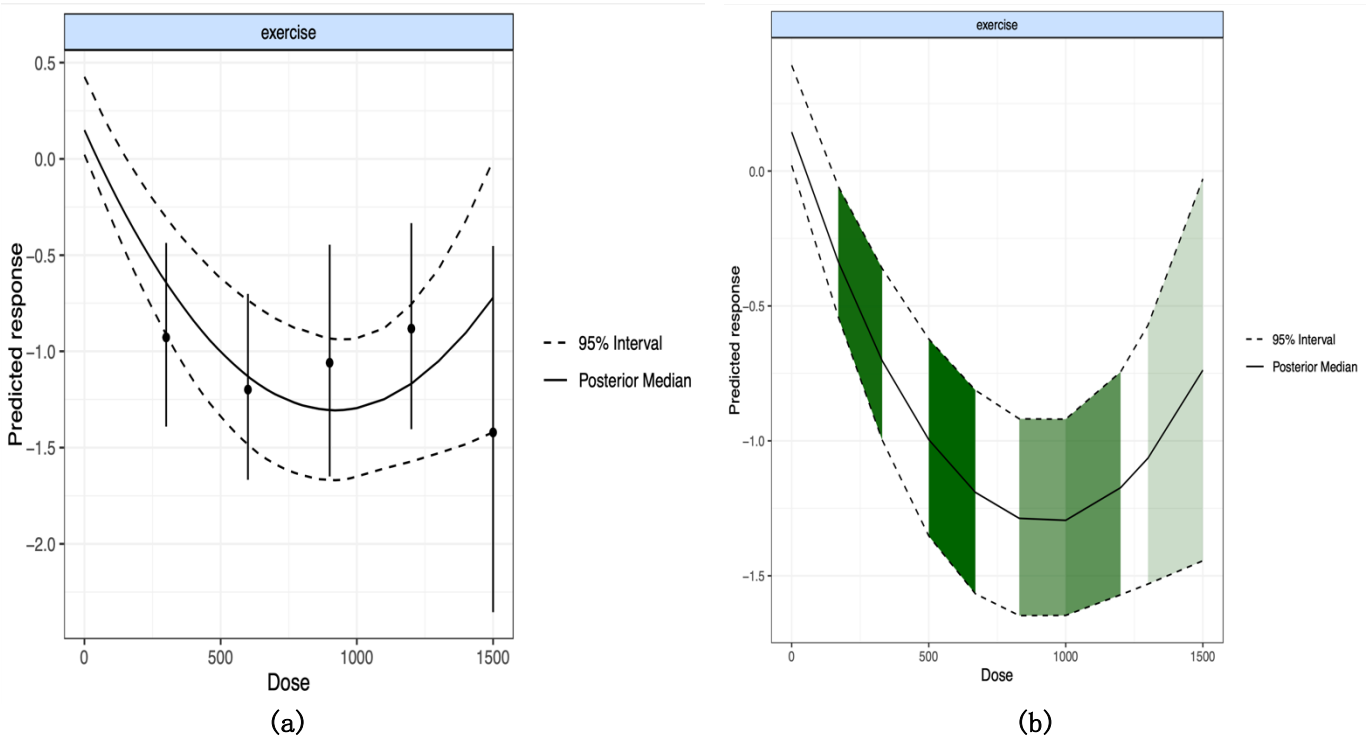


Figure 14. Dose-Response Relationship Between Exercise Dose and Sleep Quality

Figure (a): Displays the dose-response relationship and node-splitting analysis.

Figure (b): The shaded area represents the original research dataset, with darker shading indicating a larger data volume.

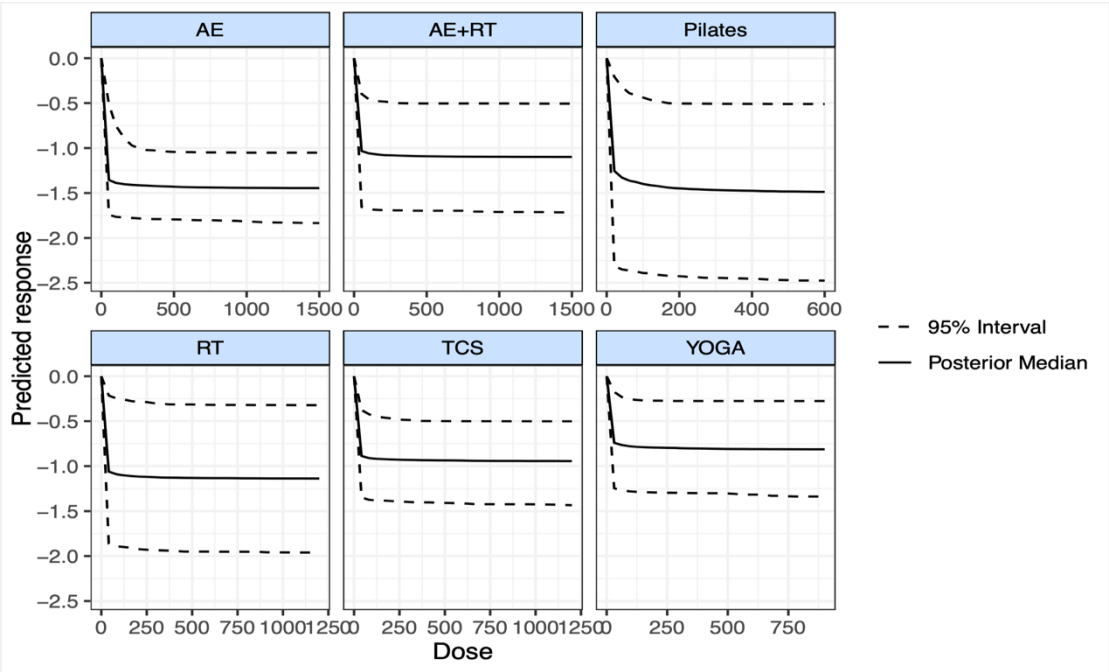
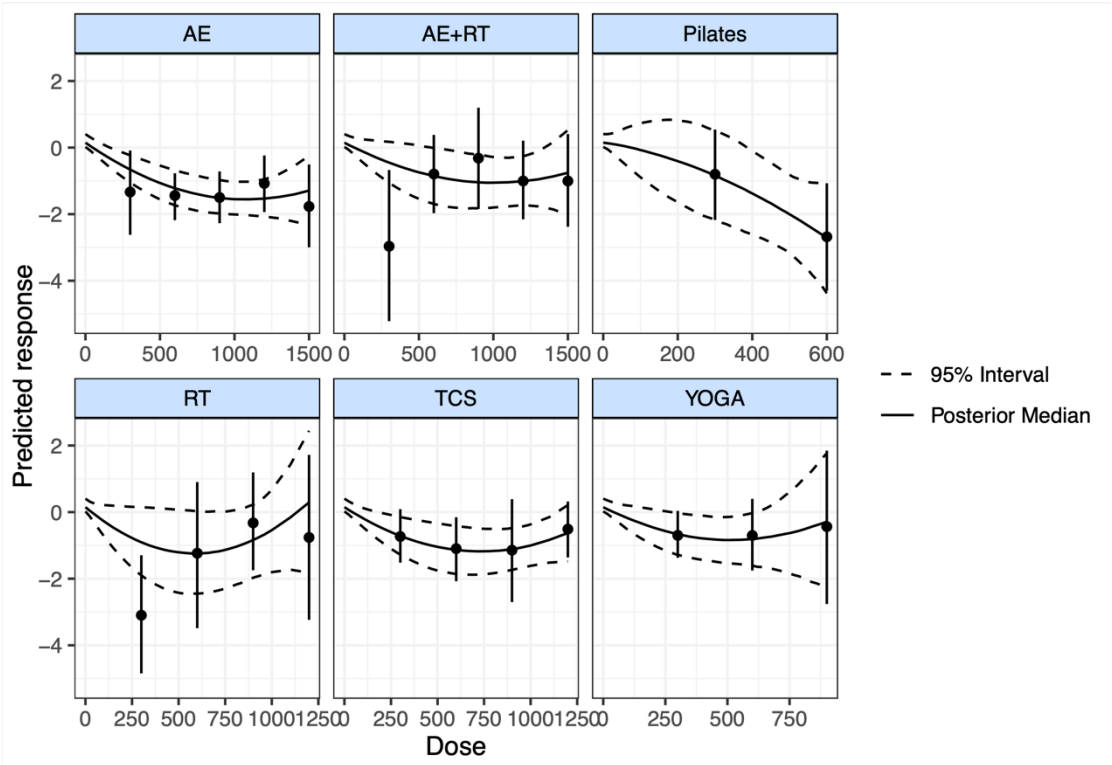


Figure 15. Prediction dose-response relationship at agent-level. PI, prediction interval

CON (Control Group), AE (Aerobic Exercise), RT (Resistance Training), AE+RT (Combined Aerobic and

Resistance Training), TCS (Traditional Chinese Sports)

a



b

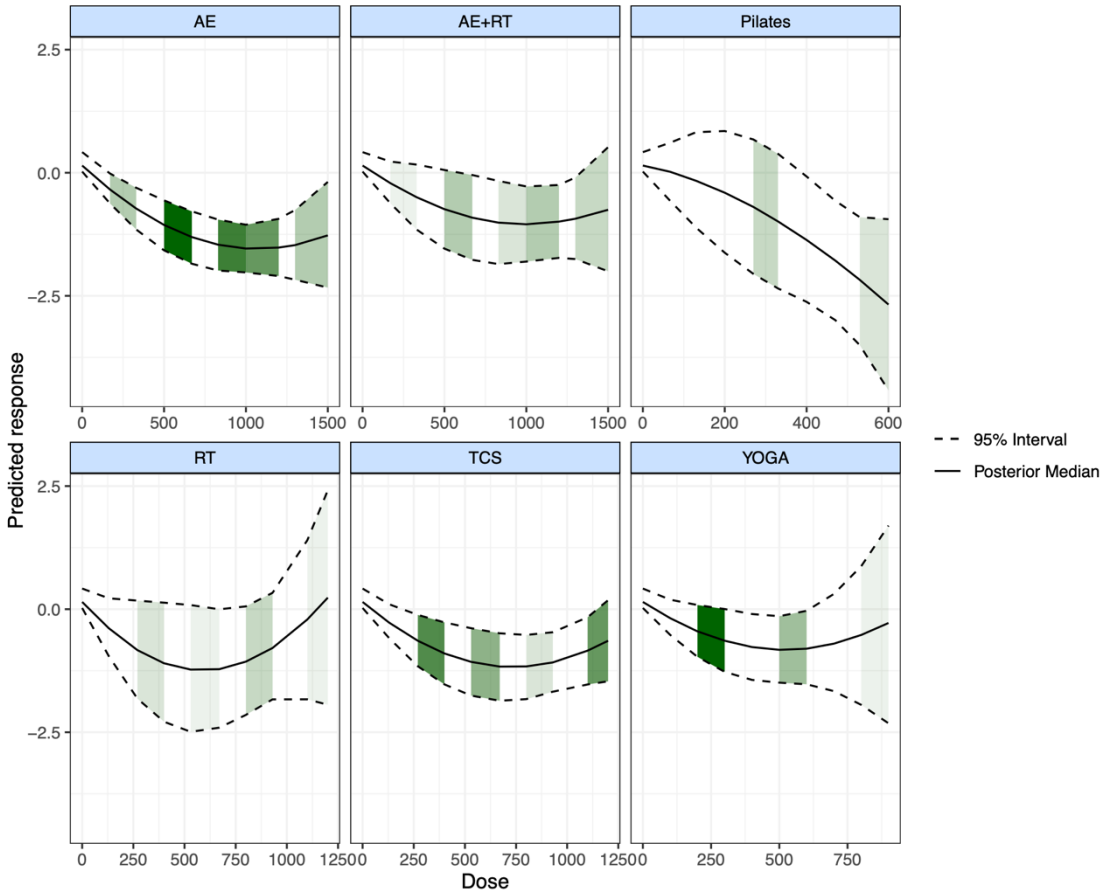


Figure 16. Dose-Response Relationships for Different Exercise Types

Figure a displays the dose-response relationships and results of the node-splitting analysis, while Figure b shows the shaded areas representing the original research dataset, with darker shading indicating larger data volumes. AE: Aerobic Exercise; RT: Resistance Training; AE+RT: Combined Aerobic and Resistance Training; YOGA: Yoga; Pilates: Pilates; TCS: Traditional Chinese Sports; CON: Control Group.

2、Ranking of effectiveness of different exercise

Figure 17 shows the probability of each intervention to be ranked from best to worst (estimated after up to 5000 iterations).

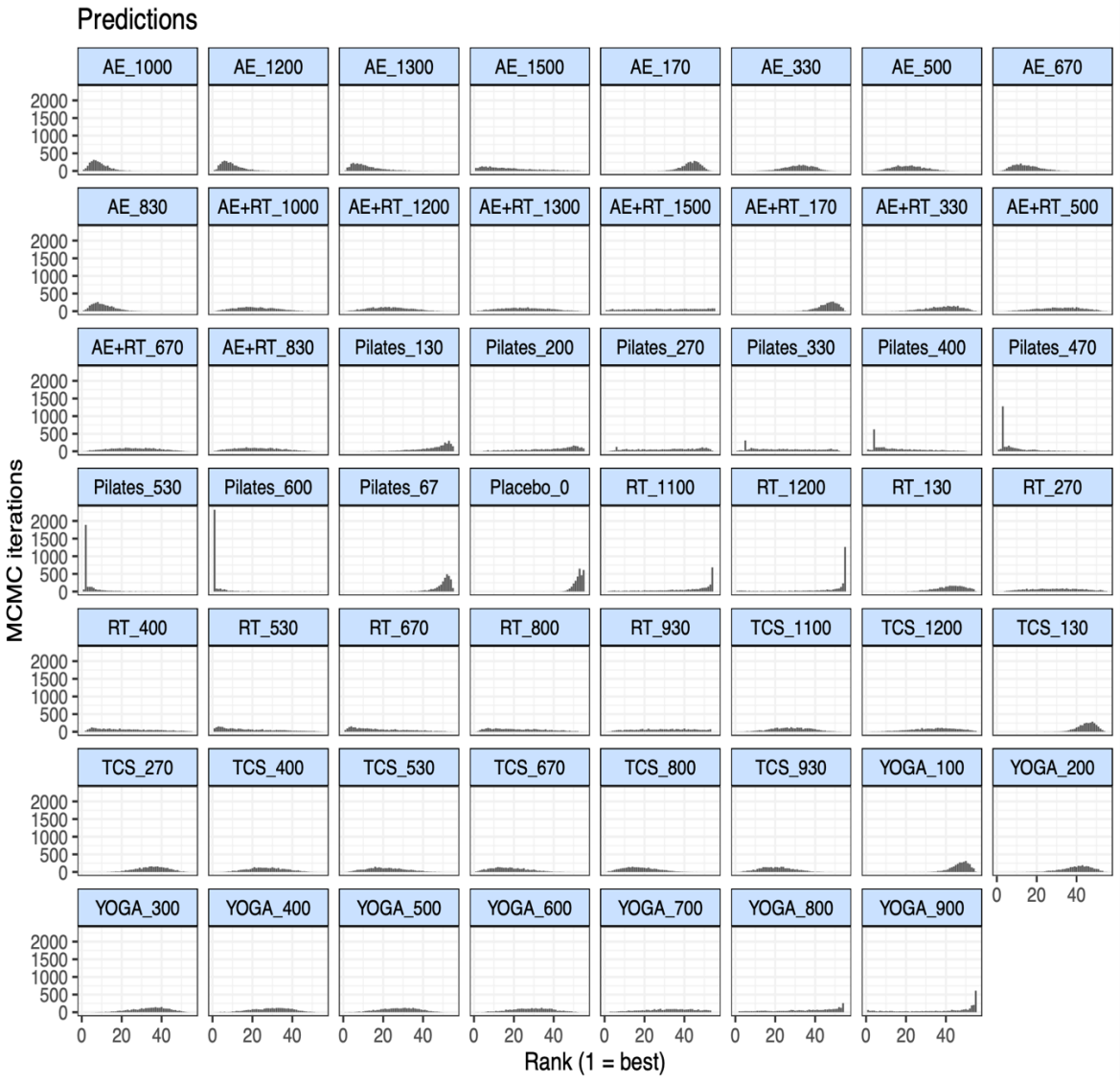


Figure 17. Effectiveness ranking by different exercise. The number that follows the exercise intervention indicates the dose of exercise (METs-min/week)

CON (Control Group), AE (Aerobic Exercise), RT (Resistance Training), AE+RT (Combined Aerobic and Resistance Training), TCS (Traditional Chinese Sports)

Table 8 Predictions ranking (from best to worst)

Treatment	Mean	Median	2.50%	97.50%
Pilates_600	3.19	1	1	25
Pilates_530	4.86	2	2	26
AE_1000	8.67	8	2	20
Pilates_470	8.69	4	2	34
AE_1200	9.6	8	2	23.03
AE_830	10.65	10	3	23
AE_1300	11.55	10	2	31
AE_670	14.74	14	5	29
Pilates_400	16	12	2	46
TCS_800	17.75	17	4	35
AE_1500	17.82	15	1	47
TCS_670	17.86	17	3	37
RT_530	18.39	15	1	49
RT_670	18.47	15	2	47
TCS_930	20.74	20	6	37
TCS_530	21.53	21	6	40
AE+RT_1000	21.57	21	5	41
AE_500	21.58	21	8	37
RT_400	22.26	20	3	51
RT_800	22.34	21	4	48
AE+RT_830	22.65	22	4	45
AE+RT_1200	23.28	23	6	43
Pilates_330	24.3	23	4	50
AE+RT_1300	25.41	25	5	48
AE+RT_670	26.11	26	5	48
TCS_400	27.12	27	10	44
YOGA_500	27.96	28	10	45
TCS_1100	28.13	28	9	46
YOGA_600	29	29	9	48
RT_270	29.58	30	7	52
YOGA_400	29.65	30	10.98	46
RT_930	29.78	30	6	52
AE+RT_1500	30.54	31	3	55
Pilates_270	31.22	33	6	53
AE+RT_500	31.62	32	11	50
YOGA_700	31.78	33	7	52
AE_330	31.81	32	16.98	44
YOGA_300	34.08	35	15	49
TCS_1200	34.34	35	11	53
TCS_270	35.02	35	20	48

YOGA_800	35.3	38.5	4	54
YOGA_900	38.42	46	2	55
Pilates_200	38.43	42	9	55
AE+RT_330	38.74	40	21	52
YOGA_200	40.22	41	24	52
RT_1100	40.68	46.5	5	54
RT_130	42.01	43	25	54
AE_170	43.36	44	33	51
RT_1200	45.01	53	4	55
Pilates_130	45.02	48	20	55
TCS_130	45.12	46	35	52
AE+RT_170	46.47	47	35	54
YOGA_100	47.22	48	37	54
Pilates_67	49.96	51	38	55
Placebo_0	52.44	53	47	55