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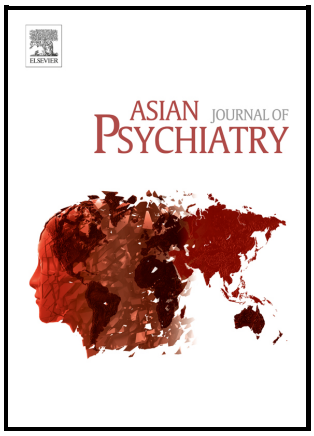

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Impact of social knowledge and skills training based on UCLA PEERS® on social communication and interaction skills of adolescents or young adults with autism: a systematic review and meta-analysis

Yichao Cheng[1, 2, 3, 4] Jiaxin Shi[1, 2, 3, 4] Xingpeng Cheng[5] Yenan Wei[1, 2, 3, 4] Jiacheng Wang[1, 2, 3, 4] Zhimei Jiang[4]

*Communication : Zhimei Jiang, Jiamusi University, Heilongjiang Province, People 's Republic of China, Email : mynard93@163.com

*First author : Yichao Cheng, Email : xiuwojiabing@qq.com

*Co-first author : Jiaxin Shi, Email : 1511134983@qq.com

*Other authors : Xingpeng Cheng, Email : 13792101536@163.com; Yenan Wei, Email : 2987028494@qq.com; Jiacheng Wang, Email : 13335289649@163.com

[1]Rehabilitation Medical College of Jiamusi University, Jiamusi, Heilongjiang ; [2]Third Affiliated Hospital of Jiamusi University, Jiamusi, Heilongjiang, [3]Heilongjiang Provincial Childhood Cerebral Palsy Prevention and Treatment Center, Jiamusi, Heilongjiang ; [4]Jiamusi University, Jiamusi, Heilongjiang; [5]Dongyuan Middle School, Dongping, Shandong

Abstract

This study provided a systematic review and meta-analysis of UCLA PEERS® for social skills improvement in adolescents or young adults with autism. A total of 21 randomized controlled trials and 10 non-randomized controlled trials were included, and six different outcome indicators were analyzed. The results showed that PEERS improved participants' knowledge of social skills, ability to apply social skills, and emotional intelligence, and the difference between caregiver-reported scores and teacher-reported scores was statistically significant. The PEERS intervention produced the smallest effect using PEERS in East Asia. This study discussed the significance of PEERS on the improvement of social skills in ASD and the reasons for the results of the subgroup analyses, and provided some recommendations for PEERS intervention methods that may help to improve the effectiveness of the intervention.

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Keywords: Autism, social skill, social knowledge, PEERS, intervention, meta-analysis

Introduction

Social communication and interaction disorder is very common in individuals with autism spectrum disorders (ASD), and this is one of the core symptoms of individuals with ASD, which are characterized by deficits in social-emotional reciprocity, deficits in nonverbal communicative behaviors, deficits in developing, maintaining, and understanding of relationships(Association, 2013). Individuals with ASD may experience developmental disorders in social communication and interaction skills early in life. Infants and young children with ASD may experience a decline in eye contact levels at around 2 months of age, and social skills development gradually begins to lag behind normal infants(Shultz et al., 2018). Children, adolescents, and adults with ASD tend to have a lack of proactive socialization behaviors, have difficulty understanding the emotions and intentions of others, and have language problems such as delayed language development and difficulty in comprehending language; in addition, they have poor adaptive skills and difficulty in regulating emotions in their environment. In addition, problems such as poor executive functioning, poor adaptation to the environment and difficulties in emotional regulation make it difficult for them to establish and maintain good interpersonal relationships(Kim et al., 2023; Lai et al., 2014). A study found that people with ASD were more talkative in boring situations and less talkative when discussing topics of interest compared to the normal population, suggesting that people with ASD have poorer ability to make self-behavioral adjustments in different social situations and poorer ability to adapt to their environments(Cola et al., 2022). Social communication and interaction disorder not only affects the interpersonal relationships and friendships of people with ASD, but also reducing their quality and ability to participate in social activities, it also makes them vulnerable to being misunderstood by others in their social lives, and their prolonged labeling and stigmatization can further trigger their mental health problems(Lai, 2023). One study found that social skills struggles were significantly correlated with the level

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of depression in adolescents with ASD, with lower social skills tending to have more severe depression(Pascoe et al., 2023). Therefore, improving the social communication and communication skills of ASD patients by providing them with social knowledge and skills training not only contributes to helping them better integrate into social life and participate in collective activities, but also prevents and ameliorates the abnormal psychological problems that may exist in ASD patients, avoids the occurrence of serious cases of self-injury and suicide(Situmorang, 2024), and further improves their quality of life.

The Program for the Education and Enrichment of Relational Skills (PEERS) is a social skills training intervention program for adolescents with autism (Laugeson et al., 2010). It was developed by Elizabeth A. Laugeson and other professionals from a research team at the Semel Institute for Neuroscience and Human Behavior at the University of California, Los Angeles (UCLA), as well as other institutions with professional backgrounds in child and adolescent psychology and social skills intervention. These professionals provide expertise and practical experience to support the development and improvement of PEERS. The PEERS intervention is a program designed to assist adolescents in developing social skills. It is a structured curriculum that is implemented in various settings, including clinical and institutional contexts, with a duration of 14 weeks, and educational institutions, with a duration of 16 weeks. The program focuses on imparting knowledge in various social skills, such as conversational skills, peer interaction strategies, coping mechanisms for social dilemmas, and the management of social reputations. The program encourages active engagement in social activities, particularly in the organization and participation of social gatherings such as get-togethers, thereby creating more opportunities for interaction with peers. Additionally, the program emphasizes fostering young people's capacity to establish meaningful and stable friendships with their peers, aiming to enhance their social skills and interaction experiences(Laugeson et al., 2009). The main purpose of PEERS is to enhance the knowledge of social skills of adolescents with autism, increase the frequency of their participation in social activities, improve the quality of their friendships, enhance their psychological well-being, and better adapt to social life. Due to its excellent intervention effects, PEERS has been translated into

Chinese, Korean, Japanese, Thai, Hebrew, Italian, and Polish and has been widely used in many countries and regions around the world(Fatta et al., 2024; Lao et al., 2024; Napat Sittanomai, 2021; Płatos et al., 2024; Rabin et al., 2020; Yamada et al., 2019; Yoo et al., 2014). But the actual effectiveness of PEERS interventions may vary somewhat due to the different cultures of individual countries and regions(Kéri, 2023), in addition, the different implementation environments of PEERS (schools or clinics) may also lead to situations where the effect size (ES) varies greatly. We also found that many related studies have used different types of outcome indicators reported by different reporters to verify the effectiveness of PEERS in improving the social skills of adolescent patients with autism from multiple perspectives. Therefore, it is necessary to explore the effectiveness of PEERS on adolescent patients with autism through meta-analysis and systematic evaluation methods in different outcome indicators, different implementation environments, and different cultural backgrounds. This will provide a reference for the future use of PEERS to intervene with adolescents with autism in various countries and regions, and provide an evidence-based basis for the selection of social skills training methods for adolescents with autism.

Methods

This study strictly followed the PRISMA 2020 statement to standardize the methods of meta-analysis and systematic evaluation(Page et al., 2021), and was registered on the international prospective systematic evaluation registration platform PROSPERO (Identification No. CRD42024626835).

1. Search Strategy and Selection Criteria

This study searched for relevant studies in five databases: PubMed, Cochrane Library, Web of Science, Embase and Google Scholar. The search results were supplemented by accessing the official website of the Semel Institute for Neuroscience and Human Behavior at the University of California, Los Angeles (https://www.semel.ucla. edu/peers) to supplement the database search results. The time range for searching each database was from the establishment of the database to December 9, 2024. Studies published in English were included. The search formula was listed in Appendix 1. The search results were imported into Endnote 21 for literature management and processing. Two researchers (JX.S and YN.W) conducted a

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preliminary screening of the included studies based on the title and abstract of each study to exclude studies that were not related to the topic of this study. Then, the included studies were further screened by reading the full text. In case of disagreement, a third researcher (JC.W) was invited to intervene and a unanimous decision was reached after discussion.

The inclusion criteria for this study were: (1) Studies in which the subject s were patients with a clinical diagnosis of ASD. (2) Studies in which the sub jects were adolescents or young adults over the age of 10. (3) Studies in whic h the intervention group used PEERS for intervention and the control group us ed a blank control or other routine intervention methods. (4) Studies that repor ted outcome measures related to social competence, including the Test of Adol escent Social Skills Knowledge (TASSK) (Laugeson et al., 2009), the Social R esponsiveness Scale (SRS) (Constantino J.N., 2005) and its second edition (SR S-2) (Constantino J. N., 2012), Quality of Socialization Questionnaire (QSQ) (F rankel, 2008), Social Skills Rating System (SSRS) (Gresham, 1990), Quality of Play Questionnaire (QPQ) (Frankel & Mintz, 2011), Empathy Quotient (EQ)(Ba ron-Cohen & Wheelwright, 2004).

2. Study Risk of Bias Assessment

Two researchers (JX.S and YN.W) independently assessed the risk of bias of the included randomized controlled trials (RCTs) using the Risk of Bias Tool 2.0 (ROB 2.0) provided on the Cochrane website. The main areas evaluated were randomization, concealment of participant allocation, blinding of participants and outcome assessors, the rate of missing data, the possibility of selective reporting, and other sources of bias. The risk of bias of non-randomized controlled trials (NRCTs) included was evaluated using the Risk of Bias In Non-Randomized Studies-of Interventions (ROBINS-I) for each study's potential risk of bias before, during and after the intervention. In case of disagreement, a final decision was made after consultation with a third researcher (JC.W).

3. Study Basic Information and Data Extraction

The basic information extracted for the study includes the first author of each study, year of publication, country, age of participants, sample size, intervention method, and

intervention frequency. Researcher JX.S collected and organized the basic information extracted from the studies using an Excel table (Microsoft Office). Another researcher, YN.W, double-checked the basic information to ensure the accuracy of the information extracted. The scores of the outcome indicators related to social skills in the included studies were counted and classified according to types, identity of the reporters, subtests and other factors of outcome indicators.

4. Statistical Analysis

This study used Stata 17.0 software to process and analyze the relevant data. For the RCTs included in the meta-analysis, we used the Standardized Mean Difference (SMD) and 95% CI to calculate the effect size of the outcome indicators for continuous variables. We used Hedge's g to correct the SMD, which can provide a more accurate estimate of the effect size in small samples. When the sample size is small, the SMD may overestimate the effect size. Hedge's g reduces this bias by adjusting for the combined variance, making the effect size estimate more robust and accurate(Hedges, 2014). The degree of heterogeneity between studies was judged by calculating the I^2 index. When the I^2 index is less than 25%, it is considered to have low heterogeneity; when the I^2 index is between 25% and 75%, it is considered to have medium heterogeneity; when the I^2 index is greater than 75%, it is considered to have high heterogeneity(Higgins et al., 2003). When I^2 is less than 50%, a fixed-effect model is used for analysis, and the resulting combined effect size is more reliable and can better represent the overall effect. When I^2 is greater than 50%, a random-effects model is used for analysis. The random-effects model not only takes into account sampling error, but also considers the heterogeneity between studies. It is assumed that the true effect size of different studies obeys a certain distribution (usually a normal distribution), and the combined effect size is obtained by taking the weighted average of the effect sizes of each study (the weight takes into account the variance within and between studies). A sensitivity analysis of the results of the meta-analysis were performed using the sequential elimination method to verify the stability of the results.The Egger test combined with funnel plot was used to assess possible publication bias in the study. The Egger test is based on a linear regression model, with the effect size (such as the standardized mean difference, odds ratio, etc.) as the dependent variable and the inverse

of the standard error as the independent variable for regression analysis. Publication bias is determined by testing whether the intercept of the regression line is significantly different from zero. If the intercept is significantly different from zero, it indicates possible publication bias. In addition, when the P value of the Egger test is less than 0.05, it also indicates possible publication bias.(Egger et al., 1997)。For NRCTs included in the systematic review, Hedge's g-corrected SMD was used to calculate the within-group ES before and after the intervention. When the SMD is between 0.2 and 0.49, it is considered to be a small effect; when the SMD is between 0.5 and 0.79, it is considered to be a medium effect; and when the SMD is greater than 0.8, it is considered to be a large effect.(Cohen, 2013)。

Results

1.Retrieved Result

This study initially retrieved 2,199 studies from five databases: 429 from PubMed, 259 from the Cochrane Library, 437 from Web of Science, 536 from Embase, and 538 from Google Scholar. Two studies that met the inclusion criteria were retrieved from the Semel Institute for Neuroscience and Human Behavior Research Institute website to search for and add two studies that met the inclusion criteria. A total of 31 studies were included in the final analysis, of which 21 were RCTs that were included in the meta-analysis, with a total sample size of 1008 ASD patients, and 10 NRCTs were included in the systematic review, with a total sample size of 261 ASD patients. The screening steps and reasons for exclusion of the retrieved studies are shown in Fig. 1.

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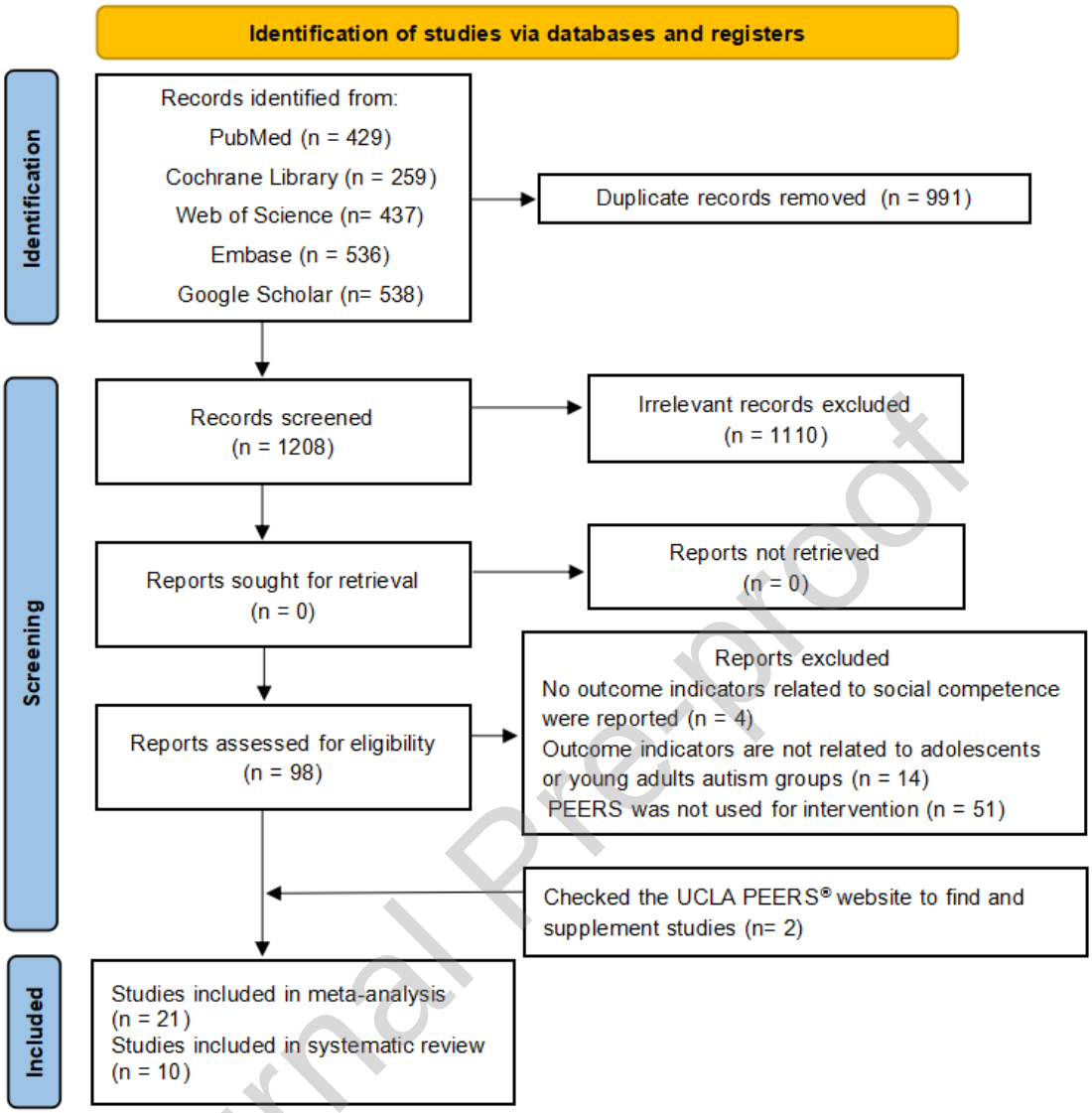

Fig. 1 PRISMA study selection flowchart

2.Characteristics of included studies

Of the 31 studies included in this review, five RCTs had a young adult population(Chien et al., 2021; Gantman et al., 2012; Laugeson et al., 2015; McVey et al., 2016; Platos et al., 2024), accounting for 17% of the total sample size in the meta-analysis. The remaining 16 RCTs were conducted on adolescent populations(Arias et al., 2021; Fatta et al., 2024; Hsiao et al., 2024; Idris et al., 2022; Laugeson et al., 2014; Laugeson et al., 2012; Laugeson et al., 2009; Matthews et al., 2018; Platos et al., 2023; Rabin et al., 2018; Rabin et al., 2020; Saima Khan, 2024; Schohl et al., 2013; Shum et al., 2018; Yamada et al., 2019; Yoo et al., 2014), and all 10 NRCTs were conducted on adolescent populations(Adler et al., 2022; Estabillo et al., 2022; Helder et al., 2024;

Hill, 2017; Hong et al., 2018; Lao et al., 2024; Lee et al., 2023; Marchica & D' Amico, 2016; Veytsman et al., 2022; Wyman & Claro, 2020)。Most of the included RCTs used PEERS for the intervention group, while the control group was a waitlist group (WL). After the end of the trial, the control group was given the same intervention method and intensity as the intervention group. However, three RCTs gave the control group non-PEERS routine treatment, and the control group was provided with active treatment control (Regulation, Organization and Autonomy Didactics; ROAD;), a psychological education training program used in the Netherlands for adolescents with neuropsychiatric disorders. ROAD can help adolescents with ASD improve their daily functioning and, in turn, improve their overall well-being and quality of life; Chien et al. provided the control group with problem-solving supportive psychotherapy and counseling; Laugeson et al (2014) conducted a study on the control group with a regular social skills curriculum intervention based on the Super Skills manual. In the daily social skills class, the teacher will explain the relevant content, guide students in discussions and exercises, and impart social skills knowledge to students through didactic instruction. Basic information on the characteristics of the RCTs and NRCTs included in this study is provided in Tables 1 and 2.

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Table 1 Basic characteristics of the included RCTs

Author	Year	Country	Age	Sample	Intervention Method	Intervention frequency	Outcome
Laugeson	2009	USA	I:14.60(1.30) C:14.60(1.60)	I:17 C:16	I: PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 12 weeks C: waitlist	TASSK, QPQ, SSRS
Gantman	2012	USA	I:19.90(1.20) C:20.90(2.00)	I:9 C:8	I: PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TYASSK, SRS, SSRS, QSQ, EQ
Laugeson	2012	USA	I:15.00(1.00) C:14.30(1.40)	I:14 C:14	I: PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TASSK-R, QPQ, SSRS
Schohl	2013	USA	I:14.00(1.28) C:13.31(1.65)	I:29 C:29	I: PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TASSK, SRS, SSRS, QSQ
Laugeson	2014	USA	I:12.68(0.67) C:12.74(0.68)	I:40 C:33	I: PEERS intervention C: Routine social skills course intervention	I: 1 course per day, 5 days a week, 30 minutes each time, for 14 weeks C: 1 course per day, 5 days per week, 30 minutes each time, for 14 weeks	TASSK-R, QPQ, SRS
Yoo	2014	South Korea	I:14.00(1.64) C:13.50(1.50)	I:23 C:24	I: Korean version of PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TASSK-R, QPQ

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Laugeson	2015	USA	I:21.01(1.73) C:19.71(2.01)	I:9 C:8	I: PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TYASSK, QSQ, SRS, SSRS, EQ
McVey	2016	USA	I:20.92(3.31) C:19.52(1.70)	I:24 C;23	I: PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 16 weeks C: waitlist	TYASSK, SRS, QSQ, EQ
Matthews	2018	USA	I:15.10(1.29) C:15.42(1.08)	I:10 C:12	I: PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TASSK, SRS, QSQ
Rabin	2018	Israel	I:14.03(1.83) C:13.95(1.72)	I:20 C:20	I: Hebrew version of PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 16 weeks C: waitlist	TASSK, EQ, QSQ
Shum	2018	Hong Kong	I:13.42(0.94) C:13.55(1.00)	I:33 C:33	I: Hong Kong Chinese version of PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TASSK, QPQ, SRS
Rabin	2020	Israel	I:14.35(1.81) C:14.45(1.72)	I:36 C:35	I: Hebrew version of PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 16 weeks C: waitlist	TASSK, EQ, SRS-2
Yamada	2020	Japan	I:13.00(1.26) C:13.17(1.04)	I:14 C:14	I: Japanese version of PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TASSK, QPQ, SRS-2
Chien	2021	Chinese Taiwan	I:25.30(4.50) C:27.60(6.00)	I:36 C:36	I: Taiwan Chinese version of PEERS intervention C: conventional therapy	I: 1 course per week, 90 minutes each time, for 16 weeks C: Face-to-face discussion was performed every 1-4 weeks, 10-30 min each time.	SRS, EQ

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Arias	2022	USA	I:13.32(1.39) C:13.42(1.65)	I:56 C:53	I: PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TASSK, SRS-2, QSQ
Idris	2022	Netherlands	I:14.65(1.51) C:14.48(1.62)	I:42 C:35	I: Dutch version of PEERS intervention C: ROAD intervention	I: 1 course per week, 90 minutes each time, for 14 weeks C: 1 course per week, 90 minutes each time, for 14 weeks	SRS-2
Płatos	2023	Poland	I:14.60(1.00) C:14.30(1.20)	I:12 C:17	I: Polish version of PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 16 weeks C: waitlist	TASSK-R, SRS-2, QSQ
Fatta	2024	Italy	I:15.14(2.26) C:15.50(1.74)	I:18 C:19	I: Italian version of PEERS intervention through telemedicine C: waitlist	I: 1 course per week, 90 minutes each time, for 14 weeks C: waitlist	TASSK, SRS
Hsiao	2024	Chinese Taiwan	I:13.70(1.52) C:14.50(1.70)	I:10 C:11	I: Taiwan Chinese version of PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 16 weeks C: waitlist	TASSK, SRS, QSQ
Płatos	2024	Poland	I:22.60(2.90) C:24.04(5.00)	I:6 C:9	I: Polish version of PEERS intervention C: waitlist	I: 1 course per week, 90 minutes each time, for 16 weeks C: waitlist	TYASSK, QSQ ,EQ, SRS-2
Saima	2024	Pakistan	not reported	I:60 C:41	I: Modified version of PEERS intervention C: not described	I: 1 course per week, 90 minutes each time, for 14 weeks C: not reported	QSQ

Abbreviations: I : Interventional Group, C : Control Group, TASSK/TASSK-R/TYASSK : Test of Adolescent Social Skills Knowledge/Test of Adolescent Social Skills Knowledge-Revised/Test of Young Adult Social Skills Knowledge, SRS/SRS-2 : Social Responsiveness Scale/Social Responsiveness Scale-2, SSRS : Social Skills Rating System, QSQ : Quality of Socialization Questionnaire, QPQ : Quality of Play Questionnaire, EQ : Empathy Quotient.

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Table 2 Basic characteristics of the included NRCTs

Author	Year	Country	Age	Sample	Intervention Method	Intervention frequency	Outcome
Marchica	2016	Canada	14.59(1.31)	11	PEERS (Revision)	1 course per week, 90 minutes each time, for 7 weeks	QPQ
Hill	2017	USA	13.40(0.89)	5	PEERS	1 course per week, 90 minutes each time, for 14 weeks	TASSK, QSQ, SRS-2
Hong	2018	South Korea	14.50(0.50)	38	PEERS (Korean version)	1 course per week, 90 minutes each time, for 14 weeks	TASSK-R, SRS
Wyman	2019	USA	18.70(NA)	63	PEERS (School version)	2 course per week, 45 minutes each time, for 14 weeks	TASSK, QSQ, SRS
Adler	2022	USA	14.00(1.50)	22	PEERS (Telehealth)	1 course per week, 90 minutes each time, for 16 weeks	TASSK SRS, QSQ
Estabillo	2022	USA	14.02(2.00)	31	PEERS (Telehealth)	1 course per week, 90 minutes each time, for 16 weeks	TASSK, QSQ, SRS-2
Veytsman	2022	USA	14.17(2.09)	13	PEERS	1 course per week, 90 minutes each time, for 16 weeks	TASSK-R, SRS-2, QSQ
Lee	2023	USA	14.83(1.47)	14	PEERS (Telehealth)	1 course per week, 90 minutes each time, for 16 weeks	TASSK, SRS-2
Helder	2024	USA	17.20(1.80)	41	PEERS	1 course per week, 90 minutes each time, for 16 weeks	TASSK, QSQ, SRS-2, EQ
Lao	2024	China	13.57(1.43)	23	PEERS (Chinese version)	1 course per week, 90 minutes each time, for 14 weeks	TASSK, SRS

Abbreviations: TASSK/TASSK-R : Test of Adolescent Social Skills Knowledge/Test of Adolescent Social Skills Knowledge-Revised, SRS/SRS-2 : Social Responsiveness Scale/Social Responsiveness Scale-2, SSRS : Social Skills Rating System, QSQ : Quality of SocializationQuestionnaire, QPQ : Quality of Play Questionnaire, EQ : Empathy Quotient.

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3.Risk of Bias Results

The risk of bias of the 21 included RCTs was evaluated using the ROB 2.0 assessment tool. The overall quality was relatively good, and most of the overall risks were low risk. Some studies used teacher-reported outcome indicators, and the participants' teachers were probably unaware of the participants' grouping and specific interventions. However, the outcome indicators in most studies were self-reported by the participants or reported by the parents. It is likely that the participants and parents knew which intervention the participants received during the experiment , which may affect the objectivity of the outcome measurement results. Therefore, most of the outcome measurement bias was Some concerns. For specific evaluation results, see Fig. 2. The 10 included NRCTs were evaluated using the ROBINS-I assessment tool and were found to be of average overall quality. Many of the NRCTs reported that the ASD adolescents or adults who received the experiment may have had anxiety disorders, depression, attention deficit hyperactivity disorder, and other conditions, rather than just ASD. Although it is well known that ASD is prone to co-occurring other psychiatric disorders(Hollocks et al., 2019), it is difficult to recruit participants without other psychiatric disorders, but this situation still produces some confounding bias. See Fig. 3 for specific evaluation results.

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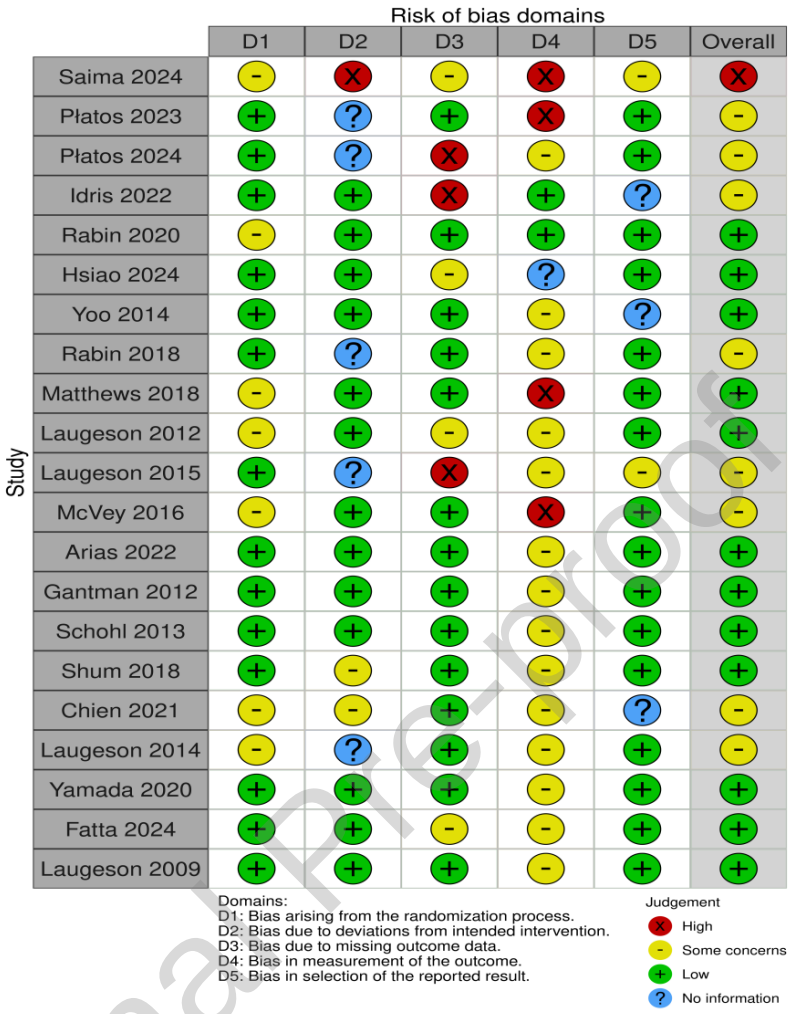

Fig. 2 Risk bias evaluation results of RCTs

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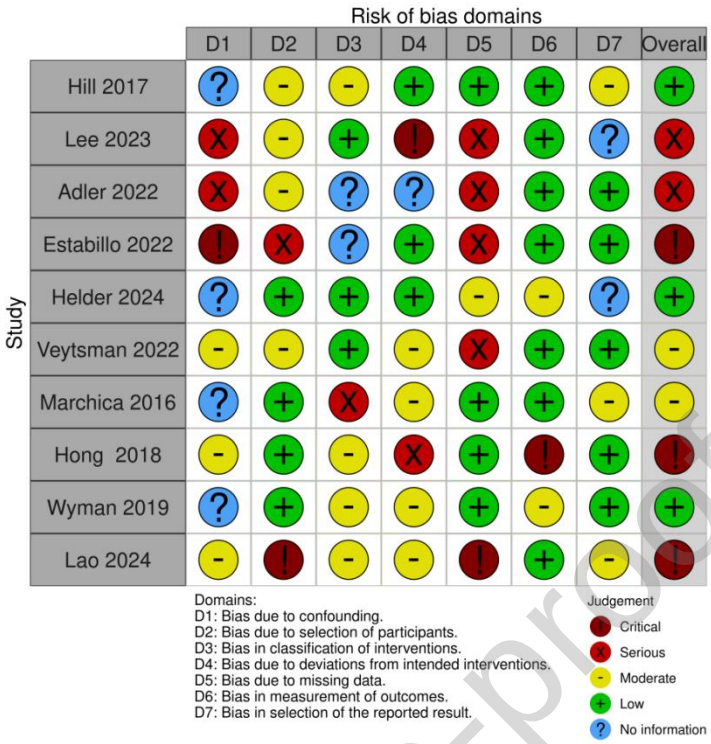

Fig. 3 Risk bias evaluation results of NRCTs

4. Meta-analysis Results

4.1 Social Skills Knowledge

TASSK was the outcome measure most frequently used in the included RCTs. A total of 18 RCTs used TASSK or other versions of TASSK as the outcome measure to observe the improvement in social skills knowledge. Through a meta-analysis of TASSK scores, we found that the PEERS intervention had a significant effect on improving the social skills knowledge of adolescents or young adults with ASD (SMD = 2.20, 95% CI [1.91, 2.49]), and the difference in scores between the intervention group and the control group was statistically significant ($P = 0.003 < 0.05$). There was moderate heterogeneity among the ES of TASSK in each study ($I^2 = 55.20\%$). See Fig. 4.

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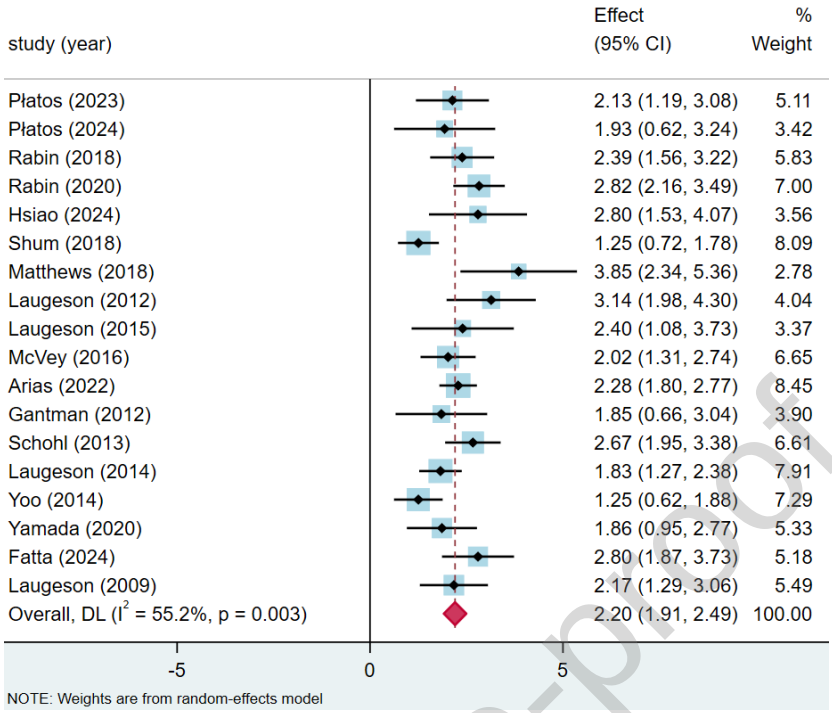

Fig. 4 Forest plot of TASSK

4.2 Application ability of social skills

4.2.1 SRS

A total of 16 RCTs used the SRS or SRS-2 as an outcome measure to evaluate the effect of the PEERS intervention in improving the social functioning of adolescents or young adults with ASD. Six of these RCTs measured both caregiver- and teacher-reported SRS scores, nine RCTs measured only caregiver-reported SRS scores, and one RCT measured only teacher-reported SRS scores. A meta-analysis of SRS scores found that caregiver-reported SRS improvements were more significant (SMD = -0.47, 95% CI [-0.64, 0.31]), and better than teacher-reported SRS (SMD = -0.09, 95% CI [-0.27, 0.10]), and the difference in ES between the two types of reports was statistically significant (P = 0.002 < 0.05). In addition, we found that there was little overall heterogeneity among studies in caregiver-reported SRS scores (I2 = 0, P = 0.468), while there was moderate heterogeneity in teacher-reported SRS scores (I^2 = 40.9%, P = 0.119). See Fig. 5.

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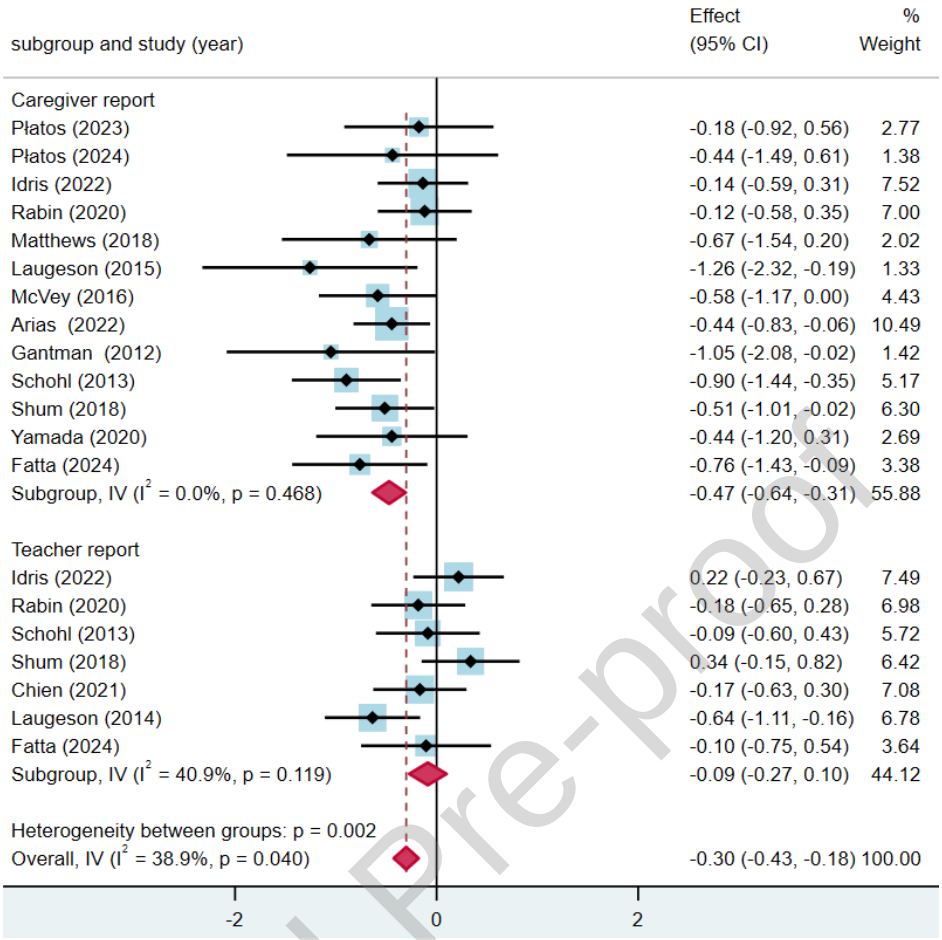

Fig. 5 Forest plot of SRS

4.2.2 SSRS

Four RCTs used the SSRS to measure the effect of the PEERS intervention on improving the social skills of adolescents or young adults with ASD in family, school, and peer interactions. Three of these RCTs reported SSRS subtest scores. We found that the intervention group had a certain improvement in the overall SSRS score compared to the control group (SMD = 0.97, 95% CI [0.68, 1.27]). In addition, the ES of the cooperative skills in each subtest was the largest (SMD = 1.11, 95% CI [0.57, 1.66]), and the ES of the self-control skills was the smallest (SMD = 0.70, 95% CI [0, 1.41]). The differences in ES among the four subtests were not statistically significant (P = 0.774>0.05). See Fig. 6.

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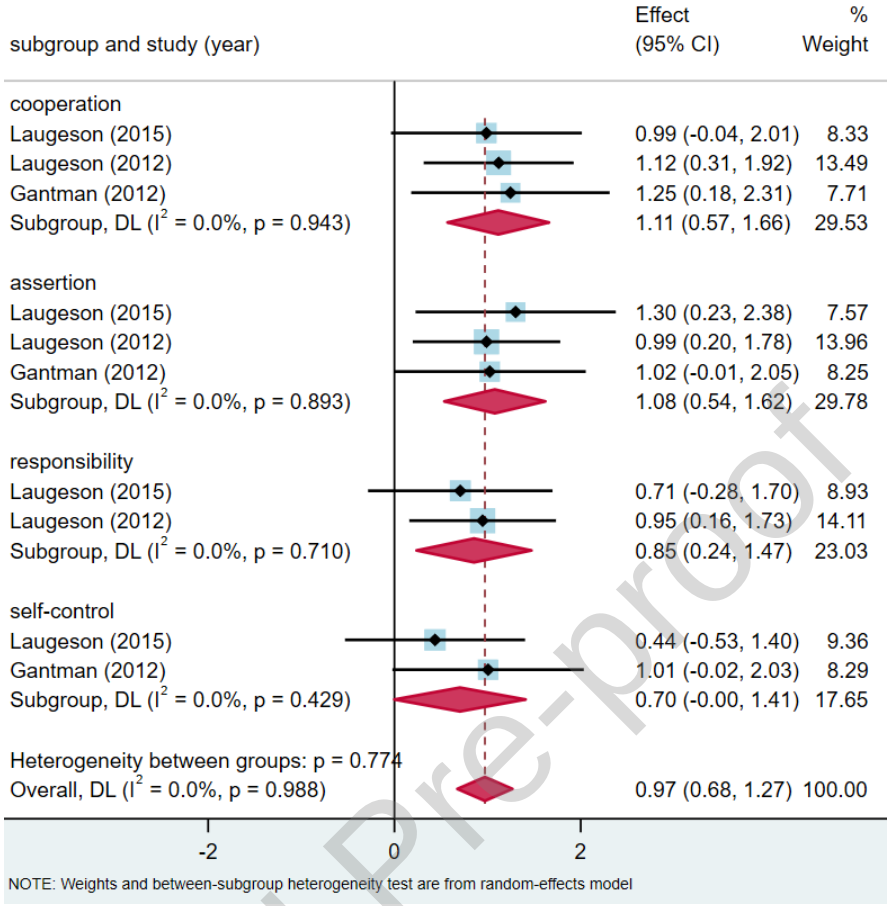

Fig. 6 Forest plot of SSRS

4.2.3 QSQ

A total of five RCTs measured the effect of the PEERS intervention on improving the quality of social interactions of adolescents or young adults with ASD by measuring the scores of the intervention and control groups in the two QSQ subtests of get-togethers and conflict. We found that the intervention group had higher scores than the control group in get-togethers (SMD = 0.96, 95%CI [0.39, 1.54]) and conflict (SMD = -1.75, 95% CI [-2.57, -0.93]). For the get-togethers, the self-reported ES (SMD = 0.70, 95% CI [−0.01, 1.42]) was smaller than the carer-reported ES (SMD = 1.33, 95% CI [0.29, 2.37]), but the difference between the two was not statistically significant (P = 0.33 > 0.05). In addition, we also found that the absolute value of the self-reported ES in the conflict (SMD = -1.64, 95% CI [-3.85, 0.56]) was also slightly smaller than the absolute value of the ES reported by the caregiver (SMD = -1.81, 95% CI [-2.45, -1.17]) was also slightly smaller, and the difference between the two was not statistically significant (P = 0.886>0.05). See Figs. 7 and 8.

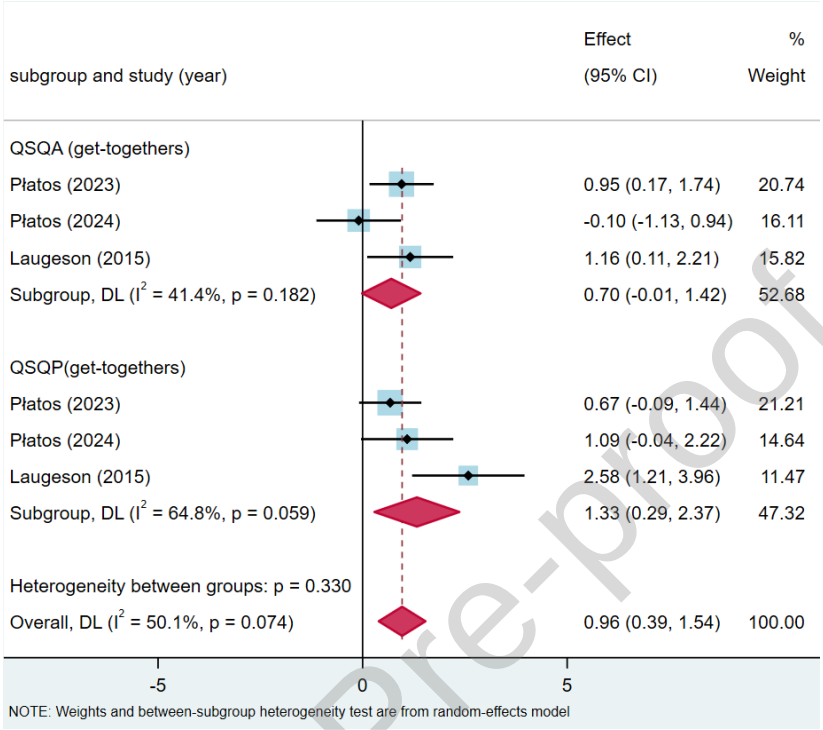

Fig. 7 Forest plot of QSQ (get-togethers)

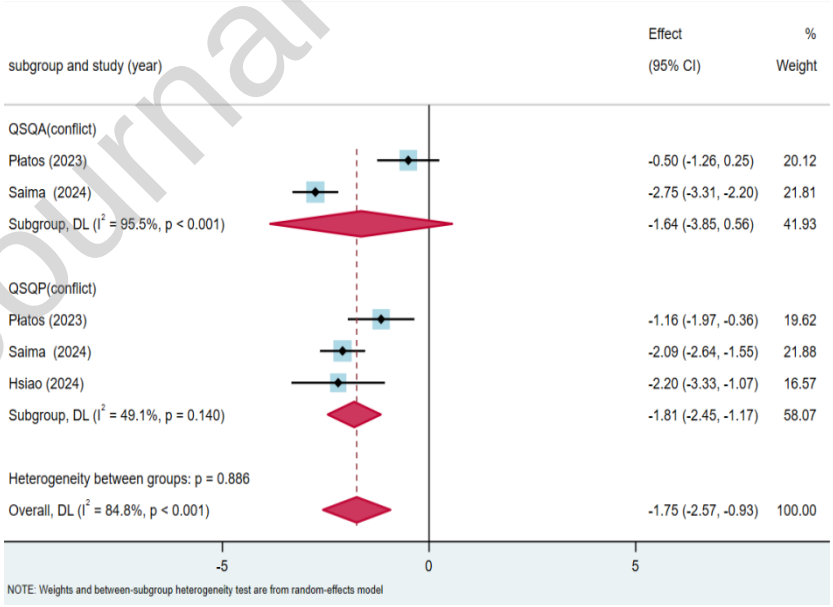

Fig. 8 Forest plot of QSQ (conflict)

4.2.4 QPQ

Four RCTs measured the effect of the PEERS intervention on improving the quality of social interactions using an outcome measure that assessed the scores of

initiative behavior (host) of ASD adolescents or young adults in get-togethers with others in the intervention and control groups. We found that the intervention group had a higher QPQ (host) score after the PEERS intervention than the control group (SMD = 0.69, 95% CI [0.46, 0.91]), and the difference between the ES reported by caregivers (SMD = 0.61, 95% CI [0.28, 0.94]) and self-reported ES (SMD = 0.75, 95% CI [0.45, 1.06]) were not statistically significant (P = 0.542 > 0.05). See Fig. 9.

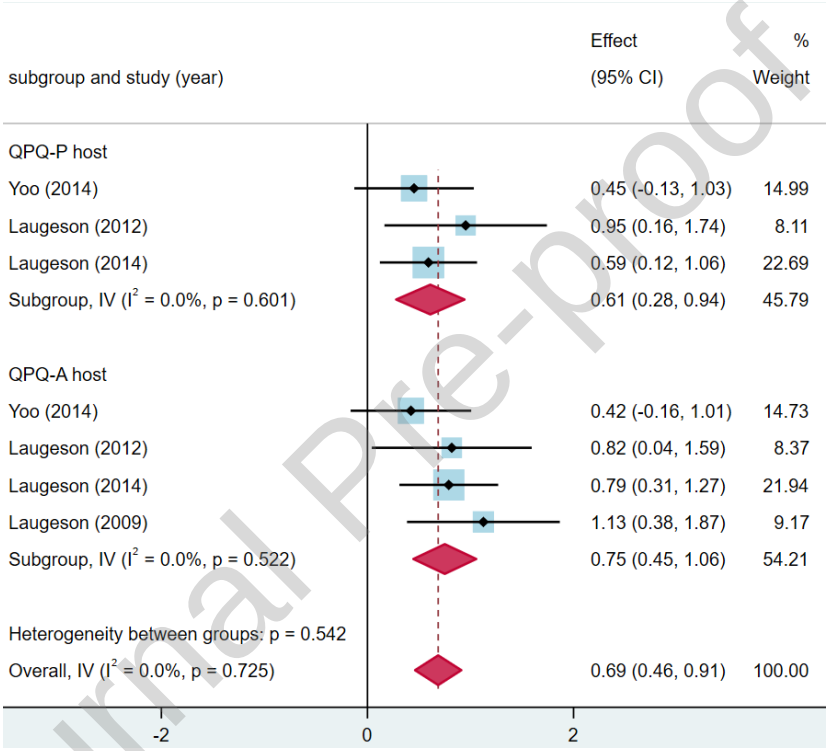

Fig. 9 Forest plot of QPQ

4.3 Empathy ability

A total of seven RCTs used EQ as an outcome measure to evaluate the effect of the PEERS intervention on improving the empathy of adolescents or young adults with ASD. We found that the intervention group's empathy after the PEERS intervention was better than that of the control group (SMD = 0.53, 95% CI [0.29, 0.77]), and there was little heterogeneity among the RCTs (I2 = 0, P = 0.776> 0.05). See Fig. 10.

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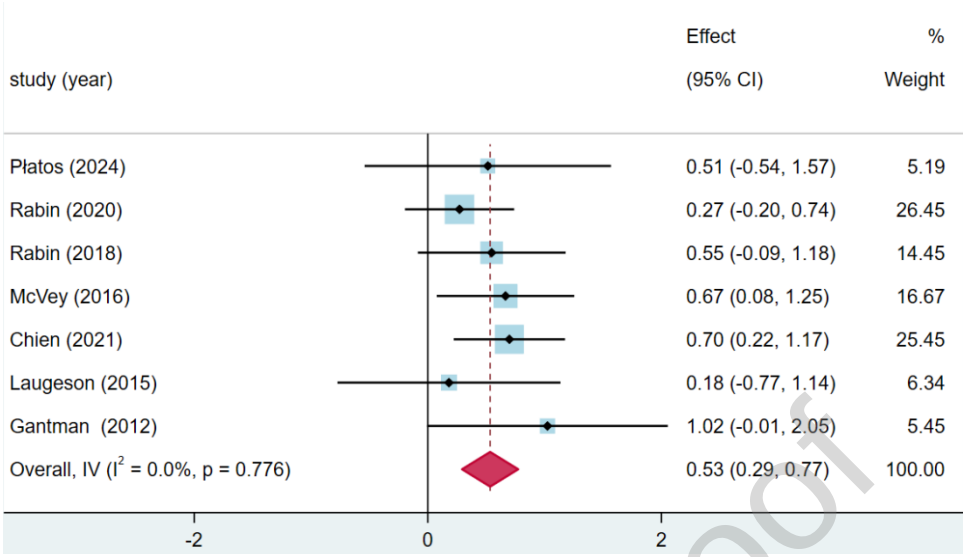

Fig. 10 Forest plot of EQ

5. Systematic review of NRCTs

We found that the TASSK and SRS outcome indicators were reported most frequently and had the most complete data in the 10 NRCTs, so we extracted the TASSK and SRS data for systematic evaluation. In Hong et al.'s study, the subjects were divided into young adolescents, middle-aged adolescents, and older adolescents. Because the number of middle-aged adolescents accounted for the largest proportion of the total number of subjects (39.58%), we chose to extract and systematically evaluate the data for the middle-aged adolescent group in this study, so we chose to extract and systematically evaluate the data of the middle-aged adolescent group in this study. TASSK was used to evaluate the improvement in social skills knowledge in adolescents with ASD, and SRS was used to evaluate the actual performance of social skills in adolescents with ASD.

5.1 Social Skills Knowledge

Nine NRCTs reported TASSK scores. We found that the ES of TASSK in the study by Veytsman et al. was the largest (SMD = 3.26), and the ES of TASSK in the study by Lee et al. was the smallest (SMD = 1.21). It was calculated that there was a large difference in the ESs of TASSK among the NRCTs ($I^2 = 65.5\%, \chi^2 = 23.21, P = 0.003$). See Table 3.

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5.2

Table 3 The ES of NRCTs on TASSK

Study	SMD(Hedge's)	SD
Adler (2022)	2.01	2.42
Estabillo (2022)	3.05	2.93
Helder (2024)	2.40	2.61
Hill (2017)	1.75	2.17
Hong (2018)	1.70	2.31
Lao (2024)	1.66	2.50
Lee (2023)	1.21	2.10
Veytsman (2022)	3.26	3.04
Wyman (2019)	1.41	2.20

Application ability of social skills

Eight NRCTs reported SRS scores. We found that the absolute value of the ES in the study by Hill et al. was the largest (SMD = -1.01), and the ES in the study by Hong et al. was the smallest (SMD = -0.28). The difference in the ESs of the SRS in each NRCT was calculated to be very small ($I^2 = 0\%$, $\chi^2 = 4.55$, $P = 0.715$). See Table 4.

Table 4 The ES of NRCTs on SRS

Study	SMD(Hedge's)	SD
Adler (2022)	-0.65	2.00
Estabillo (2022)	-0.81	2.04
Helder (2024)	-0.74	2.04
Hill (2017)	-1.01	1.39
Hong (2018)	-0.28	1.21
Lao (2024)	-0.32	1.26
Lee (2023)	-0.45	1.16
Veytsman (2022)	-0.42	1.03

5. Subgroup Analysis Results

This study used the TASSK, which was reported most frequently, as the outcome indicator, and conducted subgroup analyses according to the different environments and regions in which the PEERS intervention was implemented. We found that the ES of PEERS implemented in a school environment (SMD = 2.38, 95% CI [2.03, 2.74]) was slightly greater than the ES of PEERS implemented in a clinic or institution environment (SMD = 2.15, 95% CI [1.76, 2.54]), but the difference between the two was not statistically significant ($P = 0.379 > 0.05$). See Fig. 11. The results of the subgroup analysis of the regions showed that the Hebrew version of PEERS, which represented the Western Asia region, had the largest ES (SMD = 2.65, 95% CI [2.13,

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3.17]), while the Chinese, Japanese and South Korean versions of PEERS represented by the Chinese, Japanese, and Korean versions of PEERS had the smallest ES (SMD = 1.59, 95% CI [1.05, 2.14]), and the differences in ESs between the four regions on the TASSK were statistically significant ($P = 0.043 < 0.05$). See Fig. 12.

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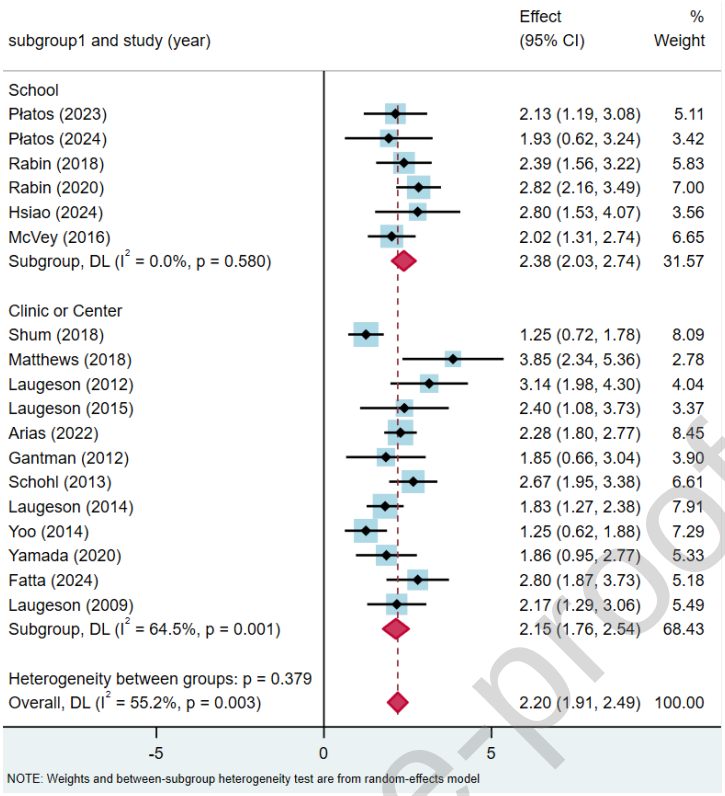

Fig. 11 Forest plot for subgroup analysis of different environments

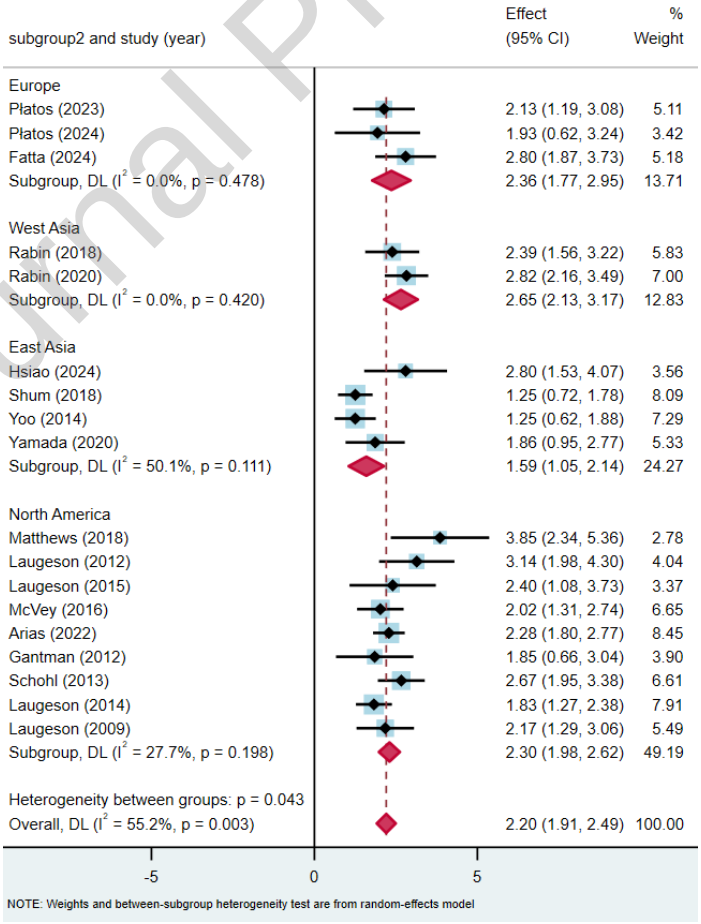

Fig. 12 Forest plot for subgroup analysis of different regions

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7. Sensitivity Analysis Results

Since the results of the meta-analysis showed moderate heterogeneity in the ESs of the RCTs when TASSK was used as the outcome index, it was necessary to conduct a sensitivity analysis to test the stability of the results when TASSK was used as the outcome index. We eliminated each study one by one using the sequential elimination method and found that the new ES generated after eliminating any study was within the confidence interval of the original ES (95% CI [1.91, 2.49]), and the new ES did not change significantly compared to the original ES. This proves that the results of the meta-analysis are relatively stable and the overall ES will not be significantly affected by the ES from a single study. See Fig. 13.

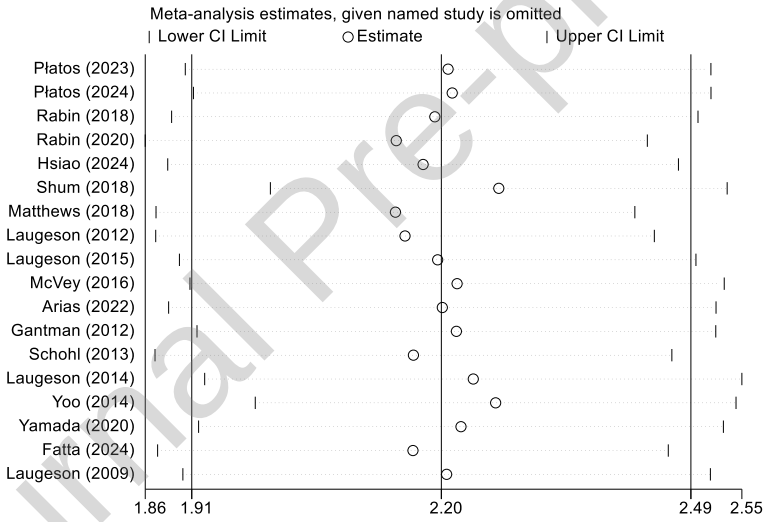

Fig. 13 The ES changes of TASSK after using sequential elimination method

8. Publication Bias Analysis Results

Egger's test found no serious publication bias in the RCTs for TASSK (t = 2.09, P = 0.053>0.05), SRS (t = -2.00, P = 0.071>0.05) and EQ (t = 0.45, P = 0.67>0.05). See Appendix 2. We found that the ES and standard error (SE) of Matthews et al. were the largest, and the ES of Shum et al. and Yoo et al. were the smallest, among the RCTs that reported TASSK. The ES of these three RCTs significantly exceeded the expected range of the overall ES, which may indicate a certain degree of publication bias. See Fig. 14. No RCTs with possible publication bias were found in the funnel plots of SRS and EQ. See Appendix 3.

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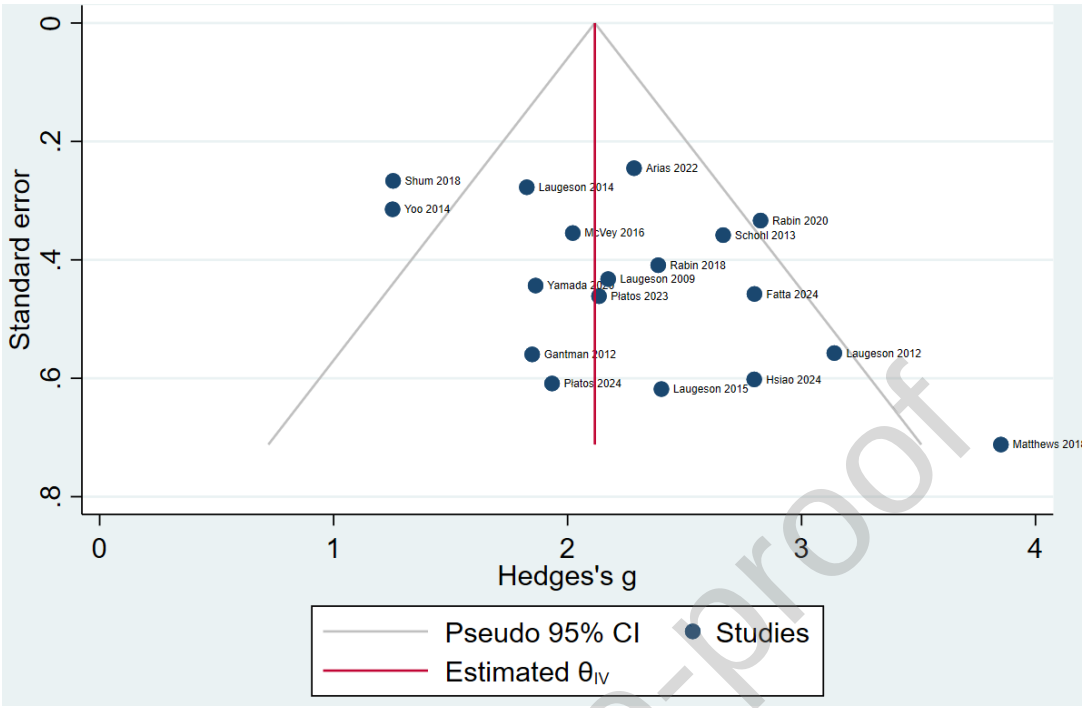

Fig. 14 Funnel plot of TASSK

Discussion

This study is the largest systematic review and meta-analysis to date of the effect of PEERS on the social skills of adolescents and young adults with ASD, with the most comprehensive analysis to date. We analyzed the effectiveness of the PEERS intervention method in improving the social problems of the subjects on the six outcome indicators of TASSK, SRS, SSRS, QSQ, QPQ, and EQ. These six outcome indicators covered the three areas related to social skills levels: social knowledge, application of social skills, and emotional intelligence. In addition, we also conducted subgroup analyses based on different implementation environments and regions to explore the impact of environmental and regional culture on the effect of the PEERS intervention.

The large ES shown on TASSK indicated that PEERS significantly improved the subjects' knowledge of social skills. The improvement in social skills knowledge is due to the comprehensive and systematic theoretical teaching content in PEERS, which covers a wide range of social skills knowledge such as conversation skills, the use of humorous language, and the organization of get-togethers. For example, in the teaching of conversation skills, the key points of each step, from starting a conversation to maintaining it and ending it, are explained in detail, providing participants with a

comprehensive framework of social skills knowledge and enabling them to systematically learn and understand social rules and strategies, thereby effectively improving their mastery of social skills knowledge. In addition, PEERS also uses a combination of various teaching methods, such as role-playing, which can visually demonstrate correct social behaviors and responses, help to visualize abstract knowledge content, and promote the mastery of social skills knowledge.(Henning et al., 2023)。However, further research into the relationship between social skills knowledge and the social interaction and communication impairments associated with ASD has shown that in some areas, people with ASD have similar levels of social knowledge to the general population. Although there are individual differences, there is no consistent and systematic deficit in social knowledge. The relationship between higher social knowledge scores and improved social skills may not be strong.(Gates et al., 2023)， Therefore there is also a need to analyze the application of social skills and other outcome indicators that are closely related to the level of social skills.

The outcome indicators analyzed in this study to assess the application of social skills included SRS, SSRS, QSQ, and QPQ. In the results of the SRS analysis we found that PEERS was effective in improving the social skills of the participants, but there was a significant difference between the caregiver-reported and teacher-reported results, with the teacher-reported results showing a poorer effect of the intervention. First reason for this may be that the teachers manage a large number of students in the classroom, and maybe do not have enough knowledge about ASD, and thus may not be sensitive to problems or changes that occur in the social skills of a particular student with ASD(Liu et al., 2016), and teachers spend time with their students in a single social scenario (mostly instructional environments), which does not allow for a comprehensive assessment of the student's demonstrated engagement in different social scenarios (e.g., get-togethers, field trips) demonstrated participation, cooperation, and ability to cope with unexpected social problems. Another reason is that because the caregivers may be aware of the participants' subgroups, the caregivers may unconsciously give more optimistic scores when reporting the outcome indicators because of the expectation of seeing positive change in participants after the intervention, in addition to the fact that caregivers may pay more attention to the

positive aspects while ignoring or downplaying any problems that still remain with the participants in their daily observations of the participants' behavior, which may result in caregivers report scores to be significantly higher than teachers report scores. The objectivity and accuracy of the assessment can be effectively improved by introducing independent observers to conduct behavioral assessment of the participants, for example, by adopting standardized behavioral coding methods, in which specific behaviors (e.g., number of initiated conversations, frequency of eye contact) are recorded by independent observers using a standardized tool (e.g., Autism Diagnostic Observation Scale, ADOS) in a natural social scenario (e.g., group activities, free communication), and in addition an ecological momentary assessment (EMA) approach can also be used to reduce recall bias by making full use of artificial intelligence technology to record participants' behaviors in daily social interaction in real time via mobile devices(Rofey et al., 2010; Wankhede et al., 2024). In the SSRS analysis, we found that participants improved better than the control group in the three subtests of cooperation, assertion, and responsibility after the PEERS intervention, but less in the subtest of self-control, which may be due to the fact that the main core goal of PEERS is to improve social interaction skills and social knowledge, with less direct training and targeted intervention on self-control. In addition, self-control is affected by a variety of factors, including level of interpretation, psychological distance, cognitive processes, and individual differences(Fujita et al., 2006), and PEERS interventions are difficult to fundamentally mitigate the effects of these deep-rooted factors, thus limiting the effects of improvements in self-control. The results of QSQ and QPQ reflect the participants' improvement in get-togethers and conflicts, and the results show that PEERS can better improve the participants' social skills in attending parties and their ability to resolve conflicts, disagreements, or clashes that arise in social interactions, in addition to improving their social skills in taking the initiative to invite other people to attend the party as the initiator of the party. Successfully organizing get-togethers will give ASD patients a new understanding and affirmation of their own abilities, thus enhancing their sense of self-worth and self-confidence, and this positive self-perception will help them to participate more actively in social activities in the future,

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forming a virtuous cycle that will further promote the development of their social interaction skills and mental health.(Camus et al., 2024)。

The phenomenon of empathy, which is mainly manifested in situational evaluation, interpersonal relationships between empathizers and others, or perspectives adopted in observing others, has a close relationship with the improvement of social skills(Singer & Lamm, 2009), and the present study indirectly evaluates the effect of PEERS in improving social skills of participants by analyzing the improvement of subjects on EQ. We found that participants improved more significantly on their EQ scores, and that the improvement in emotional intelligence helps ASD participants establish and maintain good interpersonal relationships, enabling them to behave more appropriately and friendly in social situations by understanding and responding to the emotions of others, and increasing the acceptance and goodwill of others towards them(Ciarrochi et al., 2017), thus facilitating the development of friendships and social integration, and improve their overall quality of life and social functioning.

The results of the subgroup analyses for the different environments in which PEERS was delivered indicated that interventions delivered in a clinic or institutional environment were slightly less effective than those delivered in a school environment. Although the difference was not statistically significant, this result still suggests that we should try to conduct PEERS interventions in environments closer to the real society(Kenworthy et al., 2008), in addition, caregivers, teachers and peer friends should be encouraged to participate directly or indirectly in PEERS intervention programs for people with ASD together, enriching the variety of roles and situational characteristics that may lead to better intervention effects(Pickles et al., 2016; Schleien et al., 1995). The results of subgroup analyses according to the different regions in which PEERS was conducted showed that PEERS conducted in East Asia had the least significant improvement effect on participants, which may be due to the fact that East Asian culture is distinct from other regions such as Europe and the United States. It has been shown that polymorphisms in the DRD4 gene are associated with social-cultural differences in populations from these two regions. The VNTR polymorphism in the DRD4 gene involves a duplication of a segment of the amino acid sequence in exon 3 of the gene, where the 2- or 7-repeat allele (2R/7R) of the DRD4 gene has been

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associated with a higher level of dopaminergic signaling capacity in the brain. Individuals who carry these alleles are are more sensitive to rewards and external reinforcement, which makes them more susceptible to reinforcement of culturally normative behaviors. Because individuals of European American descent carry higher dopamine signaling alleles that predispose them to independence, Asians born and raised in East Asian countries carrying the same alleles tend to be more interdependent(Javanbakht et al., 2018). While European and American cultures relatively emphasize individualism and independence, and may focus more on direct expression and self-promotion in social interactions, East Asian cultures are more deeply influenced by collectivism, and place more emphasis on harmony in interpersonal relationships, linguistic subtlety of expression, and tend to be concerned about disrupting the collective order or causing annoyance to others in their interactions, which leads to more cautious and introverted social behaviors(Park & Chesla, 2007). Differences between East Asian and European American cultures in the way they deal with emotions may also have an impact on the effectiveness of PEERS interventions. East Asian cultures tend to suppress emotions and express them less, while Western cultures emphasize more on the expression of emotions, and the euphemistic and indirect mode of communication in East Asian cultures may conflict with some of the contents of PEERS in this cultural context. Some of the social skills taught in the PEERS program that are based on American culture, such as overly direct conversation starters or assertive self-expression skills, may not be applicable in East Asian cultures(Falon et al., 2024). In addition the differences in the educational system and social environment in East Asia may also contribute to the lack of effectiveness of PEERS. The educational system in East Asia focuses more on academic performance to some extent, and students face greater academic pressure and relatively fewer opportunities for social practice (Barry et al., 2009; Yang et al., 2024), this may lead to a lack of sufficient practice scenarios for East Asian adolescents to consolidate learned social skills when PEERS is implemented, thus affecting the final effects. When PEERS is introduced and translated in East Asian countries, it can be made more suitable for East Asians by appropriately increasing the number of cases that fit into common East

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Asian social situations (e.g., family gatherings, class cooperation) and decreasing the number of scenarios that are specific to Western cultures (e.g., having a party).

We noticed that after more than a decade of development, PEERS has not only been translated into multiple languages and used in many countries and regions, but also generated a new form of online intervention (Telehealth), and a large number of studies have shown that online PEERS interventions are also effective(Adler et al., 2022; Estabillo et al., 2022; Lee et al., 2023), and the use of online interventions can greatly enhance the flexibility of PEERS interventions, reduce caregiver stress, and to some extent address regional differences in levels of treatment that result in delays in treatment(Hermaszewska & Sin, 2021). The improvement of social skills in ASD by PEERS is also reflected on a neurophysiological level, with studies showing that ASD patients who received PEERS interventions had more positive changes in left occipital-left temporal lobe (OL-TL) and right frontal-right parietal lobe (FR-PR) electroencephalographic coherence, which were associated with an increase in the number of get-togethers for people with ASD, implying that changes in connectivity in these regions have a positive impact on the frequency of social interactions (Haendel et al., 2021). Another related study found that in terms of EEG asymmetry, ASD patients who were treated with PEERS intervention shifted from right hemisphere dominance before the intervention to left hemisphere dominance after the intervention in the gamma band(Van Hecke et al., 2013), which verified that the improvement effect of PEERS intervention on social functioning of ASD patients may be achieved by modulating the neural activity of the brain, and provided a basis for the effect of the intervention to This provides a neurophysiological basis for the effect of the intervention, and also provides clues for further understanding of the relationship between the neural mechanisms and behavior of ASD. In the future, we can try to use functional magnetic resonance imaging (fMRI) to explore the effects of PEERS intervention on the default mode network (DMN) and mirror neuron system (MNS), or take the approach of brain network dynamics analysis to analyze the global efficiency and modularity changes of the functional brain networks in subjects before and after the PEERS intervention, so as to deeply reveal the neurophysiology of the improvement of social skills by PEERS.

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The present study also has some limitations; first, subgroup analyses based on specific language versions could not be conducted due to the paucity of RCTs on other language versions of PEERS interventions. While subgroup analyses by region can to some extent explore the influence of regional culture on the effects of PEERS interventions, it is not possible to examine in greater depth the possible effects of differences in national policies and national cultures. In addition, RCTs of PEERS intervention were limited by the method of assessing outcome indicators, and RCTs of PEERS intervention were not fully feasible so that subgroup information was not known to the data measurers, and thus may created a risk of bias in the measurement of outcome indicators.

Conclusion

In summary, PEERS showed relatively substantial improvements in social skills knowledge, application of social skills, and emotional intelligence in adolescents or young adults with ASD, as well as positive effects on the physiological functioning of the brain in participants. The different language versions of PEERS showed better effects on participants' social skills and other aspects, although there were some differences in the intervention effects. The present study provided some suggestions for the future direction of improvement of PEERS intervention methods that may help to improve the intervention effect, and advocated that the relevant researchers should select more outcome indicators covering multiple assessment aspects in future related studies, including neurophysiological, participants' psychological, caregiver stress, family stress and social, quality of life and other relevant endpoints, in order to comprehensively analyze the effects of the PEERS intervention approach's potential value and significance to individuals, families, and society.

Reference

Adler, E. J., Schiltz, H. K., Glad, D. M., Lehman, S. A., Pardej, S. K., Stanley, R. E., & Van Hecke, A. V. (2022). Brief Report: A Pilot Study Examining the Effects of PEERS® for Adolescents

Telehealth for Autistic Adolescents. *Journal of Autism and Developmental Disorders*, *52*(12), 5491-5499. https://doi.org/10.1007/s10803-022-05666-0

Arias, A. A., Rea, M. M., Adler, E. J., Haendel, A. D., & Van Hecke, A. V. (2021). Utilizing the Child Behavior Checklist (CBCL) as an Autism Spectrum Disorder Preliminary Screener and Outcome Measure for the PEERS® Intervention for Autistic Adolescents. *Journal of Autism and Developmental Disorders*, *52*(5), 2061-2074. https://doi.org/10.1007/s10803-021-05103-8

Association, A. P. (2013). Diagnostic and Statistical Manual, DSM-5.

Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: an investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *J Autism Dev Disord*, *34*(2), 163-175. https://doi.org/10.1023/b:jadd.0000022607.19833.00

Barry, D. T., Bernard, M. J., & Beitel, M. (2009). East Asian child-rearing attitudes: an exploration of cultural, demographic and self-disclosure factors among US immigrants. *Int J Psychol*, *44*(5), 342-350. https://doi.org/10.1080/00207590802236258

Camus, L., Rajendran, G., & Stewart, M. E. (2024). Social self-efficacy and mental well-being in autistic adults: Exploring the role of social identity. *Autism*, *28*(5), 1258-1267. https://doi.org/10.1177/13623613231195799

Chien, Y.-L., Tsai, W.-C., Chen, W.-H., Yang, C.-L., Gau, S. S.-F., Soong, W.-T., Laugeson, E., & Chiu, Y.-N. (2021). Effectiveness, durability, and clinical correlates of the PEERS social skills intervention in young adults with autism spectrum disorder: the first evidence outside North America. *Psychological Medicine*, *53*(3), 966-976. https://doi.org/10.1017/s0033291721002385

Ciarrochi, J., Parker, P. D., Sahdra, B. K., Kashdan, T. B., Kiuru, N., & Conigrave, J. (2017). When Empathy Matters: The Role of Sex and Empathy in Close Friendships. *J Pers*, *85*(4), 494-504. https://doi.org/10.1111/jopy.12255

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences. routledge.*

Cola, M., Zampella, C. J., Yankowitz, L. D., Plate, S., Petrulla, V., Tena, K., Russell, A., Pandey, J., Schultz, R. T., & Parish-Morris, J. (2022). Conversational adaptation in children and teens with autism: Differences in talkativeness across contexts. *Autism Research*, *15*(6), 1090-1108. https://doi.org/10.1002/aur.2693

Constantino J. N., G. C. P. (2012). *The social responsiveness scale (2nd ed.)*. Western Psychological Services.

Constantino J.N., G. C. P. (2005). *Constantino J.N., Gruber C.P. Social Responsiveness Scale (SRS) Manual*. Los Angeles, CA, USA.

Egger, M., Davey Smith, G., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ*, *315*(7109), 629-634. https://doi.org/10.1136/bmj.315.7109.629

Estabillo, J. A., Moody, C. T., Poulhazan, S. J., Adery, L. H., Denluck, E. M., & Laugeson, E. A. (2022). Efficacy of PEERS® for Adolescents via Telehealth Delivery. *Journal of Autism and Developmental Disorders*, *52*(12), 5232-5242. https://doi.org/10.1007/s10803-022-05580-5

Falon, S. L., Jobson, L., & Liddell, B. J. (2024). Does culture moderate the encoding and recognition of negative cues? Evidence from an eye-tracking study. *PLoS One*, *19*(4), e0295301. https://doi.org/10.1371/journal.pone.0295301

Fatta, L. M., Laugeson, E. A., Bianchi, D., Laghi, F., & Scattoni, M. L. (2024). Program for the Education and Enrichment of Relational Skills (PEERS®) for Italy: A Randomized Controlled Trial of a Social Skills Intervention for Autistic Adolescents. *Journal of Autism and Developmental Disorders*. https://doi.org/10.1007/s10803-023-06211-3

Journal Pre-proof

Frankel, F., & Mintz, J. (2008). *Measuring the quality of play dates*. Available from UCLA Parenting and Children's Friendship Program.

Frankel, F., & Mintz, J. (2011). Maternal Reports of Play Dates of Clinic Referred and Community Children. *J Child Fam Stud*, *20*(5), 623-630. https://doi.org/10.1007/s10826-010-9437-9

Fujita, K., Trope, Y., Liberman, N., & Levin-Sagi, M. (2006). Construal levels and self-control. *J Pers Soc Psychol*, *90*(3), 351-367. https://doi.org/10.1037/0022-3514.90.3.351

Gantman, A., Kapp, S. K., Orenski, K., & Laugeson, E. A. (2012). Social Skills Training for Young Adults with High-Functioning Autism Spectrum Disorders: A Randomized Controlled Pilot Study. *Journal of Autism and Developmental Disorders*, *42*(6), 1094-1103. https://doi.org/10.1007/s10803-011-1350-6

Gates, J. A., McNair, M. L., Richards, J. K., & Lerner, M. D. (2023). Social Knowledge & Performance in Autism: A Critical Review & Recommendations. *Clin Child Fam Psychol Rev*, *26*(3), 665-689. https://doi.org/10.1007/s10567-023-00449-0

Gresham, F. M., & Elliott, S. (1990). *The social skills rating system. MN: American Guidance Service.*

Haendel, A. D., Barrington, A., Magnus, B., Arias, A. A., McVey, A., Pleiss, S., Carson, A., Vogt, E. M., & Van Hecke, A. V. (2021). Changes in Electroencephalogram Coherence in Adolescents With Autism Spectrum Disorder After a Social Skills Intervention. *Autism Research*, *14*(4), 787-803. https://doi.org/10.1002/aur.2459

Hedges, L. V., & Olkin, I. . (2014). *Statistical methods for meta-analysis. .*

Helder, E. J., Bailey, F. X., Warners, A. L., & Vallance, C. (2024). Long-Term Follow-Up of the Program for the Education and Enrichment of Relational Skills (PEERS) with Adolescent Adoptees. *Adoption Quarterly*, 1-20. https://doi.org/10.1080/10926755.2024.2304342

Henning, G., de Oliveira, R. R., de Andrade, M. T. P., Gallo, R. V., Benevides, R. R., Gomes, R. A. F., Fukue, L. E. K., Lima, A. V., de Oliveira, M., de Oliveira, D. A. M., Werpp, M., Moraes, L., & Neto, F. L. (2023). Social skills training with a tabletop role-playing game, before and during the pandemic of 2020: in-person and online group sessions. *Front Psychiatry*, *14*, 1276757. https://doi.org/10.3389/fpsyt.2023.1276757

Hermaszewska, S., & Sin, J. (2021). End-user perspectives on the development of an online intervention for parents of children on the autism spectrum. *Autism*, *25*(5), 1234-1245. https://doi.org/10.1177/1362361320984895

Higgins, J. P., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *BMJ*, *327*(7414), 557-560. https://doi.org/10.1136/bmj.327.7414.557

Hill, T. L., Gray, S. A. O., Baker, C. N., Boggs, K., Carey, E., Johnson, C., Kamps, J. L., & Varela, R. E. . (2017). A Pilot Study Examining the Effectiveness of the PEERS Program on Social Skills and Anxiety in Adolescents with Autism Spectrum Disorder. *Journal of developmental and physical disabilities*, *29*(5), 797-808. https://doi.org/https://doi.org/10.1007/s10882-017-9557-x

Hollocks, M. J., Lerh, J. W., Magiati, I., Meiser-Stedman, R., & Brugha, T. S. (2019). Anxiety and depression in adults with autism spectrum disorder: a systematic review and meta-analysis. *Psychol Med*, *49*(4), 559-572. https://doi.org/10.1017/s0033291718002283

Hong, J. K., Oh, M., Bong, G., Kim, J.-H., Bahn, G., Cho, I.-H., & Yoo, H. J. (2018). Age as a Moderator of Social Skills Intervention Response Among Korean Adolescents with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *49*(4), 1626-1637. https://doi.org/10.1007/s10803-018-3859-4

Journal Pre-proof

Hsiao, M. N., Chien, Y. L., Tai, Y. M., Chen, H. M., Shih, H. H., Chen, L. W., Chen, Y. Y., Soong, W. T., Chiu, Y. N., Tsai, W. C., Laugeson, E., Tseng, M. H., & Gau, S. S. F. (2024). A preliminary randomized controlled study of the PEERS® program for Taiwanese autistic adolescents: The effectiveness on reducing school bullying and enhancing social function. *Autism Research*, *17*(8), 1705-1720. https://doi.org/10.1002/aur.3213

Idris, S., van Pelt, B. J., Jagersma, G., Duvekot, J., Maras, A., van der Ende, J., van Haren, N., & Greaves-Lord, K. (2022). A randomized controlled trial to examine the effectiveness of the Dutch version of the Program for the Education and Enrichment of Relational Skills (PEERS®). *BMC Psychiatry*, *22*(1). https://doi.org/10.1186/s12888-022-03913-3

Javanbakht, A., Tompson, S., Kitayama, S., King, A., Yoon, C., & Liberzon, I. (2018). Gene by Culture Effects on Emotional Processing of Social Cues among East Asians and European Americans. *Behav Sci (Basel)*, *8*(7). https://doi.org/10.3390/bs8070062

Kenworthy, L., Yerys, B. E., Anthony, L. G., & Wallace, G. L. (2008). Understanding executive control in autism spectrum disorders in the lab and in the real world. *Neuropsychol Rev*, *18*(4), 320-338. https://doi.org/10.1007/s11065-008-9077-7

Kéri, S. (2023). Autism and Religion. *Children 10*(8). https://doi.org/10.3390/children10081417

Kim, J. H., Song, D. Y., Han, H. S., Yoon, N. H., Cho, H. B., Lee, H. B., Choi, K. H., Chae, P. K., Bong, G., Ahn, S., & Yoo, H. J. (2023). Improving adaptive behaviors for autistic adults without intellectual disability through executive function training. *Asian J Psychiatr*, *84*, 103579. https://doi.org/10.1016/j.ajp.2023.103579

Lai, M.-C. (2023). Mental health challenges faced by autistic people. *Nature Human Behaviour*, *7*(10), 1620-1637. https://doi.org/10.1038/s41562-023-01718-2

Lai, M. C., Lombardo, M. V., & Baron-Cohen, S. (2014). Autism. *Lancet*, *383*(9920), 896-910.

Lao, U., Li, Y., Bai, W., Wang, Y., Li, Y., Xie, Y., Huang, X., Zhu, H., & Zou, X. (2024). Adaptation and Feasibility of the Mandarin Version of PEERS® for Autistic Adolescents. *Journal of Autism and Developmental Disorders*, *54*(9), 3387-3399. https://doi.org/10.1007/s10803-023-06056-w

Laugeson, E. A., Ellingsen, R., Sanderson, J., Tucci, L., & Bates, S. (2014). The ABC's of Teaching Social Skills to Adolescents with Autism Spectrum Disorder in the Classroom: The UCLA PEERS ® Program. *Journal of Autism and Developmental Disorders*, *44*(9), 2244-2256. https://doi.org/10.1007/s10803-014-2108-8

Laugeson, E. A., Frankel, F., Gantman, A., Dillon, A. R., & Mogil, C. (2012). Evidence-Based Social Skills Training for Adolescents with Autism Spectrum Disorders: The UCLA PEERS Program. *Journal of Autism and Developmental Disorders*, *42*(6), 1025-1036. https://doi.org/10.1007/s10803-011-1339-1

Laugeson, E. A., Frankel, F., Laugeson, E. A., Zaragoza, N., Kincheloe, J., Steinberg, S. R., Gorski, P. C., Pothini, S. G., Arneson, S., & Platow, M. J. (2010). *Social Skills for Teenagers with Developmental and Autism Spectrum Disorders*. Social skills for teenagers with developmental and autism spectrum disorders : the PEERS treatment manual.

Laugeson, E. A., Frankel, F., Mogil, C., & Dillon, A. R. (2009). Parent-Assisted Social Skills Training to Improve Friendships in Teens with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, *39*(4), 596-606. https://doi.org/10.1007/s10803-008-0664-5

Laugeson, E. A., Gantman, A., Kapp, S. K., Orenski, K., & Ellingsen, R. (2015). A Randomized Controlled Trial to Improve Social Skills in Young Adults with Autism Spectrum Disorder: The

Journal Pre-proof

Journal Pre-proof

UCLA PEERS® Program. *Journal of Autism and Developmental Disorders*, *45*(12), 3978-3989. https://doi.org/10.1007/s10803-015-2504-8

Lee, C. M., Petricek, C., Haga, M., Smalley, S., Pelletier, K., Essa, N., & Hudock, R. L. (2023). Examining the feasibility and effectiveness of PEERS for adolescents via telehealth during the COVID-19 pandemic. *Research in Autism Spectrum Disorders*, *109*. https://doi.org/10.1016/j.rasd.2023.102279

Liu, Y., Li, J., Zheng, Q., Zaroff, C. M., Hall, B. J., Li, X., & Hao, Y. (2016). Knowledge, attitudes, and perceptions of autism spectrum disorder in a stratified sampling of preschool teachers in China. *BMC Psychiatry*, *16*, 142. https://doi.org/10.1186/s12888-016-0845-2

Marchica, L., & D'Amico, M. (2016). Examining the efficacy of an adapted version of the UCLA PEERS® program with Canadian adolescents. *Journal of Education & Social Policy*, *3*(4), 54-65.

Matthews, N. L., Orr, B. C., Warriner, K., DeCarlo, M., Sorensen, M., Laflin, J., & Smith, C. J. (2018). Exploring the Effectiveness of a Peer-Mediated Model of the PEERS Curriculum: A Pilot Randomized Control Trial. *Journal of Autism and Developmental Disorders*, *48*(7), 2458-2475. https://doi.org/10.1007/s10803-018-3504-2

McVey, A. J., Dolan, B. K., Willar, K. S., Pleiss, S., Karst, J. S., Casnar, C. L., Caiozzo, C., Vogt, E. M., Gordon, N. S., & Van Hecke, A. V. (2016). A Replication and Extension of the PEERS® for Young Adults Social Skills Intervention: Examining Effects on Social Skills and Social Anxiety in Young Adults with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *46*(12), 3739-3754. https://doi.org/10.1007/s10803-016-2911-5

Napat Sittanomai, E. L., Sasitorn Chantaratin, Jariya Tarugsa, Duangduean Sainampran, Vipavee Sathirangkul,, Suvimon Apinantanakul,, Nattawee Songrujira, Vitharon Boon-yasidhi. (2021). Social Skills Training Using the Thai Version of UCLA PEERS® in Thai Adolescents with Autism Spectrum Disorder. *Siriraj Medical Journal*, *73*(7), 471-477. https://doi.org/10.33192/Smj.2021.61

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S.,…Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Park, M., & Chesla, C. (2007). Revisiting Confucianism as a conceptual framework for Asian family study. *J Fam Nurs*, *13*(3), 293-311. https://doi.org/10.1177/1074840707304400

Pascoe, M. I., Forbes, K., de la Roche, L., Derby, B., Psaradellis, E., Anagnostou, E., Nicolson, R., Georgiades, S., & Kelley, E. (2023). Exploring the association between social skills struggles and social communication difficulties and depression in youth with autism spectrum disorder. *Autism Research*, *16*(11), 2160-2171. https://doi.org/10.1002/aur.3015

Pickles, A., Le Couteur, A., Leadbitter, K., Salomone, E., Cole-Fletcher, R., Tobin, H., Gammer, I., Lowry, J., Vamvakas, G., Byford, S., Aldred, C., Slonims, V., McConachie, H., Howlin, P., Parr, J. R., Charman, T., & Green, J. (2016). Parent-mediated social communication therapy for young children with autism (PACT): long-term follow-up of a randomised controlled trial. *Lancet*, *388*(10059), 2501-2509. https://doi.org/10.1016/s0140-6736(16)31229-6

Płatos, M., Wojaczek, K., & Laugeson, E. A. (2023). Effects of Social Skills Training for Adolescents on the Autism Spectrum: a Randomized Controlled Trial of the Polish Adaptation of the PEERS® Intervention via Hybrid and In-Person Delivery. *Journal of Autism and Developmental Disorders*, *53*(11), 4132-4146. https://doi.org/10.1007/s10803-022-05714-9

Płatos, M., Wojaczek, K., & Laugeson, E. A. (2024). Fostering Friendship and Dating Skills Among Adults on the Autism Spectrum: A Randomized Controlled Trial of the Polish Version of the PEERS® for Young Adults Curriculum. *Journal of Autism and Developmental Disorders*, *54*(6), 2224-2239. https://doi.org/10.1007/s10803-023-05921-y

Rabin, S. J., Israel-Yaacov, S., Laugeson, E. A., Mor-Snir, I., & Golan, O. (2018). A randomized controlled trial evaluating the Hebrew adaptation of the PEERS® intervention: Behavioral and questionnaire-based outcomes. *Autism Research*, *11*(8), 1187-1200. https://doi.org/10.1002/aur.1974

Rabin, S. J., Laugeson, E. A., Mor-Snir, I., & Golan, O. (2020). An Israeli RCT of PEERS®: Intervention Effectiveness and the Predictive Value of Parental Sensitivity. *Journal of Clinical Child & Adolescent Psychology*, *50*(6), 933-949. https://doi.org/10.1080/15374416.2020.1796681

Rofey, D. L., Hull, E. E., Phillips, J., Vogt, K., Silk, J. S., & Dahl, R. E. (2010). Utilizing Ecological Momentary Assessment in pediatric obesity to quantify behavior, emotion, and sleep. *Obesity (Silver Spring)*, *18*(6), 1270-1272. https://doi.org/10.1038/oby.2009.483

Saima Khan, F. A. E. L. (2024). Role of the Peers Program for Social Skills Training for Adolescents with Autism Spectrum Disorder. *Pakistan Journal of Criminology*, *16*(1), 231-246.

Schleien, S. J., Mustonen, T., & Rynders, J. E. (1995). Participation of children with autism and nondisabled peers in a cooperatively structured community art program. *J Autism Dev Disord*, *25*(4), 397-413. https://doi.org/10.1007/bf02179375

Schohl, K. A., Van Hecke, A. V., Carson, A. M., Dolan, B., Karst, J., & Stevens, S. (2013). A Replication and Extension of the PEERS Intervention: Examining Effects on Social Skills and Social Anxiety in Adolescents with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, *44*(3), 532-545. https://doi.org/10.1007/s10803-013-1900-1

Shultz, S., Klin, A., & Jones, W. (2018). Neonatal Transitions in Social Behavior and Their Implications for Autism. *Trends in Cognitive Sciences*, *22*(5), 452-469. https://doi.org/10.1016/j.tics.2018.02.012

Shum, K. K.-M., Cho, W. K., Lam, L. M. O., Laugeson, E. A., Wong, W. S., & Law, L. S. K. (2018). Learning How to Make Friends for Chinese Adolescents with Autism Spectrum Disorder: A Randomized Controlled Trial of the Hong Kong Chinese Version of the PEERS® Intervention. *Journal of Autism and Developmental Disorders*, *49*(2), 527-541. https://doi.org/10.1007/s10803-018-3728-1

Singer, T., & Lamm, C. (2009). The social neuroscience of empathy. *Ann N Y Acad Sci*, *1156*, 81-96. https://doi.org/10.1111/j.1749-6632.2009.04418.x

Situmorang, D. D. B. (2024). Discussion, implications, and recommendations of several alternative interventions to intervene suicidal ideation in youth with autism spectrum disorder. *Asian J Psychiatr*, *101*, 104196. https://doi.org/10.1016/j.ajp.2024.104196

Van Hecke, A. V., Stevens, S., Carson, A. M., Karst, J. S., Dolan, B., Schohl, K., McKindles, R. J., Remmel, R., & Brockman, S. (2013). Measuring the Plasticity of Social Approach: A Randomized Controlled Trial of the Effects of the PEERS Intervention on EEG Asymmetry in Adolescents with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, *45*(2), 316-335. https://doi.org/10.1007/s10803-013-1883-y

Veytsman, E., Baker, E., Martin, A. M., Choy, T., Blacher, J., & Stavropoulos, K. (2022). Perceived and Observed Treatment Gains Following PEERS: A Preliminary Study with Latinx Adolescents

Journal Pre-proof

with ASD. *Journal of Autism and Developmental Disorders*, *53*(3), 1175-1188. https://doi.org/10.1007/s10803-022-05463-9

Wankhede, N., Kale, M., Shukla, M., Nathiya, D., R, R., Kaur, P., Goyanka, B., Rahangdale, S., Taksande, B., Upaganlawar, A., Khalid, M., Chigurupati, S., Umekar, M., Kopalli, S. R., & Koppula, S. (2024). Leveraging AI for the diagnosis and treatment of autism spectrum disorder: Current trends and future prospects. *Asian J Psychiatr*, *101*, 104241. https://doi.org/10.1016/j.ajp.2024.104241

Wyman, J., & Claro, A. (2020). The UCLA PEERS School-Based Program: Treatment Outcomes for Improving Social Functioning in Adolescents and Young Adults with Autism Spectrum Disorder and Those with Cognitive Deficits. *J Autism Dev Disord*, *50*(6), 1907-1920. https://doi.org/10.1007/s10803-019-03943-z

Yamada, T., Miura, Y., Oi, M., Akatsuka, N., Tanaka, K., Tsukidate, N., Yamamoto, T., Okuno, H., Nakanishi, M., Taniike, M., Mohri, I., & Laugeson, E. A. (2019). Examining the Treatment Efficacy of PEERS in Japan: Improving Social Skills Among Adolescents with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *50*(3), 976-997. https://doi.org/10.1007/s10803-019-04325-1

Yang, B., Chen, B. B., Chen, X., Hu, Z., & Qu, Y. (2024). Family obligation in Chinese adolescents: Consequences and parental antecedents. *J Res Adolesc*, *34*(2), 395-409. https://doi.org/10.1111/jora.12923

Yoo, H. J., Bahn, G., Cho, I. H., Kim, E. K., Kim, J. H., Min, J. W., Lee, W. H., Seo, J. S., Jun, S. S., Bong, G., Cho, S., Shin, M. S., Kim, B. N., Kim, J. W., Park, S., & Laugeson, E. A. (2014). A Randomized Controlled Trial of the Korean Version of the PEERS® Parent-Assisted Social Skills Training Program for Teens With ASD. *Autism Research*, *7*(1), 145-161. https://doi.org/10.1002/aur.1354

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Declaration of Competing Interest

We (Yichao Cheng, Jiaxin Shi, Xingpeng Cheng, Yenan Wei, Jiacheng Wang, Zhimei Jiang) declare that in the process of researching, writing and publishing this paper, there were no conflicts of interest that could have affected the research results and objectivity of the paper, such as

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Highlights

- PEERS effectively improved the social knowledge and social skills application ability of adolescents or young adults with ASD.
- The PEERS intervention had the smallest effect in East Asia.
- There was no statistically significant difference in the effect of PEERS intervention in clinical and community environments.
- The PEERS intervention should be conducted in an environment that is closer to real society.

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