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Effectiveness, durability, and clinical correlates of the PEERS social skills intervention in young adults with autism spectrum disorder: the first evidence outside North America

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Abstract

Background. Despite the fact that social deficits among individuals with autism spectrum disorder (ASD) are lifelong and impact many aspects of personal functioning, evidence-based programs for social skills training were not available until recently. The Program for the Education and Enrichment of Relational Skills (PEERS®) has been shown to effectively improve social skills for adolescents on the spectrum across different social cultures. However, the effectiveness for young adults beyond North America has yet to be examined. This study aimed to investigate the effectiveness of the PEERS intervention in Taiwanese young adults with ASD, and examine its durability and clinical correlates.

Methods. We recruited 82 cognitively-able young adults with ASD, randomized to the PEERS treatment or treatment-as-usual.

Results. Following treatment, significant improvement was found in aspects of social deficits, autism severity, social interaction anxiety, empathy, and social skills knowledge either by self-report or coach-report. Additionally, communicative behaviors rated by observers improved throughout the sessions, showing a trend toward more appropriate eye contact, gestures, facial expression during conversation, and appropriate maintenance of conversation and reciprocity. Most effects maintained at 3-month and 6-month follow-ups. The improvement of social deficits was positively correlated with baseline severity, while gains in social skills knowledge were positively correlated with IQ. The improvement of social deficits, autism severity, and empathy were positively correlated with each other.

Conclusion. Overall, the PEERS intervention appears to effectively improve social functioning in Taiwanese young adults with ASD. Improvement of social response and knowledge may be predicted by baseline severity and intelligence respectively.

Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by persistent social communication deficits with repetitive/stereotyped behaviors and unusual sensory response (American Psychiatric Association, 2013). Representative epidemiological studies have indicated that inadequate social skills are often the most significant problem for those on the spectrum, which persistently impair the ability to develop and maintain meaningful relationships (Reichow & Volkmar, 2010; Orsmond, Krauss, & Seltzer, 2004; Howlin, 2000), contributing to comorbidities and loneliness in adulthood. Many young adults with ASD struggle with poor social skills in basic areas such as interpreting social cues, and entering or exiting conversations (Shtayermman, 2007). For young adults who are eager to form social relationships, their atypical social responsivity may render them vulnerable to peer victimization (Humphrey & Symes, 2010; Cappadocia, Weiss, & Pepler, 2012). Although young adults with ASD often present with the same social difficulties as their adolescent counterparts (Shtayermman, 2007), there is sadly a paucity of evidence-based services targeting social skills in young adults with ASD compared to adolescents.

The Program for the Education and Enrichment of Relational Skills (PEERS) (Laugeson & Frankel, 2010) is a manualized caregiver-assisted social skills program specifically developed for high-functioning adolescents with ASD (Laugeson & Frankel, 2010). Focusing on establishing and maintaining friendships, and managing peer conflict and rejection, its efficacy and effectiveness have been established in multiple clinical trials in North America, Europe, and Asia (Laugeson, Frankel, Gantman, Dillon, & Mogil, 2012; Schohl et al., 2014; Van Hecke et al., 2015; Yamada et al., 2019; Yoo et al., 2014). The adolescent program was later modified for young adults with ASD, known as PEERS for Young Adults (PEERS-YA)

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(Laugeson, 2017), which integrates dating etiquette into the social skills training, and modifies the content and structure to fit the needs of young adults. The adapted version has been validated in three randomized-controlled studies (Gantman, Kapp, Orenski, & Laugeson, 2012; Laugeson, Gantman, Kapp, Orenski, & Ellingsen, 2015; McVey et al., 2016). In young adults with high-functioning ASD aged 18–23 years, Gantman et al. (2012) found that participants receiving the PEERS-YA curriculum exhibited significant improvement in overall social skills, social responsiveness, empathy, frequency of get-togethers, greater emotional awareness, improved social skills knowledge, and decreased loneliness. Subsequently, Laugeson et al. (2015) replicated the findings in 22 young adults with ASD, and found that most treatment gains were maintained at a 16-week follow-up assessment. Another study recruiting a larger sample ($N = 56$) (McVey et al., 2016) again demonstrated improvements in social responsiveness, social skills knowledge, empathy, direct interactions, and decreased social anxiety. Collectively, these studies demonstrated empirical support for the effectiveness of PEERS® in young adults with ASD. However, unlike the PEERS program for adolescents, the young adult version has not yet been validated in social cultures outside of North America. Although many fundamental social skills are universal across cultures, the appropriate manner in which to express personal opinions and resolve disagreements, assertiveness when using self-expression, expectations regarding social response, and preferred social activities among young adults may be divergent across different cultures, particularly in Eastern countries (Shum et al., 2019; Yamada et al., 2019; Yoo et al., 2014). Moreover, the maintenance effects of PEERS-YA was only addressed in Laugeson et al. (2015). Thus, the durability of intervention effects of PEERS-YA needs further examination with a larger sample to be conclusive.

Evaluation of the efficacy of social skill programs largely relies on self-report or caregiver-report on questionnaires, with very few exceptions utilizing standardized diagnostic tools (Yoo et al., 2014), like the Autism Diagnostic Observation Schedule (ADOS). Several studies have difficulty demonstrating significant changes after social skills intervention that have anecdotally demonstrated success (e.g. Marriage, Gordon, & Brand, 1995; Ozonoff & Miller, 1995), particularly when the changes are subtle, hard to measure, and not directly targeted by the existent measures (Hillier, Fish, Cloppert, & Beversdorf, 2007). Consequently, a more sensitive tool is needed to detect the more subtle changes resulting after intervention (Hesselmark, Plenty, & Bejerot, 2014; Hillier et al., 2007; Rogers, 2000). One study highlighted the importance of ratings by multiple informants (instead of using only self-report questionnaires) and comprehensive assessment (covering different aspects of social life and emotional status) (Hesselmark et al., 2014). Meanwhile, most effectiveness studies did not assess social communication behaviors by direct observation across the sessions of the intervention. Borrowing from the idea that structured observations can be examined to detect social behavioral changes over the course of intervention (Hillier et al., 2007), this study adopted the Communicative Behavior Observatory Scale (CBOS) to quantify the changes of communicative behaviors observed during each session over the 16-week program. This scale is routinely used in our daily practice to assess the frequency of using eye contact, facial expression, body language, maintaining or switching conversation topics, speech intonation and volume, and reciprocity during communication. In addition to the CBOS, pre-PEERS and post-PEERS autism severity were compared via direct observation on the ADOS.

With regard to clinical correlates of effectiveness, a previous study examining PEERS® intervention response concluded no gender difference on social skills knowledge, frequency of interactions, or social responsiveness (McVey et al., 2017). Another study in adolescents with ASD showed that PEERS® was similarly effective in early, middle, and late adolescence (Hong et al., 2019). However, whether age is a moderator of effectiveness in young adults with ASD has not been examined. Moreover, IQ and autism severity are also important correlates to be investigated. Studies have shown that adults on the spectrum with higher IQ and less ASD symptomology do not benefit from their higher functioning status when naturally learning social skills (Sterling, Dawson, Estes, & Greenson, 2008); instead, they tend to suffer from more depression, anxiety, social withdrawal and isolation, and peer victimization (Shtayermman, 2007) owing to greater social expectations and higher self-awareness (Sterling et al., 2008). A recent study indicated that the discrepancy between cognition and social adaptive skills in toddlers with ASD symptoms emerged early and widened over time (Bradshaw, Gillespie, Klaiman, Klin, & Saulnier, 2019). Although cognitive ability may predict social skills (Itskovich et al., 2021), academic performance (Appelbaum & Tuma, 1982), and knowledge acquisition (Rhodes et al., 2016) in most youth, social motivation seems to play a unique role in learning social skills in individuals with ASD (Itskovich et al., 2021). In other words, individuals on the spectrum with higher IQ may have an advantage in 'acquiring knowledge' of social skills rather than 'building social skills' by practice, especially when their motivation to change social habit is not as strong as those who are more ready to learn the social rules. In our clinical observation, among individuals on the spectrum with normal IQ, those with milder symptoms are sometimes more argumentative and less ready to follow the rules being taught, while those with lower average IQ, higher social anxiety, or more ASD symptomology often seem to have higher motivation to change and more space to improve. However, such empirical inference has not yet been validated in intervention studies. In addition, very few studies have examined the differential improvement on various domains of social functioning (Pallathra, Cordero, Wong, & Brodkin, 2019). It is therefore unclear whether the improvement of social deficits, social interaction anxiety, empathy, and autism severity would be correlated with each other without further study.

Toward this end, the present intervention study had three aims. First, the effectiveness of the Chinese PEERS-YA was examined by comparing multiple domains of social functioning and autism severity on direct behavioral observation, in addition to self-report and caregiver-report. Second, the durability of intervention effect was examined by two follow-up assessments at 3- and 6-months following treatment. Third, the clinical correlates of the effectiveness were explored, including age and IQ, as well as baseline symptom severity. We specifically tested the hypotheses that higher IQ is only related to better acquisition of social skills knowledge but not greater improvements in social functioning; instead, baseline autism severity and social interaction anxiety were expected to be related to greater improvement in social functioning. In a similar manner, correlations between gains in social deficits, social interaction anxiety, empathy, and autism severity were also examined.

Materials and methods

Translation and cultural adaptation of the PEERS® treatment manual

The PEERS® manual was translated into Mandarin Chinese by the first author with permission from the program developer. Expert meetings with a group of senior child psychiatrists/psychologists

who have 10–20 years of experience in assessing and treating adults with ASD were conducted for cultural adaptation. Child psychiatrists in Taiwan usually follow individuals with ASD from childhood to young adulthood and are familiar with the difficulties of these individuals across developmental stages. To enhance the ecological validity of the translated manual, we investigated social habits in typically developing Taiwanese young adults ($n = 30$, 20–30 years old) in three separate focus groups. Their observation regarding Taiwanese young adults' social behaviors was explored and clarified, including types of social activities, methods of friendship maintenance, conflict resolution, romantic relationships, as well as coping strategies when facing bullies. The translated manual was further modified accordingly (summarized in online Supplementary Table S1). The overall structure and contents of the training manual were predominantly maintained.

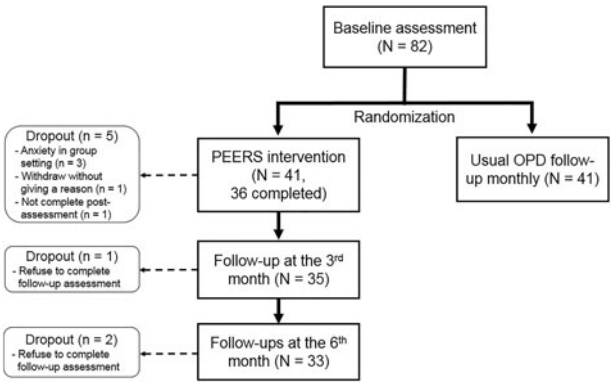

Fig. 1. Participant flow chart following Consolidated Standards of Reporting Trials (CONSORT) guidelines.

Recruitment and screening of participants

This study was approved by the Research Ethics Committee of National Taiwan University Hospital (REC no. 201612185RINC). The participants were composed of 82 patients with ASD who were recruited from Adult ASD clinics in the Department of Psychiatry, National Taiwan University Hospital. Participant ASD diagnoses were made by child psychiatrists based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth ed. (DSM-5) and the Autism Diagnostic Interview-Revised (ADI-R) (Lord, Rutter, & Le Couteur, 1994). The inclusion criteria for the study were that participants (1) be between 18 and 45 years of age; (2) had social problems as reported by both participants and caregivers; (3) were motivated to participate in the group intervention; (4) were fluent in Taiwanese Mandarin; (5) had a caregiver who was fluent in Taiwanese Mandarin and willing to participate as a social coach; (6) had a full-scale IQ>70 on the Wechsler Adult Intelligence Scale-IV; and (7) had an Autism Spectrum Quotient (AQ) total score ≥26, indicating clinical impairment associated with ASD. The exclusion criteria were (1) a history of major psychiatric disorder (i.e. schizophrenia or bipolar I disorder) or neurological disease; or (2) visual or hearing impairment that would preclude participation in group-based social activities.

After the clinical assessment and informed consent were completed, the participants underwent randomization. A total of 82 participants with ASD were stratified by gender and blindly randomized to the PEERS treatment group or a treatment-as-usual control group. Six participants who were randomized into the PEERS group later requested to switch to the control group because they could not make the schedule for the PEERS group as provided. The demographic characteristics of these six participants were not different from the rest of PEERS treatment group.

PEERS treatment group

The 41 participants who were randomized to the PEERS group intervention were then divided into four cohorts, each composed of 10–11 participants. These cohorts attended the PEERS group sessions weekly for 90 min for a total of 16-weeks. The PEERS groups were led by PEERS certified providers (the first author YLC and the clinical psychologist CLY). The other certified provider (WHC) and three research assistants (with master's or bachelor's degrees in psychology) assumed the role of behavioral coaches. Four observers (two child psychiatrists and two child psychologists) rated on the CBOS for each participant in each session.

All outcome measures were administered before the start and at the end of the PEERS intervention within 1 week of group termination. Follow-up assessments were conducted at the 3rd and the 6th month (Fig. 1). Within the PEERS condition, four of the 41 participants dropped out after the first or second sessions [three were too anxious about group settings (i.e. 'too many people in the group,' 'disliked speaking or sharing in front of so many people,' 'just can't stop feeling nervous'), while the fourth withdrew without giving a reason], and one did not complete the post-assessment after completing the 16-week intervention. Thirty-six participants completed the assessment after the treatment ended. A total of 35 participants completed the assessment at 3-month follow-up, while 33 completed the 6-month follow-up.

Control group

The 41 participants in the control condition were treated as usual in outpatient clinics whereby their socio-emotional problems, interpersonal issues, and parenting issues were discussed face-to-face for 10–30 min every 1–4 weeks, depending on the individual's needs. Supportive psychotherapy and counseling for problem solving were provided. At the conclusion of the study, control participants were given the option to join the PEERS program or not.

Outcome measures

Outcome was assessed using self-report and coach-report measures of social deficits, autism severity, social interaction anxiety, empathy, and social skills knowledge, and further assessed using the observer-rated ADOS and CBOS to assess autism severity and communicative behaviors.

The ADOS (Lord et al., 1989), a standard instrument for diagnosing and assessing autism, consists of a series of structured and semi-structured tasks that involve social interaction between the examiner and the subject. Through the tasks, the examiner observes and rates the subject's social and communication behaviors relevant to the diagnosis of autism. Module 4 was used in the current study given that the young adults had fluent speech. Each participant was rated by different interviewers pre- and post-PEERS. Although the interviewers were 'ideally' blind to the treatment assignment, some group participants spontaneously

shared their experience in PEERS during the ADOS interview during the 'Social Difficulties and Annoyance' task. The raters had adequate inter-rater reliability ($r = 0.91$) with certified research reliable examiners of the ADOS.

The AQ (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) is a 50-item self- and parent-report scale that measures autistic traits. The AQ total score ranges from 0 to 50, with higher scores representing the autistic end of the spectrum. The AQ shows good internal consistency (0.82), test-retest reliability (0.70), and good discriminative validity (Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005). The psychometric properties of its Chinese version have been validated (Lau et al., 2013) and widely used. The AQ total score was used to assess the overall autism severity, and socialness subscore to assess social deficits.

The Social Responsiveness Scale (SRS) (Constantino, 2002) is a 65-item scale of ASD symptoms occurring in natural settings. Higher scores reflect greater autism symptoms and impairment. Its Chinese version has demonstrated a satisfactory four-factor structure with high internal consistency (Cronbach's α 0.94–.95), i.e. social communication, stereotyped behaviors, social awareness, and social emotion (Gau, Liu, Wu, Chiu, & Tsai, 2013). SRS total scores, both self-report and coach-report, were used to assess general social deficits, and the four subscale scores to assess different domains of social functioning.

The Empathy Quotient (EQ) (Baron-Cohen & Wheelwright, 2004) is a self-report measure of empathy. The total score is based on the algorithm described in the previous study (Baron-Cohen & Wheelwright, 2004). The EQ has been shown to have excellent internal consistency (0.92) and test-retest reliability (0.97). Its Chinese version has satisfactory reliability and validity (Huang HY, Gau SS, unpublished).

The Empathizing/Systemizing Quotient (ESQ) is a parent-report 55-item questionnaire combining the EQ and Systemizing Quotient (Auyeung et al., 2009). A scoring method adapted from a previous study (Auyeung et al., 2009) was used to calculate the empathy-related items. The Chinese ESQ has satisfactory reliability and validity.

The Test of Young Adult Social Skills Knowledge (TYASSK) is a 30-item criterion-referenced measure based on the Test of Adolescent Social Skills Knowledge (Laugeson & Frankel, 2010) to assess young adults' knowledge about the specific social skills taught during the intervention. This measure was translated into Chinese for this study to assess social skill knowledge gains.

The Social Interaction Anxiety Scale (SIAS) (Mattick & Clarke, 1998), a 20-item self-report scale, measures experiences in social situations associated with social anxiety according to DSM-IV criteria (American Psychiatric Association, 1994). Participants rated items using a five-point Likert scale; higher total scores indicate greater levels of social anxiety. The Chinese SIAS has demonstrated good reliability and validity across clinical and community populations (Yang, 2003).

The CBOS (Chien et al., 2019) is a 10-item observer-rated scale designed to assess communicative behaviors during interpersonal interaction for individuals with ASD. Observers rated the items on a nine-point scale according to the frequency of the behaviors. Ratings of 1 or 2 or 3 indicate 'Needs to be improved' (behaviors can be observed around 10−30% of the time); ratings of 4 or 5 or 6 indicate 'Average level' (behaviors observed around 40−60% of the time); and ratings of 7 or 8 or 9 indicate 'Good level' (behaviors observed around 70−90% of the time). Higher total scores indicate greater levels of communicative competence. Items include: (1) keeps appropriate distance during conversation, (2) keeps eye contact during conversation, (3) appropriate nodding/shaking head/gestures, (4) maintains conversation appropriately, (5) switches conversation topics appropriately, (6) appropriate amount of voice/intonation, (7) appropriate facial expression when talking, (8) reciprocity during conversation, (9) emotional regulation, and (10) overall communicative behaviors. The inter-rater reliability of the CBOS between the raters was adequate ($r = 0.86$) (Chien et al., 2019). Each participant was directly observed and rated by the same rater sitting outside the group circle in the same room throughout the intervention sessions.

The 3- and 6-month follow-up assessments included all of the above outcome measures (i.e. AQ, SRS, SIAS, TYASSK, EQ, and ESQ) except the ADOS and CBOS.

Statistical analysis

Background characteristics were compared between the PEERS intervention group and control group by using the χ^2 tests (for categorical data) or two-sided independent t tests (for continuous variables). To examine the effectiveness of the intervention, we tested group (PEERS *v.* control group) by time (pre-PEERS *v.* post-PEERS) interactions by using the mixed model, treating repeated measures (i.e. pre-PEERS and post-PEERS) as paired data and controlling age and gender effects in the model. To examine the maintenance effect, we tested the differences between pre-PEERS and post-PEERS, between pre-PEERS and 3-month follow-up, and between pre-PEERS and 6-month follow-ups, respectively by paired t test.

To explore the clinical correlates of the intervention effect, we examined whether age and full-scale IQ correlated with the improvement on social deficits, autism severity, social interaction anxiety, empathy, and social skills knowledge by Pearson's correlation analysis. The improvement was defined as the percentage of change, i.e. (pre-post)/pre. Also, we examined whether the improvement of social deficits or social knowledge correlated with baseline autism severity, social interaction anxiety, or empathy. Meanwhile, the inter-relationships between the percentages of improvement among the measures were also examined by Pearson's correlation analysis to see the relatedness between the changes in social deficits, social interaction anxiety, empathy, and autistic severity.

Results

Demographics and baseline assessment

The mean ages and gender distribution were not statistically different between the PEERS group (25.3 ± 4.5 years; female $n = 6$, 14.6%) and the control group (27.6 ± 6.0 years; female $n = 7$, 17.1%) (Table 1). Full-scale IQ was also comparable between the two groups (PEERS: 99.6 ± 16.5; control: 103.8 ± 16.1).

Pre-PEERS v. post-PEERS

Using a mixed model to examine the interaction between group effect (PEERS *v.* control) and time effect (pre-PEERS *v.* post-PEERS), we found significant interactions on self-reported SRS total and subscales (i.e. social communication, stereotyped behaviors, and social emotion), AQ socialness subscale, SIAS, EQ, and SS (Table 2), revealing that the PEERS group

Table 1. Demographics and baseline assessment

	PEERS ($N = 41$)		Control ($N = 41$)		Statistics	
Variable	Mean or n	S.D. or (%)	Mean or n	S.D. or (%)	t or x^2	p
Age	25.3	4.5	27.6	6.0	1.96	0.053
Female	$n = 6$	(14.6%)	$n = 7$	(17.1%)	0.09	0.762
Full-scale IQ	99.6	16.5	103.8	16.1	1.01	0.318
Education (college or above)	$n = 34$	(82.9%)	$n = 31$	(75.6%)	0.67	0.413
Employment (current)	$n = 11$	(30.6%)	$n = 16$	(43.2%)	1.28	0.249
Employment (ever)	$n = 26$	(72.2%)	$n = 25$	(64.1%)	0.75	0.487
Living with parents	$n = 31$	(79.5%)	$n = 32$	(88.9%)	1.45	0.236
Self-reported						
SRS total scores	88.6	29.5	90.7	25.4	0.34	0.733
AQ total scores	95.8	13.0	100.7	11.3	1.44	0.153
EQ total scores	24.9	11.5	22.4	10.3	−1.02	0.309
SIAS	43.6	15.0	45.7	15.7	0.6	0.552
Social skill knowledge	16.0	2.7	16.0	2.8	−0.04	0.968
Coach-reported						
Coach age	53.8	9.2	57.2	7.3	1.82	0.073
Relations					0.45	0.799
Father	$n = 10$	(25.0%)	$n = 8$	(19.5%)		
Mother	$n = 27$	(67.5%)	$n = 30$	(73.2%)		
Others	$n = 3$	(7.5%)	$n = 3$	(7.3%)		
Education (high school or above)	$n = 32$	(78.0%)	$n = 34$	(82.9%)	0.31	0.577
SRS total scores	97.0	24.7	92.5	25.4	−0.8	0.425
AQ total scores	101.4	10.3	101.5	10.7	0.05	0.964
ESQ total scores	18.0	7.1	18.1	6.5	0.03	0.976
Interviewer-rated						
ADOS: module 4						
Communication	4.9	2.4	4.6	2.7	−0.47	0.640
Social reciprocity	7.6	2.8	7.9	3.0	0.43	0.671
Restricted, repetitive behavior	2.6	1.8	2.3	1.4	−0.80	0.428
ADI-R (current)						
Reciprocal social interaction	12.7	4.1	13.1	3.5	0.47	0.643
Verbal communication	9.2	3.6	8.6	3.3	−0.67	0.507
Non-verbal communication	4.0	2.4	3.8	2.4	−0.4	0.693
Restricted, repetitive, stereotyped patterns of behavior	3.8	2.4	3.7	2.4	−0.17	0.866

ADI-R, Autism Diagnostic Interview-Revised; ADOS, Autism Diagnostic Observation Schedule; AQ, Autism Spectrum Quotient; EQ, Empathy Quotient; ESQ, Empathizing/Systemizing Quotient; SIAS, Social Interaction Anxiety Scale; SRS, Social Responsiveness Scale.

demonstrated greater improvement on these measures. With regard to coach-reported outcomes, the only outcome measure collected was the SRS, which revealed a significant interaction on the social communication subscale score, but not SRS total scores (Table 2), suggesting that those in the PEERS condition improved to a greater extent than controls. The ADOS subscale scores also had significant interactions in social reciprocity, communication, and restricted/repetitive behaviors (Table 2), consistently showing that the PEERS group demonstrated greater improvement than controls.

There were no differences in the outcomes for the groups led by different group leaders (online Supplementary Table S2). Moreover, treatment outcomes were not significantly related to the person (mother *v.* others) as social coach, the education level, employment status, or marital status of the social coach (online Supplementary Table S3).

Table 2. Pre-PEERS (Time 0) *v.* post-PEERS (Time 1) in the PEERS group and control group and group-by-time interaction

	PEERS		Controls		Mixed model Peers × time		PEERS
Mean ± S.D.	Time 0 ($n = 41$)	Time 1 ($n = 36$)	Time 0 ($n = 41$)	Time 1 ($n = 36$)	t	p	Effects: Cohen's d
Self-reported							
SRS: social communication	38.9 ± 15.8	32.6 ± 15.4	39.1 ± 13.9	38.5 ± 16.7	−2.63	0.010	0.40
SRS: stereotyped behaviors	19.0 ± 8.2	16.6 ± 7.2	19.9 ± 6.9	19.1 ± 6.9	−2.56	0.013	0.32
SRS: social awareness	18.4 ± 7.2	17.3 ± 5.3	19.5 ± 4.2	19.8 ± 4.7	−1.08	0.284	0.18
SRS: social emotion	12.2 ± 4.9	10.5 ± 4.7	12.2 ± 4.5	12.9 ± 5.0	−3.42	0.001	0.37
SRS: total score	88.6 ± 29.5	76.9 ± 27.7	90.7 ± 25.4	90.4 ± 27.8	−3.17	0.002	0.41
AQ: socialness	35.3 ± 7.5	31.5 ± 7.1	37.5 ± 6.6	36.7 ± 6.9	−2.55	0.013	0.51
AQ: total	95.8 ± 13.0	90.8 ± 14.2	100.7 ± 11.3	99.5 ± 12.3	−1.95	0.056	0.37
SIAS	43.6 ± 15.0	39.1 ± 15.5	45.7 ± 15.7	45.7 ± 15.7	−2.13	0.037	0.30
EQ: total score	24.9 ± 11.5	29.4 ± 13.3	22.4 ± 10.3	21.3 ± 9.3	3.46	0.001	−0.36
Social skills knowledge	16.0 ± 2.7	20.4 ± 3.5	16.0 ± 2.8	16.7 ± 3.0	5.71	<0.0001	−1.42
Coach-reported							
SRS: social communication	41.6 ± 13.1	32.1 ± 10.2	37.7 ± 13.4	34.4 ± 13.9	−2.32	0.023	0.81
SRS: total score	97.0 ± 24.7	81.2 ± 18.5	92.5 ± 25.4	85.0 ± 26.1	−1.81	0.075	0.73
ADOS: module 4							
Communication	4.9 ± 2.4	3.2 ± 2.2	4.6 ± 2.7	4.9 ± 2.3	−4.3	<0.0001	0.73
Social reciprocity	7.6 ± 2.8	4.0 ± 2.6	7.9 ± 3.0	8.0 ± 3.3	−8.57	<0.0001	1.30
Restricted, repetitive behavior	2.6 ± 1.8	1.4 ± 1.5	2.3 ± 1.4	1.9 ± 1.3	−2.37	0.021	0.67

ADI-R, Autism Diagnostic Interview-Revised; ADOS, Autism Diagnostic Observation Schedule; AQ, Autism Spectrum Quotient; EQ, Empathy Quotient; ESQ, Empathizing/Systemizing Quotient; SIAS, Social Interaction Anxiety Scale; SRS, Social Responsiveness Scale.
Social skills knowledge, total scores on the Test of Young Adult Social Skills Knowledge.

Social communication behaviors during intervention sessions

Trend tests showed significant improvement on the CBOS domains of 'keeps eye contact,' 'appropriate nodding/shaking head/gestures,' 'maintains conversation appropriately,' 'appropriate facial expression,' 'to-and-fro reciprocity,' and 'overall communicative behaviors' across the sessions (Fig. 2). When comparing the first and the last ratings by paired t test, we found significant gains on 'maintains conversation,' 'switches conversation topics,' 'appropriate facial expression,' 'reciprocity,' and 'overall communicative behaviors.' By contrast, there was no significant improvement on 'keeping appropriate distance,' 'appropriate volume and intonation,' and 'emotional regulation.'

Maintenance of intervention effects

Figure 3*a* shows the overall severity ratings on the SRS and AQ, with the total scores at post-PEERS, 3-month, and 6-month follow-up assessments significantly different from those at pre-PEERS, according to both self-report and coach-report. Figure 3*b* shows both self-report and coach-report social deficit subscales (SRS: social communication; AQ: socialness) at post-PEERS, 3-month, and 6-month follow-up assessments were significantly different from those at pre-PEERS. Similarly, social emotion problem (SRS) (Fig. 3*c*) for self-report and coach-report at post-PEERS and 3-month follow-up assessment, and for coach-report (but not self-report) at 6-month follow-up assessment, were significantly different from those at pre-PEERS.

Other than the main outcomes, stereotyped behaviors (SRS) at post-PEERS, 3-month, and 6-month follow-up assessments were significantly different from those at pre-PEERS across self-report and coach-report (Fig. 3*d*). Likewise, self-report social interaction anxiety (SIAS, Fig. 3*e*), social skills knowledge (TYASSK, Fig. 3*f*), and empathy (EQ/ESQ, Fig. 3*g*) at post-PEERS, 3-month, and 6-month follow-up assessments were significantly different from those at pre-PEERS (with the exception of the SIAS at 6-month follow-up). Online Supplementary Table S4 provides a summary of the statistical results.

Clinical correlates of the improvement

Age was not correlated with any changes on SRS total, AQ total, SS, EQ, and SIAS, while full-scale IQ was only correlated with SS change. These changes were mostly correlated with each other (Table 3). Specifically, improvement on SRS total was correlated with improvement of AQ total, EQ, SIAS, but not SS. However, improvement on SS was only correlated with improvement in EQ. Moreover, we examined whether the pre-PEERS status correlated with the improvement on SRS total and SS, and found that improvement on SRS total was positively correlated with pre-PEERS AQ total ($r = 0.35$, $p = 0.032$), and SIAS ($r = 0.34$,

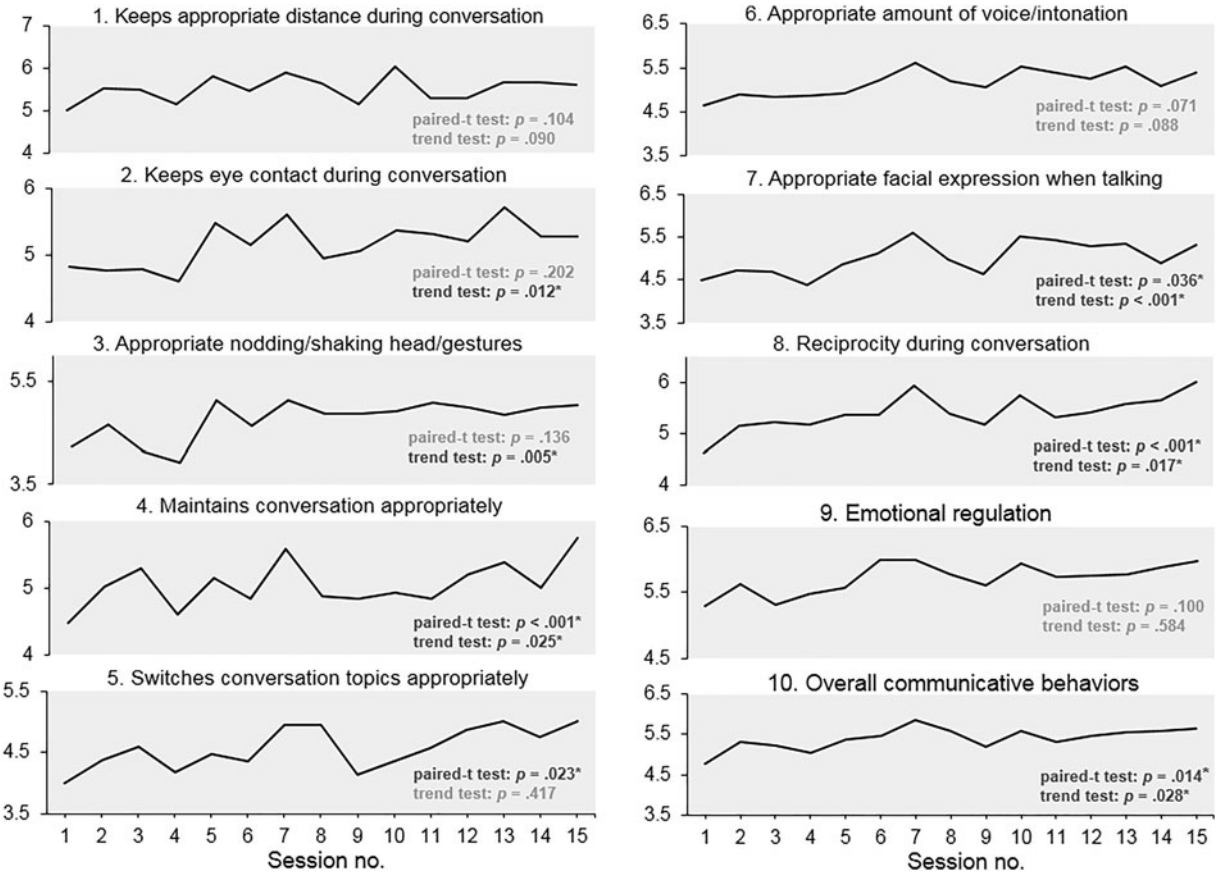

Fig. 2. Changes in communicative behaviors over the course of the PEERS intervention. The mean scores of each of the 10 items of the Communicative Behaviors Observatory Scale were shown separately in each panel across the prior 15 sessions of the PEERS intervention. *p* values of paired *t* test and trend test were shown for each panel. $^*p < 0.05$.

$p = 0.037$), while improvement on SS was not correlated with any scale.

Discussion

As the first study outside of North America examining the effectiveness of the PEERS social skills training for young adults with ASD, we found that PEERS-YA effectively improved social deficits, social interaction anxiety, social skill knowledge, and empathy in Taiwanese young adults. Communicative behaviors improved across the course of intervention, showing a significant trend toward more appropriate eye contact, gestures, facial expressions during conversation, appropriate maintenance of conversations and reciprocity, as well as overall communicative behaviors across the sessions. As for the durability, the intervention gains generally maintained at 3- and 6-month follow-up assessments.

The significant improvement in social deficits, social interaction anxiety, empathy, and social skills knowledge replicated previous findings in young adults with ASD from North America (Gantman et al., 2012; Laugeson et al., 2015; McVey et al., 2016). Apart from social functioning, our findings that autism severity (measured by the AQ and ADOS) improved after intervention were also consistent with previous findings showing a significant reduction of ASD symptoms (Laugeson et al., 2015). More specifically, we found that the severity of social emotion problems and stereotyped behaviors reduced, reflecting that the PEERS intervention not only improved social skills as its primary target, but also improved emotional problems and stereotyped behaviors, leading to reduced overall autism severity.

Similar to Laugeson et al. (2015), deficits in social awareness did not show significant improvement, suggesting such impairment could be a core deficit inherent to ASD psychopathology and may not be substantially repaired by instruction and practice in the rules and steps of social skills in a time-limited intervention. A recent article reviewed studies targeting social cognitive training (e.g. emotion recognition or face/voice identification) for adults on the spectrum (Pallathra et al., 2019) and demonstrated significant improvements on closely related tasks, but the effects did not generalize to more distant tasks (Bolte et al., 2002) or daily life (Faja et al., 2012), reflecting that training on such core deficits remains a challenge in most social skills training programs for those with ASD.

Using a novel approach to directly assess communicative behaviors throughout the sessions, we found significant improvement in eye contact, non-verbal communication, maintaining conversation topics and reciprocity. Although improvements were not perfectly linear, the overall communicative behaviors rated by the observers did improve across the sessions, demonstrating observable behavioral changes consistent with self-report and coach-report improvement in social skills. This new approach to assessing behavioral change is worthy of consideration in future studies to delineate the learning trajectory across social skills training.

Both self-report and coach-report data showed maintenance of training effects at both 3- and 6-month follow-up assessments on

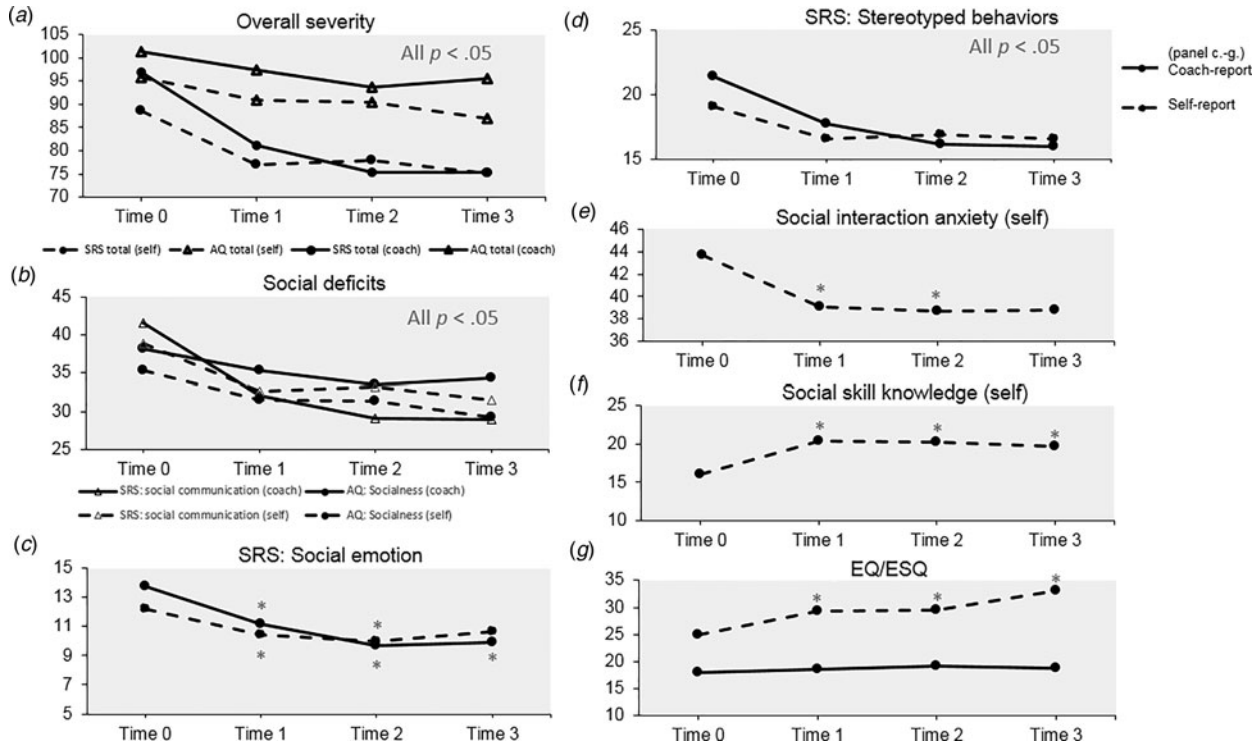

Fig. 3. Maintenance of intervention effects at 3-month (Time 2) and 6-month (Time 3) follow-up assessments. (*a*) Overall severity (total scores of SRS and AQ); (*b*) social deficit subscales (SRS, social communication, AQ, socialness); (*c*) social emotion problem (SRS). (*d*) stereotyped behaviors (SRS); (*e*) social interaction anxiety (SIAS total scores); (*f*) social skills knowledge (on the TYASSK); (*g*) empathy (EQ/ESQ). AQ, Autism Spectrum Quotient; EQ, Empathy Quotient; ESQ, Empathizing/Systemizing Quotient; SIAS, Social Interaction Anxiety Scale; SRS, Social Responsiveness Scale; TYASSK, Test of Young Adult Social Skills Knowledge; *$p < 0.05$; dashed line, self-report; solid line, coach-report. Time 0: pre-treatment assessment, Time 1: post-treatment assessment.

overall social deficits, autism severity, and several domains of social functioning. The durability examined in the present study is longer than Laugeson et al. (2015) in which most treatment gains were maintained at a 16-week follow-up assessment. Current findings are also in accordance with several studies investigating PEERS effectiveness in adolescents with ASD from North America (Laugeson et al., 2012; Mandelberg, Frankel, Cunningham, Gorospe, & Laugeson, 2014) or other countries [e.g. 14-week follow-up in Japan (Yamada et al., 2019), and 3-month follow-up in Hong-Kong (Shum et al., 2019)]. Durability of treatment gains is contributable to active caregiver involvement in the program (Laugeson et al., 2015), who were trained to provide social coaching in multiple settings, thus carrying forward the social learning after treatment has been terminated. By including caregivers in the program, our findings showed that the potential benefits maintained for at least 6-months after intervention had ended.

By assessing multiple domains of social functioning and autistic characteristics, we found that improvement of social deficits, autism severity, and empathy was significantly correlated with each other. Improvement in social interaction anxiety was also correlated with improvement in social deficits and autism severity. It is possible that these domains influenced each other and improved together; thus, building social skills may essentially compensate for social and empathy deficits, subsequently reducing social anxiety and moderating autism severity. Another possibility is that the common root of these social functioning phenotypes (e.g. perspective taking) was directly targeted during the training, so that the different facets of social functioning observed are changed. The underlying mechanism of how the training effect occurred is intriguing and warrants further examination through qualitative or social cognition studies.

Age was not correlated with intervention changes, consistent with previous findings in adolescents with ASD (Hong et al., 2019). As the first to investigate the relationship between IQ and improvement, we found that full-scale IQ was only correlated with improvement in social skills knowledge, but not the other domains of improvement. This finding suggests that participants with higher full-scale IQ scores indeed acquire social skills knowledge to a greater extent than those with lower IQ score. However, higher IQ does not translate to greater reductions in social deficits, autism severity, and social interaction anxiety, or improved empathy.

On the contrary, improvement in social skills correlated with baseline autism severity and social interaction anxiety before the intervention, suggesting that participants with higher baseline autism severity and social interaction anxiety gain more on social responsiveness following intervention. One explanation is that participants with greater impairment may show higher motivation to practice, and in turn, may also have more space to grow given a lower start. Meanwhile, improvement of social skills knowledge was not correlated with baseline social deficits, autism severity, and social interaction anxiety, reflecting that social skills knowledge acquisition was not dependent on baseline autism severity or social deficits. However, improvement of social skills knowledge indeed was correlated with improvement of empathy. Given the complex nature of these relationships, future studies targeting social skills training effects may seek to disentangle the interactive relationship between social skills knowledge, social cognition, empathy, and different domains of social functioning.

Table 3. Correlations between change percentages of social deficits, autistic severity, empathy, and social skill knowledge

	Changes in AQ total	Changes in TYASSK	Changes in EQ	Changes in SIAS
Changes in SRS total	0.43*	−0.14	−0.48**	0.48**
Changes in AQ total		−0.22	−0.57***	0.66***
Changes in SS			0.36*	−0.24
Changes in EQ				−0.32

AQ, Autism Spectrum Quotient; EQ, Empathy Quotient; SRS, Social Responsiveness Scale; TYASSK, the Test of Young Adult Social Skills Knowledge.
*$p < 0.5$, **$p < 0.005$, *** $p < 0.0005$.

Several limitations need to be addressed. Firstly, the study results may not generalize to females with ASD given fewer females in the sample. Although a previous study has shown that gender was not a significant factor for the intervention effect (Hong et al., 2019), recruiting more female participants may allow further corroborative analysis on clinical correlates of intervention effects being either gender-specific or not so. Secondly, ASD participants with major psychiatric disorders were excluded from the study. Given that psychiatric comorbidities are common in ASD individuals (Chien, Wu, & Tsai, 2021; Lugnegard, Hallerback, & Gillberg, 2011), future studies may extend the study population to individuals on the spectrum with comorbid conditions in order to examine the effectiveness of PEERS-YA in the real world. Thirdly, although we used standardized assessment (i.e. ADOS) to estimate autism severity in both the PEERS group and control group at pre- and post-test, other domains such as empathy lacked objective reporting in the controls. Moreover, follow-up assessment did not include direct observational measures, and behavior ratings across sessions (i.e. CBOS) were not blind to the intervention status. Independent-rater reports of social functioning (e.g. teachers or friends) and objective measurement by social tasks might be considered in future studies during the intervention and follow-up. Fourthly, instead of adopting the waiting list control design in previous studies, this study compared the PEERS intervention effect to the 'treatment-as-usual' control group in which participants received individual counseling in natural settings focused on the issues they were concerned with, hence the treatment intensity was on a case-by-case basis without standard intervention. Although this 'treatment-as-usual' control group reflected the clinical practice in the real world, introducing a control group receiving a more comparable amount of support or another structured intervention program should be considered in future research. Fifthly, we anecdotally observed that many participants developed self-efficacy during social interaction after intervention, but self-efficacy is difficult to assess using current measures. Qualitative research will be of help in capturing changes of mind or self-image. Lastly, one may argue the possibility of selection bias in recruiting participants with ASD who can afford the 16-week intervention. This randomized controlled study was designed to reduce such selection bias as much as possible by scheduling the intervention groups on the weekend, providing services without additional payment, and randomizing only after the participants agreed with the schedule. Hence, both the PEERS intervention group and control group were subject to the same bias, if any. Meanwhile, in our subsidiary analysis, the person (mother *v.* others) as social coach, the education level, employment, and marital status of the social coach were not related to the treatment outcome. However, socio-economic status such as the total income of the family was not controlled for and may need to be considered in future studies. Despite the limitations, this study used standardized diagnostic measures including the ADOS and the ADI-R, repeated ADOS assessment after intervention, directly observed social behaviors across the sessions, and assessed multiple domains of social functioning. The correlates of effectiveness were examined and the relationship between the measures was explored. The durability of intervention effect was assessed at three time points up to 6-months after treatment. The results may provide valuable evidence for future practice.

This study combined multiple informants' reports consistently showing that social deficits, social interaction anxiety, empathy, and social skills knowledge were improved by PEERS-YA among Taiwanese young adults with ASD. Meanwhile, most of the gains were maintained at 6-month follow-up. Findings imply that PEERS-YA may be an effective social skills program in cognitively-able young adults with ASD outside of North America. Additionally, social deficits, social interaction anxiety, and empathy might improve together after intervention, reflecting the dynamics of different domains of social functioning that warrant further research. Although higher intelligence predicted better social skills knowledge learning, reduced social deficits were most significant in participants with higher autism severity and social interaction anxiety. Thus, heterogeneity within the autism spectrum needs to be addressed in terms of social skills training effectiveness so that behavioral coaching during treatment can better fit individual needs.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291721002385.

Author contributions. EL trained and certified the group leaders. YLC, CLY, WHC facilitated the PEERS groups. YLC, WCT, SSG, YNC did case referral and clinical assessment. YLC did the translation of the PEERS-YA program into Mandarin, and WTC, YNC, SSG, and WTS reviewed the translation. SSG, YNC, and WTS supervised the study. YLC did statistical analysis and drafted the manuscript. EL did rigorous revision on the manuscript.

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Conflict of interest. None.

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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