Age as a Moderator of Social Skills Intervention Response Among Korean Adolescents with Autism Spectrum Disorder

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Abstract

Few studies have investigated the effect of age on treatment effectiveness of evidence-based social skills training in autism spectrum disorder (ASD) adolescents. This study evaluated the effectiveness of Program for the Education and Enrichment of Relational Skills (PEERS®) in different ages of ASD adolescents. A total of 110 ASD adolescents aged 11–19 years were divided into early, middle, and late adolescence groups, and the changes in outcome measures following intervention were compared among the three groups. We found that the improvements in social competence after PEERS® were significant, but the treatment effects were not significantly different among the three age groups. The findings suggest that PEERS® is beneficial for ASD adolescents regardless of patient age and adolescence stage.

Keywords PEERS · Social skills training · Autism spectrum disorder · Adolescent · Age difference

Autism spectrum disorder (ASD) is characterized by deficits in communication, impairments in social interactions, and restricted and repetitive patterns of behavior (American Psychiatric Association 2013). Impaired social functioning, a hallmark feature of ASD, is a priority treatment target. It is more challenging for ASD adolescents with impaired social functioning to overcome the marked changes that occur in adolescence and to adjust themselves to the complex social environment, which requires more delicate and skillful social strategies (Coleman 2011; Feldman and Elliott 1990). Previous studies have revealed that adolescents with ASD are more depressed and anxious (Lasgaard et al. 2010; Sterling et al. 2008) and report higher levels of loneliness and poorer quality of friendships (Bauminger and Kasari 2000; Mazurek 2014) than their typically developed peers. In addition, having close friends and being socially connected can decrease loneliness and improve depression and anxiety symptoms, thus contributing to better general well-being in individuals with ASD (Bauminger et al. 2004; Mazurek 2014; Whitehouse et al. 2009). The manifestation of ASD-related behaviors in children and adolescents in Korea is similar to that in Western countries (Kim et al. 2016). However, few studies have examined the characteristics of ASD adolescents in Korea. Significant parental concerns include biological and psychological transitions, career development, social identity, school bullying, and development of appropriate peer relationships (Jeong and Kim 2015; Lee and Lee 2013).

Adolescence is a critical transitional period, far more than simply bridging childhood and adulthood. Not only do physical changes and sexual maturity occur, but brain development and neural reorganization are also reactivated with the accompanying hormonal changes during this period (Blakemore and Choudhury 2006; Crone and Dahl 2012; Fuhrmann et al. 2015; Peper and Dahl 2013; Santrock 2016). Neural growth promotes the development of higher-level cognitive processes, including social cognition (Arain et al. 2013; Choudhury et al. 2006; Ochsner 2004). It has also been suggested that adolescence represents a period of heightened plasticity, and some evidence from animal...
studies reveals that adolescence is a sensitive period for the effects of stress on mental health (Pattwell et al. 2012; Ver Hoeve et al. 2013). Heightened plasticity may be attributed to brain development and increased cognitive function, and it may result in increased vulnerabilities (Fuhrmann et al. 2015). There is a trajectory in the development of social relationships, cognitive maturity, and brain maturation in adolescents (Blakemore and Choudhury 2006), and it is generally accepted that this developmental period can be subdivided into early, middle, and late stages of adolescence (Barrett 1996; Sadock et al. 2015). Psychosocially, early adolescents start to perceive the “self” apart from family ties, pay more attention to their peer relationships (Vartanian 2000), and spend greater time with peers (Forehand and Wierson 1994). The friendship formation process is the most active from early to middle adolescence (Coleman 2011), and most teens belong to at least one friendship group at the age of 13 years (Ryan 2001). Throughout early and middle adolescence, teens begin to reject the parental value, and deviant behaviors and opinions may increase as they struggle to achieve autonomy and independence (Barrett 1996; Forehand and Wierson 1994; Palmonari et al. 1991). In late adolescence, identity formation, future planning, and successful transition to adulthood are the most fundamental developmental tasks (Zarrett and Eccles 2006). Notably, late adolescents tend to be less vulnerable to peer pressure, and the parent–child relationship improves (Sumter et al. 2008; Westenberg and Gjerde 1999). Neuroranatomically, the gray matter volume gradually increases, reaches a peak at the age of 11 years in girls and 13 years in boys, and then begins to decrease, showing an inverted U-shape growth pattern. The white matter volume increases linearly throughout childhood and adolescence (Lenroot and Giedd 2006). Therefore, age may be a moderating factor for outcome interventions aimed at improving social relationships and fostering independence from parents.

Group-based social skills intervention, one of the most widely used and studied treatments, aims to improve social skills in children and adolescents with ASD (McMahon et al. 2013; White et al. 2007). Limited manuals and studies of interventions have focused on adolescents with ASD, and some of these studies are randomized control trials (RCTs) (Choque Olsson et al. 2017; Gantman et al. 2012; Laugeson et al. 2009; Schohl et al. 2014; White et al. 2013; Yoo et al. 2014). The Program for the Education and Enrichment of Relational Skills (PEERS®) (Laugeson and Frankel 2010) is one of the most studied social skills interventions designed for adolescents with ASD; its efficacy has been investigated in multiple studies (Gantman et al. 2012; Laugeson et al. 2009; McVey et al. 2016; Schiltz et al. 2018; Schohl et al. 2014; Van Hecke et al. 2015; Yoo et al. 2014). It was originally developed at the University of California, Los Angeles, and the effects of the PEERS® intervention have been established by the group (Laugeson et al. 2009, 2012). An independent study has replicated the findings, and it also demonstrated that this program could improve social knowledge and friendship skills; additionally, this group also reported the ability of PEERS® to diminish social anxiety (Schohl et al. 2014). Changes in neural functioning (i.e., EEG asymmetry) following PEERS® have also been suggested in a RCT (Van Hecke et al. 2015). In this RCT, participants with ASD, who initially had right-hemisphere dominant EEG asymmetry, showed left-hemisphere EEG asymmetry after PEERS®, in addition, the left-hemisphere asymmetry was observed to be associated with more social contacts and knowledge and fewer ASD symptoms. The Korean version of PEERS® has been translated and modified from the original PEERS®, and its efficacy has been examined in an RCT in South Korea (Yoo et al. 2014). In this RCT, the program was shown to increase social competence and reduce internalizing symptoms, including anxiety and depression; the results are consistent with those in studies in North America (McVey et al. 2016; Schiltz et al. 2018; Schohl et al. 2014).

The moderating factors affecting the outcome of social skills interventions for adolescents have been reported. Participant characteristics such as age, sex, cognitive ability, comorbid psychiatric conditions, and psychopharmacological medication may be potential moderators for treatment outcomes (McMahon et al. 2013); thus, social skills interventions might not be equally beneficial for each participant because of the different characteristics.

Although limited studies have examined the effects of age on social skills interventions for adolescents, early intervention is one of the rules of maxim for the treatment of ASD during the toddler and childhood period (Dawson 2008; Dawson and Osterling 1997; Rogers 1996). The effect of age in different stages of adolescence is not well-known, especially with respect to treatment modulated by higher cognitive functions. One RCT in Sweden evaluated the moderating effects of age and sex on the efficacy of social skills training using “The Frankfurt Social Skills Training” (KONTAKT), a manualized program aiming at improving social interaction for children and adolescents with ASD. In this RCT, the three-way interaction term (time by treatment by age group) reached a statistical significance, leading to the conclusion that age acted as a moderator on the effects of social skills training; in particular, the Social Responsiveness Scale scores significantly improved in the intervention group compared with the non-intervention group in adolescents but not in children (Choque Olsson et al. 2017). Another study examined whether multiple factors, including age, intelligence quotient (IQ), and baseline social functioning, can be used to predict positive social skill outcomes following PEERS® in ASD teens, and multiple regression analysis revealed that baseline age was not a significant
This study aimed to further evaluate the effect of age on social skills training for ASD across adolescence, which is a critical and dynamic period. The Korean version of PEERS® was administrated to adolescents, and differences in treatment effects among the three different age groups (i.e., early, middle, and late adolescence) were assessed. We hypothesized that individuals in the early adolescence group might show the greatest benefits from PEERS® based on their trajectories in psychosocial and brain development. Early adolescence might be an optimal period to establish a peer group based on common interests, and it might be less challenging to enter or create novel peer groups during early adolescence than to intervene in more consolidated, pre-formed groups during middle adolescence. In addition, because the initial phase of brain developmental reactivation begins at puberty, individuals in the early adolescence group are assumed to have greater capacity for plasticity for learning and acceptance of new rules. We also hypothesized that adolescents in the late adolescence group might have the second highest advantage, possibly because of a more mature brain, higher cognitive functions, and less vulnerability to peer conflict.

Methods

This was a retrospective cohort study conducted at the Child and Adolescent Psychiatry Clinic in the Seoul National University Bundang Hospital in Seongnam-si, Gyeonggi-do, South Korea.

The following screening process was conducted for each participant. Eligibility of participants was assessed using initial phone screening based on the Phone Screening Script in PEERS® Treatment Manual (Laugeson and Frankel 2010). For those eligible, social motivation was evaluated by an interview with the Teens Intake Interview Checklist (Laugeson and Frankel 2010). Through the interview, more detailed information about PEERS® was provided to the teens, and their social relationships and motivation to participate in the program were thoroughly investigated (Laugeson and Frankel 2010). Subsequently, ASD was diagnosed by child psychiatrists based on the Diagnostic and Statistical Manual of Mental Disorders 5th edition (DSM-5®; American Psychiatric Association 2013) or the DSM 4th edition—Text Revision (DSM-IV-TR; American Psychiatric Association 2000), in which ASD includes pervasive developmental disorder—not otherwise specified (PDD-NOS), Asperger’s disorder, and autistic disorder. The Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2008) and Autism Diagnostic Interview-Revised (ADI-R; Lord et al. 1994) were also consulted to aid in the diagnosis. IQ was assessed using the Korean Educational Development Institute-Wechsler Intelligence Scale for Children-Revised (KEDI-WISC; Park et al. 2002), Korean-Wechsler Intelligence Scale for Children-III (K-WISC-III; Kwak et al. 2001), or Korean Wechsler Adult Intelligence Scale-IV (K-WAIS-IV; Hwang et al. 2012). Demographic data were collected by a telephone screening interview with the teens’ parents. Socioeconomic status (SES) was assessed based on a question from the Korean version of the Child Behavior Checklist (K-CBCL; Achenbach 1991; Oh and Lee 1990): “How would you rate your family’s socioeconomic status?” The five response categories were high, middle-high, middle, middle-low, and low. The psychiatrists reviewed the electronic medical records to retrieve the prescription information.

All procedures were conducted in accordance with the ethical standards of the Institutional Review Board of Seoul National University Bundang Hospital as well as the 1964 Helsinki declaration and its amendments. Written informed consent and assent were obtained from all parents and adolescents who participated in this study.

Participants

A total of 126 adolescents with ASD participated in PEERS® between November 2011 and October 2016. Participants were selected according to the following original inclusion criteria: (a) aged 11–19 years; (b) currently enrolled in school between the sixth grade of elementary school and the third year of high school; (c) experiencing social difficulties, as recognized by parents; (d) previously diagnosed with ASD by a reliable mental health professional (i.e., a child and adolescent psychiatrist or licensed psychologist) or strongly suspected to have ASD by a trained professional at the time of referral; (e) verbally fluent with a verbal IQ ≥ 65 according to a standardized intelligence test; (f) substantially motivated to participate in treatment; (g) no history of major mental illness (e.g., schizophrenia, bipolar disorder, severe major depressive disorder with significant suicidal ideation, or other types of psychotic disorders); (h) no current problems such as aggressive behavior or severe oppositional tendencies; (i) no hearing, visual, or physical disabilities that would prevent participation in outdoor sports activities; and (j) no other clinically significant physical or neurological illnesses that would prevent participation in treatment. The inclusion criteria were primarily based on the study by Yoo et al. which demonstrated efficacy of the Korean version of PEERS® in Korean ASD adolescents aged 12–18 years with a verbal IQ above 65 (Yoo et al. 2014). The
age range for participation in the current study was expanded to 11–19 years by the psychiatrists based on the individuals’ clinical needs. One 11-year-old participant with superior intelligence and high motivation but in the sixth grade and two 19-year-old individuals in the third grade of high school were thus included in this study.

Data obtained from all the 126 cases were retrospectively screened. One participant with a verbal IQ lower than 65 (verbal IQ = 63, performance IQ = 103, full scale IQ [FSIQ] = 77) and 15 participants who completed the intervention but did not participate in the follow-up survey were not included in the current study. Among the 15 participants, 1 withdrew after the first session, and we could not determine the reason; 14 had completed the intervention, but post-treatment scores were not available probably owing to non-compliance because no further visits were recorded. Finally, a total of 110 adolescents and their parents who had completed the program, pre-evaluation, and post-evaluation were included in the analysis.

Measures

The assessments were performed during the first treatment session (pre-treatment at week 1) and the last treatment session (post-treatment at week 14). Primary outcome measures including self-test and caregiver-rated questionnaires mainly evaluated teens’ social ability and problems. Secondary outcome measures included scales for symptoms of depression and anxiety.

Primary Outcome Measures

Social Communication Questionnaire, Current Form The Social Communication Questionnaire (SCQ) is a useful screening measure of ASD and is rated by primary caregivers. This questionnaire is composed of 40 items selected from ADI-R (Lord et al. 1994), one of the most comprehensive clinical diagnostic instruments of ASD. Each item asks whether an abnormal behavior is present, and a score of either 1 or 0 is then assigned. The first item does not receive a score but determines whether a child is verbal or non-verbal. Only verbal children are assigned to the six items associated with abnormal language. Therefore, the total scores range from 0 to 39 for verbal people and from 0 to 33 for non-verbal people (Rutter et al. 2003). The Korean version of SCQ (K-SCQ) was translated, back-translated, and approved (Yoo 2008). The validation study of the K-SCQ showed good internal consistency (α = 0.95 in K-SCQ Lifetime; α = 0.93 in K-SCQ Current), and the K-SCQ showed a significant correlation with K-ADI-R subdomain scores and SRS total scores (Kim et al. 2015). In the current study, Cronbach’s internal consistency was 0.85 in the K-SCQ.

Social Responsiveness Scale The Social Responsiveness Scale (SRS) is a 65-item questionnaire rated by a teacher, parent, or other primary caregivers to assess social awareness, social cognition, social communication, social motivation, and autistic mannerisms of a child or adolescent aged 4–18 years. The response of each item is rated from 1 (not true) to 4 (almost always true) but is recoded from 0 to 3 for analytic purposes. Due to its quantitative nature, the SRS is useful for measuring ASD symptom severity and the response to interventions over time (Constantino and Gruber 2005). Confirmatory factor analysis by Frazier et al. suggests the use of a two factor model of the SRS: Social Communication/Interaction (SCI; subscale items for social awareness, social cognition, social communication, and social motivation) and Restricted/Repetitive Behavior (RRB; autistic mannerisms) (Frazier et al. 2012, 2014). The SRS-SCI and SRS-RRB scales contain 53 and 12 items, respectively. In our study, responses on the SRS-SCI and SRS-RRB were analyzed. The current data were obtained from the teens’ parents using the Korean version of the SRS. The Korean version of the SRS showed good internal consistency in the population sample in the present study (α = 0.93 for SRS-SCI and α = 0.79 for SRS-RRB).

Test of Adolescent Social Skills Knowledge—Revised The Test of Adolescent Social Skills Knowledge—Revised (TASSK-R) was originally developed by investigators of PEERS® to assess changes in adolescents’ knowledge of the specific social skills taught during the intervention (Laugeson and Frankel 2010). Two items were extracted from key elements in each session of 13 (26 items in total), and a total score of 0–26 was obtained. Cronbach’s alpha was 0.56 in this study, and this low internal consistency was acceptable considering the broad domain of questions (Laugeson et al. 2009). The TASSK-R, which was translated to Korean, back translated, and then reviewed and edited again, showed an internal consistency of 0.85 in a previous Korean study (Yoo et al. 2014). In our study, the α of the TASSK-R was 0.40, and the low internal consistency is comparable with that observed in other studies in both adolescents and young adults (Laugeson et al. 2009; McVey et al. 2016; Schohl et al. 2014).

Secondary Outcome Measures

Child Depression Inventory The Child Depression Inventory (CDI) is a 27-item self-report questionnaire widely used for assessing depressive symptoms in children and adolescents aged 7–17 years. Each item consists of three statements, and severity is scored from 0 to 2. The total scores range from 0 to 54, with the cutoff score set at 13 in clinical settings and 19 or 20 in non-clinical settings (Kovacs 1985). The Korean version of the CDI has been
Korean teens. Teens frequently use. Most changes are based on a survey of phrasing or jokes have been replaced by words that Korean favored by Korean teens, and the examples of appropriate get-togethers have been substituted with activities replaced or modified. For example, the suggestions for activities that are not applicable to Korean teens have been conducted in the Korean version. Some contents orency: α = 0.88 for A-state and α = 0.83 for A-trait) (Cho and r = 0.69 for A-state and r = 0.75 for A-trait; internal consist-

In addition, the reliability and validity of the Korean form of the STAIC has also been examined (test–retest reliability: r = 0.69 for A-state and r = 0.75 for A-trait; internal consistency: α = 0.88 for A-state and α = 0.83 for A-trait) (Cho and Choi 1989). The α was 0.90 for the STAIC-T and 0.91 for the STAIC-S in this sample. Considering that the STAIC-T, which reflects the trait, would be less affected by an intervention, only the STAIC-S data were analyzed as treatment outcome measures.

State and Trait Anxiety Inventory for Children (STAIC-T and STAIC-S) consists of two 20-item scales that separately measure a person’s state anxiety (A-state) and his/her trait anxiety (A-trait). The A-state measures how the children feel at the present time and assesses short-term anxiety that is usually situationally specific. The A-trait examines long-term anxiety and relatively stable individual differences. The scoring system is based on a 3-point rating scale, and the total scores range from 20 to 60 for each scale (Spilberger and Edwards 1973). The normative data in the STAIC are available for children aged between 8 and 14 years, and the STAIC has been used in adolescents. The reliability and validity of the STAIC has been examined in an adolescent population sample (Kirisci and Clark 1996). In addition, the reliability and validity of the Korean form of the STAIC has also been examined (test–retest reliability: r = 0.69 for A-state and r = 0.75 for A-trait; internal consistency: α = 0.88 for A-state and α = 0.83 for A-trait) (Cho and Choi 1989). The α was 0.90 for the STAIC-T and 0.91 for the STAIC-S in this sample. Considering that the STAIC-T, which reflects the trait, would be less affected by an intervention, only the STAIC-S data were analyzed as treatment outcome measures.

Korean Version of PEERS®

PEERS® is a manual-based, parent-assisted social skills training program for adolescents with ASD. As described by Yoo et al. (2014), cultural adaptation of PEERS® has been conducted in the Korean version. Some contents or activities that are not applicable to Korean teens have been replaced or modified. For example, the suggestions for activity-based get-togethers have been substituted with activities favored by Korean teens, and the examples of appropriate phrasing or jokes have been replaced by words that Korean teens frequently use. Most changes are based on a survey of Korean teens.

PEERS® consists of 14 sessions with different themes; each session takes 90 min per week. The themes mainly focus on making and keeping friends and managing peer rejection and conflict. Parents and teens participate in concurrent sessions separately. Each session is composed of homework review, didactic lessons, role-play demonstrations by trained leaders, behavioral rehearsal exercises by teens, and homework assignments. After each session, participants repeat and rehearse the newly learned skills with parental assistance. (Laugeson and Frankel 2010).

In this study, the group sessions were conducted by six trained treatment leaders and three coleaders. The trained treatment leaders comprised board-certified child psychiatrists, licensed clinical psychologists, and special education teachers who received training under the PEERS® Certified Provider. Coleaders, who were psychology or special education graduate students or clinical psychology trainees, were supervised throughout the intervention delivery.

Power Analysis

A priori power analysis was conducted using G*Power 3.1.9.2 (Faul et al. 2007), and a large effect size was used according to a previous study (Gantman et al. 2012; f = 0.54 for multivariate analysis of variance [MANOVA]). At a 0.05 significance level, 30 participants would be needed to detect differences among three groups with four variables at β = 0.80. In this study, a total of 110 teens were enrolled, and the sample size was thus sufficient for adequate power.

Statistical Analyses

Participants were divided into three age groups: early adolescence (11–13 years; n = 39), middle adolescence (14–15 years; n = 43), and late adolescence (16–19 years; n = 28). The division of adolescence into three stages is a generally accepted way to understand the developmental trajectory of this rapidly changing period (Barrett 1996; Sadock et al. 2015). The definition of the boundary in each period varies in different studies (Braet et al. 2013; Clark-Lempers et al. 1991; Onrust et al. 2016). We divided the adolescence period into early, middle, and late adolescence based on the assumption that middle adolescents are approximately 14–16 years of age. However, we decided to define middle adolescence more narrowly to compensate for the sample size differences and to reflect that most teens enter high school at 16 years of age.

Analysis of variance for means and chi-squared test for frequency variables were performed to examine intergroup differences in demographic characteristics and baseline scores. Considering the correlation among the outcome variables, differences between pretreatment and posttreatment variables and comparisons of the treatment effects among the three groups were analyzed using repeated-measures MANOVA.
Statistical analyses were performed using IBM SPSS Statistics, version 23.0 (SPSS Inc., Chicago, IL, USA). Data are presented as mean ± standard deviation for continuous variables and as percentage for frequency variables. Statistical significance was defined as \( p < 0.05 \).

## Results

The data of 11 cases of SCQ, 4 of SRS, 6 of TASSK-R, 3 of CDI, and 3 of STAIC were unavailable. Listwise deletion was used to manage missing data of outcome variables.

Baseline characteristics of adolescents in each group are shown in Table 1. All participants were Korean adolescents with Korean as their first language. The average ages of participants in the early, middle, and late adolescence groups were 12.36 ± 0.54, 14.49 ± 0.51, and 16.79 ± 0.88 years \( (p < 0.001) \), respectively, and the mean parental ages increased with the teens’ ages (paternal age: \( p = 0.001 \); maternal age: \( p = 0.009 \)). All but one early adolescent and five middle adolescents were male (male percentage: 97.4, 88.4, and 100% in the early, middle, and late adolescence groups, respectively; \( p = 0.118 \)). No significant differences were observed in SES or parental education among the three groups (SES: \( p = 0.996 \); paternal education: \( p = 0.605 \); maternal education: \( p = 0.483 \)). Mean verbal IQ scores (108.31, 94.50, and 95.52 in the early, middle, and late adolescence groups, respectively) and mean FSIQ scores (105.8, 94.4, and 94.7 in the early, middle, and late adolescence groups, respectively) were significantly different among the three groups (verbal IQ: \( p < 0.001 \); FSIQ: \( p = 0.003 \)), but performance IQ scores were not (101.6, 97.7, and 95.3 for the early, middle, and late adolescence groups, respectively; \( p = 0.424 \)). No significant differences were observed among the three groups in baseline ADOS (language and communication domain, \( p = 0.730 \); reciprocal social interaction domain, \( p = 0.452 \); stereotyped behaviors and restricted interests domain, \( p = 0.748 \); imagination domain, \( p = 0.391 \)), SCQ (lifetime scores, \( p = 0.575 \); current scores, \( p = 0.370 \)), SRS-SCI (\( p = 0.233 \)), SRS-RRB (\( p = 0.095 \)), and TASSK-R (\( p = 0.578 \)); however, significant inter-group differences were found in pretreatment CDI (\( p = 0.002 \)), STAIC-T (\( p = 0.005 \)), and STAIC-S (\( p < 0.001 \)) scores. The only significant difference in drug use among the three groups was stimulant use rate (41.0, 45.2, and 7.4% for the early, middle, and late adolescence groups, respectively; \( p = 0.003 \)).

Repeated-measures MANOVAs were performed to compare scores before and after the intervention to assess the treatment effectiveness (Table 2). Primary and secondary outcome measures were analyzed by two separate MANOVAs. A significant main effect of treatment (Wilks’ Lambda = 0.944; \( F[4,92] = 52.53, p < 0.001 \), partial \( \eta^2 = 0.70 \)) was observed for primary outcomes, SCQ, SRS-SCI, SRS-RRB, and TASSK. Univariate tests revealed significant decreases in SCQ, SRS-SCI, and SRS-RRB (SCQ: \( F[1,95] = 11.08, p = 0.001 \), partial \( \eta^2 = 0.10 \); SRS-SCI: \( F[1,95] = 23.02, p < 0.001 \), partial \( \eta^2 = 0.20 \); SRS-RRB: \( F[1,95] = 9.28, p = 0.003 \), partial \( \eta^2 = 0.09 \)) and significant increases in social skills knowledge, assessed by TASSK (\( F[1,95] = 189.62, p < 0.001 \), partial \( \eta^2 = 0.67 \)), after the treatment. For secondary outcome measures, no significant main effects of treatment were observed (Wilks’ Lambda = 0.944; \( F[2,103] = 3.03, p = 0.053 \), partial \( \eta^2 = 0.06 \)), although the mean scores of self-reported depression and anxiety based on CDI and STAIC-S decreased after treatment. Univariate analysis revealed significant effects only in STAIC-S (\( F[1,104] = 5.45, p = 0.021 \), partial \( \eta^2 = 0.05 \)) but not in CDI (\( F[1,104] = 3.09, p = 0.082 \), partial \( \eta^2 = 0.03 \)).

Mean pre-treatment and post-treatment scores of the three groups are shown in Table 3. Repeated-measures MANOVAs in the same way were performed separately to examine the treatment effectiveness in each group. The global treatment effect for primary outcome measures was significant in the three age groups (\( p < 0.001 \) in each group), while the global treatment effect for secondary outcome measures was significant only in the late adolescence group (\( p < 0.001 \) but not in the early (\( p = 0.216 \)) or the middle (\( p = 0.956 \)) group. Additionally, the following univariate analyses revealed some differences among the three age groups. In the early adolescence group, significant improvements after treatment were observed in SRS-SCI (\( p = 0.024 \)), SRS-RRB (\( p = 0.022 \)), and TASSK-R (\( p < 0.001 \)) but not in SCQ (\( p = 0.110 \)), CDI (\( p = 0.236 \)), or STAIC-S (\( p = 0.084 \)). In the middle adolescence group, significant changes following treatment were found in SCQ (\( p = 0.026 \)) and TASSK-R (\( p < 0.001 \)) but not in SRS-SCI (\( p = 0.077 \)), SRS-RRB (\( p = 0.941 \)), CDI (\( p = 0.853 \)), or STAIC-S (\( p = 0.867 \)). The late adolescents showed significant improvements in SRS-SCI (\( p < 0.001 \)), SRS-RRB (\( p = 0.002 \)), TASSK-R (\( p < 0.001 \)), CDI (\( p = 0.023 \)), and STAIC-S (\( p = 0.010 \)) but not in SCQ (\( p = 0.110 \)).

To examine intergroup differences in the treatment effect, repeated-measures MANOVAs were conducted as a mixed model design (Time by Group; Time: pre-treatment and post-treatment; Group: early, middle, and late adolescence). Verbal IQ and the use of stimulants, which significantly differed among the three groups, were adjusted as covariates. Multivariate analyses of SCQ, SRS-SCI, SRS-RRB, and TASSK-R demonstrated no significant Time*Group interaction effects (Wilks’ Lambda = 0.878; \( F[8,158] = 1.32, p = 0.24 \), partial \( \eta^2 = 0.06 \)). Univariate analyses revealed significant Time*Group interaction effects in SRS-RRB (\( F[2,82] = 4.68, p = 0.012 \), partial \( \eta^2 = 0.10 \)) but not in SCQ (\( F[2,82] = 0.07, p = 0.929 \),
multivariate analyses for secondary outcome measures revealed no significant Time*Group interaction effects (Wilks' Lambda = 0.966; $F_{[4,180]} = 0.78$, $p = 0.54$, partial $\eta^2 = 0.02$).

Table 1 Baseline characteristics of participants in the three adolescence groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Groups</th>
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<tbody>
<tr>
<td></td>
<td>Early adolescence (n = 39)</td>
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<td></td>
<td>Middle adolescence (n = 43)</td>
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<td></td>
<td>Late adolescence (n = 28)</td>
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<td></td>
<td>Mean (SD)/%</td>
<td>Mean (SD)/%</td>
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<tr>
<td>Age (years)</td>
<td>12.4 (0.5)</td>
<td>14.5 (0.5)</td>
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<tr>
<td>Male (%)</td>
<td>97.4</td>
<td>88.4</td>
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<td>SES</td>
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<td>2.95 (0.69)</td>
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<td>Parental age</td>
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<tr>
<td>Father (years)</td>
<td>46.6 (3.7)</td>
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<td>44.5 (4.0)</td>
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<td>Parental education</td>
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<tr>
<td>Father (years)</td>
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<td>15.4 (2.1)</td>
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<tr>
<td>Mother (years)</td>
<td>15.0 (2.4)</td>
<td>14.9 (2.1)</td>
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<tr>
<td>Intelligence</td>
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<tr>
<td>Verbal IQ</td>
<td>108.3 (11.2)</td>
<td>94.5 (16.6)</td>
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<tr>
<td>Performance IQ</td>
<td>101.6 (16.8)</td>
<td>97.7 (19.7)</td>
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<tr>
<td>Full-scale IQ</td>
<td>105.8 (13.1)</td>
<td>94.4 (16.7)</td>
</tr>
<tr>
<td>ADOSa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>4.04 (1.34)</td>
<td>4.03 (1.38)</td>
</tr>
<tr>
<td>Social interaction</td>
<td>8.04 (2.08)</td>
<td>8.55 (2.61)</td>
</tr>
<tr>
<td>Stereotyped behaviors and restricted interests</td>
<td>0.85 (0.66)</td>
<td>0.81 (0.60)</td>
</tr>
<tr>
<td>Imagination</td>
<td>0.74 (0.81)</td>
<td>0.71 (0.64)</td>
</tr>
<tr>
<td>SCQ-lifetime</td>
<td>17.1 (6.9)</td>
<td>18.4 (7.7)</td>
</tr>
<tr>
<td>SCQ-current</td>
<td>12.3 (5.6)</td>
<td>13.7 (6.1)</td>
</tr>
<tr>
<td>SRS-SCI</td>
<td>70.2 (19.3)</td>
<td>69.6 (17.3)</td>
</tr>
<tr>
<td>SRS-RRB</td>
<td>14.2 (6.2)</td>
<td>13.3 (5.8)</td>
</tr>
<tr>
<td>TASSK-R</td>
<td>13.9 (3.8)</td>
<td>13.2 (2.7)</td>
</tr>
<tr>
<td>CDI</td>
<td>16.5 (9.5)</td>
<td>16.5 (7.8)</td>
</tr>
<tr>
<td>STAIC-T</td>
<td>33.8 (8.4)</td>
<td>33.9 (7.9)</td>
</tr>
<tr>
<td>STAIC-S</td>
<td>34.6 (8.1)</td>
<td>34.6 (7.6)</td>
</tr>
<tr>
<td>Medication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None (%)</td>
<td>48.7</td>
<td>38.1</td>
</tr>
<tr>
<td>Antidepressant (%)</td>
<td>17.9</td>
<td>16.7</td>
</tr>
<tr>
<td>Stimulant (%)</td>
<td>41.0</td>
<td>45.2</td>
</tr>
</tbody>
</table>

Comparisons of means were performed using analysis of variance (ANOVA), and comparisons of frequency variables were performed using chi-squared test.

ADOS Autism Diagnostic Observation Schedule, SCQ Social Communication Questionnaire, SRS-SCI Social Communication/Interaction factor of Social Responsiveness Scale, SRS-RRB Restricted/Repetitive Behavior factor of Social Responsiveness Scale, TASSK-R Test of Adolescent Social Skills Knowledge—Revised, CDI Child Depression Inventory, STAIC-T/STAIC-S State and Trait Anxiety Inventory for Children, ns not significant

*aThe numbers of participants were 22, 25, and 16 in the early, middle, and late adolescence group, respectively.

Partial $\eta^2 = 0.00$, SRS-SCI ($F_{[2,82]} = 2.09$, $p = 0.131$, partial $\eta^2 = 0.05$), or TASSK-R ($F_{[2,82]} = 0.10$, $p = 0.905$, partial $\eta^2 = 0.00$).

Multivariate analyses for secondary outcome measures revealed no significant Time*Group interaction effects (Wilks’ Lambda = 0.966; $F_{[4,180]} = 0.78$, $p = 0.54$, partial $\eta^2 = 0.02$). Univariate analyses of CDI and STAIC-S showed no significant Time*Group interaction effects (CDI: $F_{[2,90]} = 1.54$, $p = 0.22$, partial $\eta^2 = 0.03$; STAIC-S: $F_{[2,90]} = 0.58$, $p = 0.56$, partial $\eta^2 = 0.01$) either.
Discussion

Our findings suggest that PEERS® is similarly effective in ASD patients in early, middle, and late adolescence. We hypothesized that adolescents in the early group, which benefit from early-adolescent formation of social relationships and brain development, would show the best response to PEERS®. In this study, multivariate analyses did not show significant differences in global treatment effects among the three age groups for both primary and secondary outcome measures. Univariate analyses revealed significant intergroup differences in score changes of SRS-RRB, which did not affect the global treatment effect.

The present results suggest that PEERS® might be equally beneficial in all of the three groups despite differences in biological and psychosocial development characteristics among the three stages. Age has been suggested as a moderating factor in social skills interventions for adolescents, although the few published studies have shown mixed results. Our results support the findings in a previous investigation of PEERS®, which did not show a clear effect of age on social outcome measures using the linear regression analysis (Chang et al. 2014). A meta-analysis concluded that age could not be used to predict the self-report intervention effects (Gates et al. 2017). Altogether, these results suggest that despite possible innate differences in developmental trajectories and tasks among different ages, group-based social skills intervention, in combination with personalized approaches including homework assignments, parental participation, and accompanied side meetings to address personal issues throughout treatment, can benefit all adolescent age groups.

Table 2 Comparisons of outcome variables before and after treatment

<table>
<thead>
<tr>
<th>Variables</th>
<th>Before treatment</th>
<th>After treatment</th>
<th>F*</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary outcome variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCQ</td>
<td>13.3 (6.5)</td>
<td>11.5 (6.4)</td>
<td>11.08</td>
<td>0.001</td>
</tr>
<tr>
<td>SRS-SCI</td>
<td>73.1 (22.5)</td>
<td>64.6 (22.5)</td>
<td>23.02</td>
<td>0.000</td>
</tr>
<tr>
<td>SRS-RRB</td>
<td>14.3 (6.1)</td>
<td>12.7 (6.4)</td>
<td>9.28</td>
<td>0.003</td>
</tr>
<tr>
<td>TASSK-R</td>
<td>13.7 (3.2)</td>
<td>20.0 (3.9)</td>
<td>189.62</td>
<td>0.000</td>
</tr>
<tr>
<td>Secondary outcome variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDI</td>
<td>18.3 (9.4)</td>
<td>17.1 (9.5)</td>
<td>3.09</td>
<td>0.082</td>
</tr>
<tr>
<td>STAI-C-S</td>
<td>36.5 (8.4)</td>
<td>34.9 (7.9)</td>
<td>5.45</td>
<td>0.021</td>
</tr>
</tbody>
</table>

Differences between pretreatment and posttreatment variables were analyzed using repeated-measures multivariate analysis of variance (MANOVA)

n = 96

n = 105

Results of univariate repeated measure ANOVAs following repeated measure MANOVAs

Table 3 Mean pre-treatment and post-treatment scores of the three groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Group</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post</th>
<th>Pre</th>
<th>Post</th>
<th>Pre-Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary outcome variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCQ</td>
<td>Early Adolescence (n = 38)</td>
<td>12.06 (5.75)</td>
<td>10.50 (5.66)</td>
<td>1.56</td>
<td>0.348</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRS-SCI</td>
<td>Middle Adolescence (n = 38)</td>
<td>13.75 (6.21)</td>
<td>12.05 (6.49)</td>
<td>1.70</td>
<td>0.096</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRS-RRB</td>
<td>Late Adolescence (n = 24)</td>
<td>13.97 (5.93)</td>
<td>11.77 (5.74)</td>
<td>2.21</td>
<td>0.028</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TASSK-R</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary outcome variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDI</td>
<td>Early Adolescence (n = 38)</td>
<td>16.51 (9.53)</td>
<td>14.76 (9.60)</td>
<td>1.75</td>
<td>0.811</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>STAI-C-S</td>
<td>Middle Adolescence (n = 38)</td>
<td>34.61 (8.24)</td>
<td>32.74 (8.13)</td>
<td>1.87</td>
<td>0.064</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Late Adolescence (n = 24)</td>
<td>34.60 (7.65)</td>
<td>32.74 (7.65)</td>
<td>1.87</td>
<td>0.064</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant differences between pretreatment and posttreatment (p < 0.05)

†Significant differences between pretreatment and posttreatment (p < 0.05)

‡Significant differences between pretreatment and posttreatment (p < 0.05)
However, our findings are different from those in other studies, which showed either positive or negative effects of age on outcomes measures of social relationships or comorbid emotional symptoms (Choque Olsson et al. 2017; Herbrecht et al. 2009; Solomon et al. 2004). In a study performed in Sweden, statistically more improvement was observed in the SRS scores in the older group than in the younger group (Choque Olsson et al. 2017). Another study showed the opposite results: a greater benefit from the training was found in the younger group than in other groups (Herbrecht et al. 2009). However, because these two studies compared participants between the early adolescence (7–12 years or 9.3–12.7 years) and the remaining adolescence (13–17 years or 14.6–19.5 years), the findings in these two studies are not directly comparable to those in our study. In another study, the older adolescents showed greater improvement in depressive symptoms, while the younger adolescents showed greater improvement in emotional understanding, suggesting that the cognitive-emotional development, and thus the treatment response, across age groups might not be identical even though the target of the treatment is the same (Solomon et al. 2004). These inconsistent findings suggest that individual characteristics (such as verbal IQ, comorbid symptoms, participants’ motivation and compliance, baseline social functioning, or self-awareness of social deficits), rather than general characteristics (such as sex or age), are moderators of intervention efficacy (Chang et al. 2014; Gates et al. 2017; McMahon et al. 2013; Pelliccia and Wierson 1994; Palmonari et al. 1991); therefore, the motivation and cooperativeness to the social skills training program, especially a parent-assisted program such as PEERS®, might be affected.

The results obtained from the 15 participants, who were excluded from this study because of missing post-treatment data, were not significantly different from those obtained from the 110 included participants. The excluded participants comprised 4 early adolescents, 10 middle adolescents, and 1 late adolescent. No significant differences were observed between excluded and included participants in verbal IQ (99.36 vs. 93.80, p = 0.30), sex (94.5 vs. 93.3% males, p = 0.85), baseline SCQ (13.4 vs. 14.2, p = 0.78), SRS-SCI (72.6 vs. 71.3, p = 0.84), SRS-RRB (14.4 vs. 13.5, p = 0.57), TASSK (13.6 vs. 13.6, p = 0.95), CDI (18.3 vs. 21.9, p = 0.17), or STAIC-S (36.6 vs. 38.4, p = 0.46). Therefore, the bias was not considered large.

This study has several limitations. First, compared with a more typical classification according to a 3-year interval in each period, the early, middle, and late adolescence stages were classified in a slightly arbitrary manner because of uneven numbers of participants in this study. Second, the verbal IQ was not evenly distributed in each age group and was adjusted as a covariate statistically. This might be because only those with relatively high verbal ability could be eligible for participation in the intervention in the younger teen group compared with other age groups. Third, the effects of concurrent treatments were not completely controlled during PEERS®, therefore, there is a possibility that the participants were under other kinds of psychosocial interventions, such as individual counseling or school-based intervention. Fourth, although stress and pressure might affect the intervention in terms of the least change after the intervention in the middle adolescence group, the participants’ social and academic environment was not completely examined. Finally, direct observations reflecting improvement in a real-life situation or third-party assessments including teaching ratings scales were lacking in this study.

In conclusion, the treatment effects of social skills training programs targeting adolescents with ASD, based on learning through didactic lessons and metacognitive approaches such as PEERS®, seem to be beneficial regardless of the patient age and the adolescence stage.

Acknowledgments This research was supported by a National Research Foundation of Korea (NRF) grant funded by the Korea government [NRF-2017M3c7a1027467] and by Disease-focused...
Healthcare Technology R&D project by Ministry of Health and Welfare (MOHW), Republic of Korea [HI14C2336]. We would like to thank the teens and the families who participated in this study. This paper has presented as a poster presentation at the Cognition, Sleep, Mood, and Stress (COSMOS) February 2018 under the title: Differences in the Treatment Effects of the PEERS® Social Skills Training Depending on Age in Adolescents with ASD.

**Author Contributions** JKH participated in the conception and design of the study, conducted the statistical analyses and interpretation of the data, and drafted the manuscript; MO participated in the delivery of the intervention, and helped draft the manuscript; GB, JHK, GB, and IHC participated in the delivery of the intervention and data acquisition, and reviewed the manuscript; HYJ conceived of the study, participated in its design and measurement, led the delivery of the intervention and data acquisition, reviewed the statistical analyses and interpretation of the data, and revised the manuscript. All authors read and approved the final manuscript.

**References**


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