康复学报
Rehabilitation Medicine

·综 述·

国外人工智能辅助自闭症谱系障碍诊断及其康复训练研究进展

马博森[1*],曾小荣[2],龚 然[1],李发睿[1]

1 浙江大学外国语言文化与国际交流学院,浙江 杭州 310058;
2 江西农业大学外国语学院,江西 南昌 330045
* 通讯作者:马博森,E-mail:mabosen@126.com

收稿日期:2019-09-03;接受日期:2019-10-27
基金项目:国家社科基金重点项目(17AYY009)
DOI:10.3724/SP.J.1329.2019.06065
开放科学(资源服务)标识码(OSID):

摘要 旨在综述国外运用人工智能技术辅助自闭症谱系障碍诊断及其康复训练的相关研究,为国内该领域的研究提供借鉴。自闭症谱系障碍是一类以社交障碍及刻板行为为核心特征的神经发育障碍性疾病。作为一种谱系障碍,其亚类之间乃至亚类内部的异质性明显。近年来,自闭症谱系障碍发病率不断攀升,但早期诊断及康复训练资源匮乏。随着人工智能技术的持续进步,利用人工智能来辅助诊断自闭症谱系障碍及康复训练逐步成为研究的热点。国外的人工智能辅助诊断研究通过训练神经网络模型对相关数据进行分析来实现,这些数据主要为:① 脑成像数据,由自闭症谱系障碍人群数据及匹配组人群数据组成;② 多模态数据,自闭症谱系障碍婴儿或儿童产出的语言、动作、面部表情等多模态数据及诊断过程的数据。康复训练方面,基于人工智能技术的非机器人干预设备和机器人干预设备在研究中广泛使用。就非机器人干预设备的康复训练研究而言,早期研究主要关注单项交际技能的康复训练。随着人机交互技术及虚拟现实技术的进步,相关的研究逐步转向综合训练。与单项训练相比较,综合训练不仅关注交际能力,且所创设的情境更接近真实的生活语境。就机器人干预而言,相关研究包括:探讨使用机器人教授自闭症儿童社交技能的方法及效果;或探讨训练这一人群感知动作的能力;或将机器人与传统干预技术结合使用。这些研究取得两方面进展:其一,更加关照自闭症谱系障碍人群,特别是儿童的心理特点和使用体验;其二,针对缺乏个性化这一自闭症谱系障碍康复训练领域亟待解决的问题,开始探讨个性化康复技术的解决方案。目前国内自闭症谱系障碍的人工智能辅助诊断及康复训练研究得到了学界和医疗界的关注,但现有研究成果及应用还远不能满足这一庞大群体对高质量诊断和康复训练资源的需求。借鉴国外研究的成果,国内相关领域的研究可从推动不同学科领域合作、推进个性化干预及研发符合我国自闭症谱系障碍人群的心理特征及喜好的康复训练设备这三方面拓展和深化。

关键词 自闭症谱系障碍;人工智能;辅助诊断;辅助康复训练

自闭症谱系障碍是一类以社交交流和社交互动缺陷,以及受限的、重复的行为模式、兴趣或活动为主要特征的神经发育障碍性疾病[1]。美国自闭症与发展障碍监测网络对美国 11 个州 8 周岁儿童的监测显示,2014 年,自闭症谱系障碍的发病率约为 1:59,与 2000—2002 年的发病率(1:150)相比,攀升 119.4%[2]。虽然自闭症谱系障碍的发病率在升高,但相应的早期诊断及康复资源匮乏。随着人工智能研究的持续推进,如何利用人工智能技术辅助自闭症谱系障碍的诊断及康复训练逐步成为研究热点。

本文简述人工智能运用于自闭症谱系障碍辅助诊断和康复训练的基本原理,介绍国外相关研究

引用格式:马博森,曾小荣,龚然,等. 国外人工智能辅助自闭症谱系障碍诊断及其康复训练研究进展[J]. 康复学报,2019,29(4):65-69.
MA B S,ZENG X R,GONG R. Advances in the study of AI-assisted diagnosis and rehabilitation of ASD [J]. Rehabilitation Medicine,2019,29(6):65-69.
DOI:10.3724/SP.J.1329.2019.06065

近10年的进展，探讨国外研究对国内相关研究的借鉴意义。

1 人工智能及其辅助诊断和康复训练的基本工作原理

人工智能研究是研究如何使计算机做过去只有人才能做的智能工作。随着移动互联网、大数据、超级计算、传感器等新理论和技术的出现，人工智能得到了迅速发展，促进了社会各个领域的智能化[3]。人工智能辅助诊断自闭症及进行康复训练主要运用基于统计学和数学的机器学习理论。就人工智能辅助诊断而言，目前研究主要运用多模态数据驱动下的特征学习与分类。就康复训练而言，主要技术路线为通过机器学习来发现自闭症谱系障碍人群的兴趣爱好等个性化特点，然后针对这些特点进行康复训练。

2 基于人工智能技术的自闭症谱系障碍辅助诊断研究

自闭症的人工诊断国际上一般采用《自闭症诊断访谈量表（修订版）》[4]（autism diagnostic interview-revised，ADI-R）和《自闭症诊断观察量表（第2版）》[5]（autism diagnostic observation schedule，second edition，ADOS-2）。前者是针对自闭症家长和主要看护人的访谈工具，通过他们提供诊断对象在婴幼儿阶段的语言、行为、基本生活能力、兴趣等诸多方面的信息，在此基础上进行诊断；后者是一个半结构化的评估工具，用于评估儿童在社会互动、游戏、沟通和想象性利用材料方面的能力。这两种量表合并称为自闭症谱系障碍诊断的金标准。在我国港台地区，这两种量表主要用于研究。我国内地由于ADOS-2、ADI-R的中文版尚未出版，目前仍未能直接使用于临床。目前我国内地临床使用的筛查和诊断评估工具主要有儿童ASD评定量表（childhood autism rating scale，CARS）、ASD行为量表（autism behavior checklist，ABC）等[6]。

国外人工智能辅助诊断自闭症谱系障碍的研究主要采用训练神经网络模型对相关数据进行分析来实现。根据数据类型，这些研究包括以下两类：① 基于脑成像数据的研究。HAZLETT等[7]利用深度学习神经网络分析6～12个月大的高风险自闭症婴儿的大脑皮层成像信息，以此来预测他们在24个月大时的诊断结果。这一研究报道的预测准确率达81%。HEINSFELD等[8]利用人工智能的方法对比来自Autism Brain Imaging Data Exchange（ABIDE）数据库中的505名自闭症患者和530名匹配对照组的脑成像数据，辅助诊断的准确度最高达到70%。ABIDE数据库为国际脑成像数据分享项目（international neuroimaging data-sharing initiative，INDI）整合全球多个实验室脑结构和功能影像数据建设的自闭症脑成像交换数据库。其中，2012年发布的第一期数据库中包括539例自闭症谱系障碍患者及匹配的573例正常人群的fMRI数据；2016年发布的第二期数据库则包括521例自闭症谱系障碍患者及593例匹配组的数据。② 基于语言、动作、面部表情等多模态数据及诊断过程数据的研究。HASHEMI等[9]参照《婴儿自闭症观察量表》，以12例5～18个月大的自闭症高风险婴儿为对象，发展出一套算法来计算婴儿对自闭症风险评估任务和观察量表中活动的反应。该研究将计算机的评估结果与医生的评估结果进行对比，发现计算机能够抓住重要的行为表征，并观察到医生尚未看到的表征。WALL等[10]采用人工智能的研究方法分析2 867例自闭症谱系障碍患者的ADI-R访谈诊断过程数据。研究发现，虽然该量表共包含93个访谈项目，但其中7个项目的访谈结论便能够预测全量表访谈诊断的结果，预测准确率可高达99%。这7个项目分别为：项目29（能否理解简单的语言）、项目35（能否进行互动交谈）、项目48（是否会玩想象性游戏）、项目49（是否会与团体玩想象性游戏）、项目50（是否有直接注视）、项目64（是否会与同龄人一同玩游戏）和项目86（最早出现明显异常的年龄）。

3 人工智能运用于自闭症谱系障碍康复训练研究

由于模态交互技术的进步以及自闭症谱系障碍人群康复训练市场需求的日益增加等原因，基于人工智能的自闭症人群康复训练研究近年来逐步兴起[11]。这类研究通过人机互动的方式进行，其中“机”的类型主要包含：① 非机器人干预设备，如平板电脑和智能眼镜；② 机器人干预设备，既包括非人形机器人，也包括人形机器人。以下分别介绍使用这两类设备进行康复训练的研究进展。

3.1 非机器人设备应用于康复训练

利用非机器人设备进行自闭症谱系障碍人群的康复训练研究从21世纪初开始起步。早期，非机器人设备所实施的康复训练主要针对自闭症患者的面部表情识别等单项交际技能[12-13]。随着人机交

互技术和虚拟现实技术的进步,近 10 年的相关研究逐步转向综合训练。与单项训练相比较,综合训练以提高这一人群的整体交际能力为目标,且所创设的情境更接近真实的生活语境,如基于人机交互技术的 ECHOES 项目[11]。该项目中,一名自闭症男孩通过触摸式屏幕与该项目中的虚拟人物进行互动。屏幕的上端和两侧各有一个摄像头,用于实时捕捉男孩头部、脸部及注视的多模态数据。在 E-CHOES 项目创设的虚拟互动环境中,物体是可以被触摸和移动的,且儿童可与情境中的虚拟人物共同完成某一交际任务。

除人机交互技术外,融合人工智能的虚拟现实技术也用于训练自闭症谱系障碍人群的社交技能[14-16],如 LIU 等[15]介绍的 Brain Power System (BPS)数字行为辅助系统。该系统不仅能利用人工智能分析患者所处环境、互动情况等方面的量化数据,且在此基础上研发了个性化的、具有增强现实技术的智能眼镜。该眼镜能为患者提供包括情感识别、面对面的凝视、眼神接触和自我行为管理在内的综合训练。该研究选取年龄分别为 8 岁和 9 岁的 2 名自闭症男孩作为实验对象,研究 BPS 的实用性。结果发现,两名男孩的非言语交流、眼神接触、易怒性、嗜睡、刻板行为、多动或不配合性等方面均有所改善。

3.2 使用机器人设备进行康复训练

相对于非人形机器人或普通玩具而言,诸多自闭症儿童对具有典型机器人外表的机器人更感兴趣,不仅对其动作的反应更快,而且表现出更多的社交行为[17]。基于这一优点,近 10 年的相关研究或探讨使用机器人教授自闭症儿童社交技能的方法及效果,这些技能包括模仿、阅读面部表情及进行眼神交流[18-19];或训练这一人群感知动作的能力[20-21];或将机器人与传统干预技术相结合使用[22],主要取得了以下两方面的进展:① 所使用的机器人更符合儿童的心理特点,从而提升使用体验,如SHAMSUDDIN 等[18]使用机器人 Nao 来训练自闭症儿童的目光注视。Nao 是法国 Aldebaran Robotics 公司制造的机器人,功能丰富,能走路、说话、跳舞。陪伴自闭症孩子的过程中,Nao 机器人会与孩子一同参与活动,试图提高他们阅读面部表情的能力和适当进行眼神交流的能力。除机器人更具亲和力外,机器人康复训练还与游戏场景结合,也被证明具有康复效果,如结合乐高(LEGO)治疗法和人形机器人的康复训练模式[23-24]。这一模式中,人形机器人辅助自闭症儿童一同玩乐高。此外,人形机器人还被用于对自闭症儿童的表现进行反馈或鼓励,来达到强化行为的康复训练效果。如在治疗中,机器人模仿美式足球里触底得分的手势对儿童的行为提供积极反馈。② 开始探讨个性化的康复手段。缺乏个性化康复手段是运用机器人进行自闭症谱系障碍儿童康复训练亟待解决的问题。针对这个问题,BEKELE 等[25]设计一种可以自主适应不同需求并且做出个性化反馈的机器人协同技术。该技术主体是一台人形机器人,它拥有头部追踪器和更广阔的视觉范围,可以迅速地捕捉到自闭症儿童的头部移动,并做出个性化的反应。研究表明,该技术对自闭症儿童早期的社交行为具有良好的个性化训练效果。

4 国外相关研究对国内研究的借鉴意义

由于国内自闭症方面的医疗资源比较匮乏,因此采用人工智能的研究方法,开展自闭症谱系障碍的辅助诊断和康复训练研究得到医学界的关注。在辅助诊断方面,国内已有学者通过采集自闭症谱系障碍儿童、正常发育儿童和发育迟缓儿童的多模态行为数据,并运用人工智能方法分析其韵律特征、目光及面部表情识别等数据来辅助诊断的研究[26]。康复训练方面,王广帅等[27]构建面向包含自闭症儿童在内的特殊儿童的多模态智能化学习平台,涵盖认知理解、社交技巧、精细动作、情绪管理等 6 大类学习活动。实践表明,该平台能够有效提高特殊儿童社会适应能力、数学计算及语言表达等功能。

目前,我国约有 1 400 多万自闭症谱系障碍人群[28],国内现有相关研究成果及应用还远不能满足这一庞大群体对高质量诊断和康复训练资源的需求。结合本文所介绍的国外研究进展和国内资源匮乏的现状,国内相关研究可从以下 3 个方面进行拓展和深化:① 推动计算机、医学、语言学、康复治疗学等不同学科领域的合作,实现研究资源共享,基于更大的样本数量和更加丰富的数据类型,合作开展基于人工智能的自闭症谱系障碍辅助诊断研究,进一步提高智能辅助诊断的准确率。② 自闭症谱系障碍包含自闭症、阿斯伯格综合症、儿童期瓦解障碍和非特定广泛性发育障碍,这些亚类乃至亚类内部成员的异质性明显。为了提升康复训练的效果,未来研究应利用基于大数据的人工智能技术,通过便携式设备,采集自闭症谱系障碍患者的个性化多模态行为数据,从而为制定个性化康复训练方案乃至研发个性化康复技术奠定基础。③ 设备的使用体

验方面，研究人员可研发符合我国自闭症谱系障碍人群的心理特征及喜好的康复训练设备，包括人机交互平台、虚拟现实平台及佩戴式的设备，通过提升设备的使用体验来改善康复训练的效果。如同工业时代的蒸汽机和信息时代的互联网，人工智能在大数据时代正扮演着越来越重要的角色，可以预见的是，未来它将在自闭症谱系障碍辅助诊断和康复训练领域扮演更加重要的角色。

参考文献

[1] 陈卓铭. 语言治疗学[M]. 北京：人民卫生出版社，2018：287-288.

[2] BAIO J，WIGGINS L，CHRISTENSEN D L，et al. Prevalence of autism spectrum disorder among children aged 8 years-autism and developmental disabilities monitoring network，11 sites，united states，2014 [J]. MMWR Surveill Summ，2018，67(6)：1-23.

[3] 冯志伟. 人工智能领域得语言者得天下[J]. 语言战略研究，2018，5(3)：1-2.

[4] RUTTER M，LE COUTEUR A，LORD C. The Autism Diagnostic Interview-Revised (ADI-R) [M]. Los Angeles，CA：Western Psychological Services，2003：67-68.

[5] LORD C，RUTTER M，DILAVORE P C，et al. Autism Diagnostic Observation Schedule. 2nd ed. (ADOS-2) [M]. Torrance，CA：Western Psychological Services，2012：89-90.

[6] 周浩，王艺. 中文版儿童孤独症谱系障碍评估工具的现况分析[J]. 临床儿科杂志，2017，35(12)：949-953.

[7] HAZLETT H C，GU H，MUNSELL B C，et al. Early brain development in infants at high risk for autism spectrum disorder [J]. Nature，2017，542(7641)：348-351.

[8] HEINSFELD A S，FRANCO A R，CRADDOCK R C，et al. Identification of autism spectrum disorder using deep learning and theabidedataset [J]. Neuroimage Clin，2018，17(7)：16-23.

[9] HASHEMI J，TEPPER M，SPINA T V，et al. Computer vision-tools for low-cost and noninvasive measurement of autism-related behaviorsin infants [J]. Autism Res Treat，2014，20(14)：1-12.

[10] WALL D P，DALLY R，LUYSTER R，et al. Use of artificial intelligence to shorten the behavioral diagnosis of autism [J]. Plos One，2012，7(8)：43855-43856.

[11] PORAYSKA-POMSTA K，FRAUENBERGER C，PAIN H，et al. Developing technology for autism：an interdisciplinary approach [J]. Pers Ubiquitous Comput，2012，16(2)：117-127.

[12] GOLAN O，BARON-COHEN S，HILL J，et al. The "reading the mind in films" task：complex emotion recognition in adults with and without autism spectrum conditions [J]. Soc Neurosci，2006，1(2)：111-123.

[13] FAJA S，AYLWARD E，BERNIER R，et al. Becoming a face expert：a computerized face-training program for high-functioning individuals with autism spectrum disorders [J]. Dev Neuropsychol，2008，33(1)：1-24.

[14] DIDEHBANI N，ALLEN T，KANDALAFT M，et al. Virtual reality social cognition training for children with high functioning autism [J]. Comput Hum Behavi，2016，62(8)：703-711.

[15] LIU R，SALISBURY J P，VAHABZADEH A，et al. Feasibility of an autism-focused augmented reality smartglasses system for social communication and behavioral coaching [J]. Front Pediatr，2017，5(8)：145-146.

[16] KESHAV N U，SALISBURY J P，VAHABZADEH A，et al. Social communication coaching smart glasses：well toleratedin a diverse sample of children and adults with autism [J]. JMIR Mhealth Uhealth，2017，5(9)：140-141.

[17] DIEHL J J，SCHMITT L M，VILLANO M，et al. The clinical use of robots for individuals with autismspectrum disorders：a critical review [J]. Res Autism Spectr Disord，2012，6(1)：249-262.

[18] SHAMSUDDIN S，YUSSOF H，ISMAIL LI，et al. Initial response in HRI-acase study on evaluation of child with autism spectrum disorders interacting with a humanoid robot Nao [J]. Proc Eng，2012，41(8)：1448-1455.

[19] SO W C，WONG M K Y，CABIBIHAN J J，et al. Using robot animation to promote gestural skills in children with autism spectrum disorders [J]. J Comput Assist Lear，2016，32(6)：632-646.

[20] COSTA S，LEHMANN H，DAUTENHAHN K，et al. Usinga humanoid robot to elicit body awareness andappropriate physical interaction in children with autism [J]. Int J Soc Robot，2015，7(2)：265-278.

[21] MOORTHY R S，PUGAZHENTHI S. Teaching psychomotorskills to autistic children by employing a robotictraining kit：a pilot study [J]. Int J Soc Robot，2017，9(1)：97-108.

[22] VANDERBORGHT B，SIMUT R，SALDIEN J，et al. Using the social robot Probo as a social story telling agent for children with ASD [J]. Interact Stud，2012，13(13)：348-372.

[23] BARAKOVA E I，BAJRACHARYA P，WILLEMSEN M，et al. Long-term LEGO therapy with humanoid robot for children with ASD [J]. Expert Syst，2015，32(6)：698-709.

[24] HUSKENS B，PALMEN A，VAN DER WERFF M，et al. Improving collaborative play between children with autism spectrum disorders and their siblings：the effectiveness of a robot-mediated intervention based on Lego therapy [J]. J Autism Dev Disord，2015，45(11)：3746-3755.

[25] BEKELE E T，LAHIRI U，SWANSON A R，et al. A step towards developing adaptive robot-mediated intervention architecture (ARIA) for children with autism [J]. IEEE Trans Neural Syst Rehabil Eng，2013，21(2)：289-299.

[26] LIU W，LI M，YI L. Identifying children with autism spectrum disorder based ontheir face processing abnormality：a machine learning framework [J]. Autism Res，2016，9(8)：888-898.

[27] 王广帅，陈靓影，张坤，等. 生态系统论视野下人机交互技术教育应用SWOT分析及对策：以自闭症等特殊儿童教育为例[J]. 中国电化教育，2018，39(5)：15-22.

[28] SUN X，ALLISON C，AUYEUNG B，et al. Areview of health care service and education provision ofautism spectrum condition in mainland China [J]. Res Dev Disabil，2013，34(1)：469-479.

Advances in the Study of AI–assisted Diagnosis and Rehabilitation of ASD

MA Bosen[1*], ZENG Xiaorong[2], GONG Ran[1], LI Farui[1]
[1] *School of International Studies, Zhejiang University, Hangzhou, Zhejiang 310058, China;*
[2] *College of Foreign Languages, Jiangxi Agricultural University, Nanchang, Jiangxi 330045, China*
*Correspondence: MA Bosen, E-mail: mabosen@126.com

ABSTRACT This paper reviews the research on AI-assisted diagnosis and rehabilitation of autism spectrum disorder (ASD) with the purpose of enhancing relevant studies in China. ASD is a neurodevelopmental disorder characterized by impairment in communication skills, social interactions, as well as restricted, repetitive, and stereotyped patterns of behavior. As a spectrum disorder, it demonstrates obvious between-subgroup as well as within-subgroup heterogeneity. Despite the rapid increase in the prevalence of ASD in recent years, the medical facilities and staff for its early diagnosis and rehabilitation are still in severe shortage. With the advancement of artificial intelligence (AI) technology, AI-assisted diagnosis and rehabilitation of ASD have become a research focus. The AI-assisted diagnosis research analyzes relevant data mainly by training the artificial neural network. The data include: ① brain imaging data from the ASD group and the matched group. ② multimodal data of speech, movements and facial expressions produced by infants or children with ASD and data of the diagnostic process. With regard to rehabilitation training, AI-assisted non-robot intervention equipment and robot intervention equipment are widely used in research. While early research on rehabilitation with non-robot intervention equipment mainly focuses on the single skill training, recent studies have gradually shifted to the comprehensive training due to the technological advancement of human-computer interaction and virtual reality (VR). Different from the single skill training, the comprehensive training is not only concerned with communicative competence, but also creates situations close to real life. As for robot intervention equipment, while some studies explore methods and effectiveness of using robots to teach autistic children, others discuss the training of the ASD group's ability to perceive movements or combine the use of robots with traditional intervention techniques. Two advances in this line of research are as follows: ① paying more attention to people with ASD, especially autistic children's psychological characteristics and user experience. ② starting to develop individualized rehabilitation training programs which are in urgent need in ASD rehabilitation training. In China, the research on AI-assisted diagnosis and rehabilitation has drawn wide attention from researchers and medical practitioners. However, the research findings and their application can barely meet the demand for high-quality diagnosis and rehabilitation training for ASD population. Drawing on the overseas research, Chinese researchers in relevant fields can expand their research in the following three aspects: encouraging collaborations among different disciplines such as computer science, speech pathology, linguistics etc.; promoting individualized intervention, and developing rehabilitation training equipment in line with the psychological characteristics and preferences of the ASD group in China.
KEY WORDS autism spectrum disorder; AI; AI-assisted diagnosis; AI-assisted rehabilitation
DOI:10.3724/SP.J.1329.2019.06065

(上接第 58 页)

Special Education Combined with Sensory Integration Training for Children with Autism Spectrum Disorder

SHAN Ya*, ZHU Min
Children's Hospital of Nanjing Medical University, Nanjing, Jiangsu 210008, China
*Correspondence: SHAN Ya, E-mail: shanyas@126.com

ABSTRACT **Objective:** To investigate the clinical effect of special education combined with sensory integration training on children with autism spectrum disorder (ASD). **Methods:** A total of 100 ASD children in the department of rehabilitation medicine, Children's Hospital affiliated Nanjing Medical University were randomly assigned to the special sensation group and the single special group by random number table method, with 50 cases in each group. The single special group was given special education intervention, the children should be intervened according to the special education curriculum, including the positive and negative reinforcement, systematic desensitization, extinction, temporary isolation and retribution. We would choose appropriate disgust, warning and other stimuli to minimize the incentives for bad behavior in children with negative reinforcement. For the children with positive reinforcement, we would choose effective reinforcement and gradually depart from the reinforcement process, after education, family members of the children should be guided to intervene at home according to the given intervention operations, which were synchronized with treatment, 40 minutes each time, 6 times a week, 3 months as a course of treatment. The special sensation group was given sensory integration training on the basis of the special education intervention, the personalized sensory integration training program was developed according to the condition, social ability and development of ASD children, which was included the training of tactile, vestibular and proprioceptive sensory, 2 hours each time, 3 times a week, 3 months as a course of treatment. Before the treatment and after 3, 6 months treatment, the children's autism was assessed by children's autism rating scale (CARS), the children's behavior was assessed by children's autism behavior scale (ABC), the children's therapeutic efficacy was assessed by autism treatment evaluation checklist (ATEC). **Results:** There was no significant difference in the CARS score, ABC score and ATEC score between the two groups before the treatment (P>0.05); after 3 and 6 months of treatment, the CARS score, ABC score and ATEC score in the two groups were significantly lower than those before the treatment; after 3 and 6 months of treatment, the degree of decrease of CARS score, ABC score and ATEC score in the special sensation group were significantly more than those in the single special group (P<0.05). After 6 months of treatment, the effective rate in the special sensation group (84.00%) was significantly higher than that in the single special group (64.00%), and the difference was significant (P<0.05). **Conclusion:** Special education combined with sensory integration training can effectively improve ASD children's autistic degree and behavior state, and improve the therapeutic effect on children, which is worthy of further clinical promotion.
KEY WORDS autism spectrum disorder; children; special education; sensory integration training; autism degree; behavior state
DOI:10.3724/SP.J.1329.2019.06055