

Karate: Effective tools to improve social, emotional, and executive functions of students with autism

Rama Kurniawan^{1abcdef}, Ega Yusti Sianti^{2abc}, Annisaa^{3acef}, Suni Rohana^{4bcd}

¹²³⁴Faculty of Sport Science, State University of Malang, East Java, 65145, Indonesia

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Abstract

Patients with Autism Spectrum Disorder (ASD) are increasing daily, requiring appropriate intervention. Martial arts can improve their social, emotional, and executive functioning. This study uses karate martial art to reduce social dysfunction, emotional dysfunction, and stereotyped behavior in children with autism. The Single Subject Research (SSR) method was used with an A-B design that includes two research stages: baseline and intervention stages. Data was collected using a questionnaire adapted from ICD-10 and DSM-IV once a week. The samples used were four children with autism in SLB Lab UM. After training for six weeks, the data were analyzed using the SSR method to present the results in graphical form. The study results illustrated that the emotional, social, and executive functions in children with ASD increased. Karate training can be used as therapy for children with autism to improve and develop their social, emotional, and executive functions. This research has a limited number of involved subjects and needs an extended duration of intervention for future research. This research confirmed that karate could be an alternative therapy to improve the development of students with autism.

Keywords: karate, social, emotional, executive, autism.

INTRODUCTION

Autism Spectrum Disorder (ASD) can occur at any age (Saxena & Chahrour, 2017). ASD is a neurodevelopmental disorder with a high prevalence resulting in significantly impaired social interaction and restricted and repetitive stereotyped behavior patterns or interests (Greco & De Ronzi, 2020). Symptoms commonly experienced by children with ASD include a lack of social communication and interaction, such as low imagination skills, below-average intelligence, and limited verbal and non-verbal communication. Limited communication includes low eye ability to look at

other people when speaking and difficulty expressing faces ([American Psychiatric Association, 2013](#)). Children with ASD tend to have limited interest in something and perform repetitive movements or behaviors. There are about 40% of children with autism who are still infantile suffer from moderate, severe, and very severe mental retardation, 30% of children with autism suffer from mild mental retardation, then others have normal intellectual development ([Nugraheni, 2016](#)).

Other symptoms that are also seen in ASD children are disturbed emotional functions such as experiencing sudden fear, laughing for no reason, crying suddenly for no apparent reason, and sudden hitting movements ([Nugraheni, 2016](#)) and experiencing delays in executive functions which include self-control such as maintaining politeness in a social environment, working memory or keeping the information in mind, as well as cognitive flexibility or adjustment to a change such as a new idea or perspective ([Diamond, A., & Lee, 2011](#)). Most children with ASD have difficulty communicating, resulting in limited play, achievement, and social integration behavior. Executive function deficiency in autistic children significantly affects self-control adaptive behavior from social and emotional aspects ([Trimarco et al., 2020](#)). Thus, interventions to improve communication in children with ASD are critical to the success of a school and functional programs and real-world adaptation ([Prelock, P., Paul, R., & Allen, 2011](#)).

The exact cause of autism is unknown, but some experts argue that autism is caused by genetic and environmental factors that affect brain development ([Hodges et al., 2020](#)). Predictions to the [World Health Organization \(2021\)](#), there will be 1 in 160 children who have autism in 2018. The development of children's social, emotional, and executive functions must be monitored and monitored continuously. The development of social functions greatly influences the child's relationship with the environment, for example, interaction with other people, ways of communicating and adapting to the surrounding environment, as well as a learning process to form good social character and behavior ([Musyarofah,](#)

2018). Good management of emotional abilities in childhood can positively impact their adulthood, such as better well-being and adjustment, mental health and better career or workplace performance, and increased academic achievement (Cosso et al., 2022). The executive function must also be developed properly because it can help children improve cognitive abilities, think critically, store information (working memory), and improve their abilities to achieve goals and solve problems (Zulherma & Suryana, 2019).

Children with ASD that are increasing day by day require appropriate intervention. Some of the interventions that have been carried out include speech therapy, occupational therapy, physical therapy, behavioral interventions, and parents' autism intervention (Virués-Ortega, 2010; Wilson et al., 2021; Yazici, M. S., & McKenzie, 2019). An integrative approach has been recommended to help children with ASD gain a healthier quality of life and allow them to participate in other physical, social, and informal activities (Hochhauser, M., & Engel-Yeger, 2010; Klein, N., & Kemper, 2016). Children with ASD who actively participate in these activities have a better quality of life than children who do not participate (Billstedt, E., Gillberg, I. C., & Gillberg, 2011).

Based on those situations, each of these therapies effectively improves the development of ASD sufferers. However, some of these interventions still focus on one function only. So other interventions are needed that include emotional, social, and executive functions of children with ASD. Interventions that can be done are through martial arts. Interventions through exercise and physical activity have improved their motor function (Busti Ceccarelli et al., 2020; Duquette et al., 2016; Hassani et al., 2020; Huang et al., 2020; Ruggeri et al., 2020; Sorensen & Zarrett, 2014). Based on the research results on swimming and martial arts programs in children with ASD, it is stated that there are benefits to social interaction and communication (Bahrami et al., 2012; Epp, 2008; Pan, 2010). Martial arts traditionally consist of rigidity of physical movements, teamwork, respect for others, self-discipline, and complex cognitive abilities

(Movahedi et al., 2013) to improve their emotional, social, and executive functioning abilities.

However, until now research examining the role of self-defense in children with ASD is still very few and limited. For example, martial arts training in taekwondo for children with autism can improve children's concentration, control emotions, obey the coach's orders, and interact with the surrounding environment (Damayanti et al., 2018). Mixed martial arts (MMA) can improve social skills and reduce social dysfunction in children with ASD (Phung & Goldberg, 2021).

The Kata technique is one of the techniques in karate that is done by using imagery movements against the opponents (Filingeri et al., 2012). Movements in the Kata technique also do not involve noncontact combat (Doria et al., 2009). This technique's movement is appropriately trained in children with ASD. Therefore, this research is needed to examine the impact of karate on children with ASD. This study used "kata" technique training as a Japanese martial art style namely karate which can reduce stereotyped behavior (Bahrami et al., 2012) and social dysfunction in children with ASD (Movahedi et al., 2013). In addition, because stereotyped behavior can be associated with executive function, it can also reduce executive dysfunction in children with ASD, namely being able to control and exercise self-control (Chan et al., 2013).

METHOD

This research consisted of screening stages, baseline data collection, training, intervention data collection, and data analysis. This research was conducted at SLB Lab UM from July to August 2021. The purposive sampling was used with the criteria of respondents aged 8-12 years. After the screening process, a research sample of 4 boys with ASD with mild to moderate autism levels and no history of other disabilities was obtained. The Single Subject Research (SSR) method was used with an A-B design that includes two research stages: baseline and intervention. The baseline stage is the observation stage, where the respondent is in an initial state and has not received any treatment. Observations at this stage were

carried out to observe the development of children's social, emotional, and executive functions before receiving intervention in the form of karate training. Parents made observations about who often interacted with their children for two weeks. Parents observed their social, emotional, and executive aspects during the observation period.

Furthermore, parents gradually filled out the questionnaire as a research instrument one time per week to answer the research objectives. Next is the intervention stage, where respondents will receive treatment in karate training for six weeks. Data was collected using a questionnaire adapted from ICD-10 and DSM-IV once a week. This study used a questionnaire consisting of 15 closed questions adapted from the International Classification of Diseases (ICD-10) by WHO and the Diagnostic and Statistical Manual (DSM-IV) by the American Psychiatric Association (Nugraheni, 2016). The questionnaire has been tested for content validity through expert judgment by karate material experts, psycho-social experts, and experts on children with special needs before being given to the sample. The data that has been obtained is then graphed to be analyzed descriptively and interpreted.

This study obtained 8 data were, 2 data before training (observation stage) and 6 data from training (intervention stage). The A-B design consists of an observation stage (A) before training and an intervention stage (B) during karate training. Furthermore, the already available data is processed and presented in the form of a line chart. The data analyzed was obtained from filling out the questionnaire from their parents. Then the data was analyzed using the Single Subject Research (SSR) model to document the changes that occurred before and after the training using a line graph. The data that has been processed and presented is data that affects the executive, social, and emotional dysfunction of children with ASD.

As for the training process, the research sample received 18 training sessions for 30-45 minutes in 6 weeks. In the first week of training, participants are given an introduction and training in basic movements in the form of a punch that leads to the solar plexus (oi-zuki-chudan). In the

2nd week, they are given training on punch movements that lead to the mouth or face (oi-zuki-jodan). In week 3, the research sample was asked to practice the gedan-barai parry movement. In the 4th week, the agi-uke parry was introduced, parried the oi-zuki-jodan punch. In the 5th week, the research sample performed the uchi-ude-uke parrying movement which parried the oi-zuki-chudan blow. In the 6th week, they practice the soto-ude-uke parry movement which blocks the oi-ziki-chudan movement.

Results of the questionnaire were then analyzed using percentages to describe each developmental function. It is also calculated based on the total, standard deviation, and mean.

RESULT

This study aimed to examine the effect of karate training on the emotional, social, and executive functions of children with ASD. The study reports can be seen in table 1:

Table 1. Description of social, emotional, and executive function data

Weeks	N	Social			Emotional			Executive		
		Σ	SD	\bar{X}	Σ	SD	\bar{X}	Σ	SD	\bar{X}
1	4	38	1	10	39	0.95	10	40	0.82	10
2	4	38	0.57	10	35	0.95	9	37	1.5	9
3	4	37	1.5	9	33	0.5	8	36	0.82	9
4	4	36	1.15	9	29	0.5	7	31	0.95	8
5	4	32	0.82	8	30	0.57	8	30	0.57	8
6	4	33	0.95	8	31	0.5	8	28	1.15	7
7	4	31	0.95	8	29	0.95	7	29	0.5	7
8	4	29	0.95	7	28	1.15	7	27	0.95	7

In the first week, the social function value was obtained with a total value of 38 with an average of 10 and a standard deviation of 1. A consistent decrease occurred until the fifth week, with a total value of 32 with a standard deviation of 0.82 and an average of 8 points. Although there was an increase of 1 the number becomes 33 in the following week (sixth week), the total and average scores tend to decrease again until they touch an average of 7.

The same thing also happened to emotional function, where in the first week, the total score was 39, and the average score for the whole

sample was 10. In the fifth and sixth weeks, the total score rose to 30 and 31, respectively. In both weeks, the average group's average score also increased to number 8. Meanwhile, until the last week, the average value decreased again at number 7. Different conditions occurred in executive functions where the total score consistently decreased from 40 in the first week and ended at 27 in the week 6th after training. The group means decreased from 10 in the first week to 7 in the sixth week after training.

In general, the development trend of emotional, social, and executive dysfunction in children with ASD has decreased as shown in the figure below:

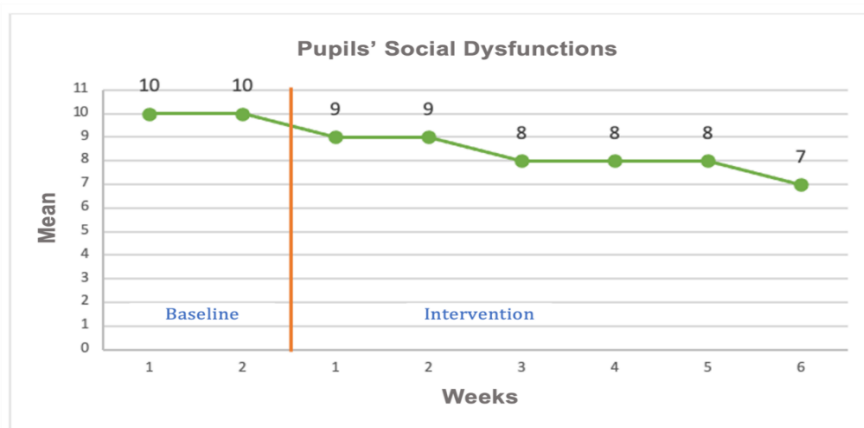


Figure 1. Development of social dysfunction in students

Based on the development graph above, it can be seen that social dysfunction in children with autism has decreased. At the baseline stage or before being given intervention in the form of karate training, it was seen that the development of social dysfunction in children with autism was consistent at number 10. There was no change in the initial condition of the sample before karate training. Furthermore, the sample was given intervention in karate training three times a week. From the first to the second week, the average development of social function in children with autism was number 9. However, in the third to sixth week of the intervention period, it was seen that the average development of social function in children with autism improved. This can be seen from the graph, which tends to decline consistently. So it can be concluded that social dysfunction

in children with autism has decreased along with the provision of intervention in karate training.

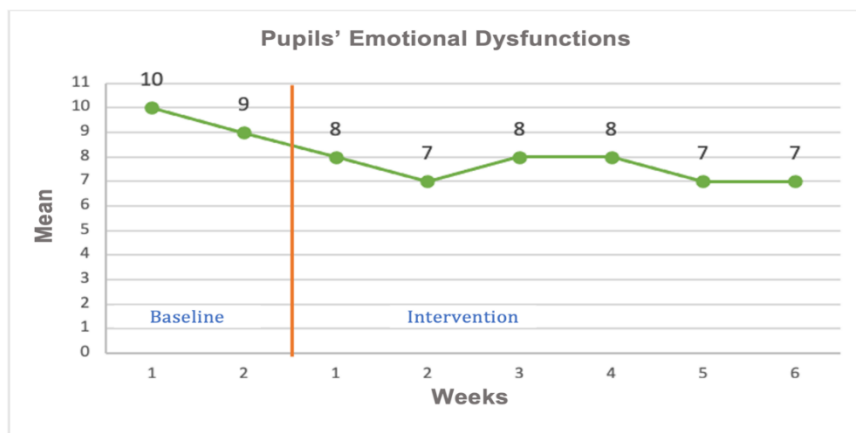


Figure 2. The development of emotional dysfunction in students

Based on the development graph above, it can be seen that emotional dysfunction in children with autism appears to be decreasing. At the baseline stage or before being given intervention in the form of karate training, it was seen that the development of emotional function in children with ASD was consistent in the range of numbers 10 to 9. This means that there was no significant change in the initial condition of the sample before karate training. Furthermore, the sample was given intervention in karate training three times a week. In the first week, the average development of emotional function in children with ASD was 8. However, in the third to sixth week of the intervention period, it was seen that the average development of emotional function in children with ASD improved. This can be seen from the graph, which tends to decline consistently. So it can be concluded that emotional dysfunction in children with autism decreased along with the intervention in the form of karate training.

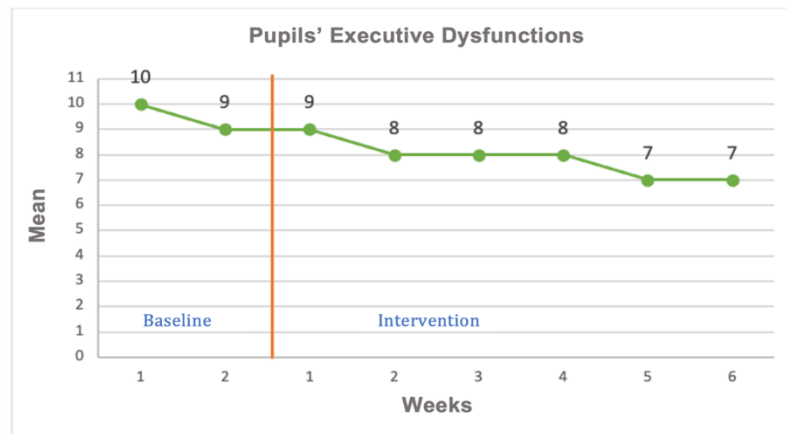


Figure 3. The development of executive dysfunction in students

Based on the development chart above, it can be seen that executive dysfunction in children with autism appears to be decreasing. At the baseline stage or before being given intervention in the form of karate training, it was seen that the development of executive function in children with autism was consistent in the range of numbers 10 and 9. This means that there was no significant change in the initial condition of the sample before karate training, furthermore, after being given intervention in the form of karate training three times a week. In the first week, the average development of executive function in children with autism was 9. However, in the third to sixth week of the intervention period, it was seen that the average development of executive function in children with autism improved. This can be seen from the graph, which tends to decline consistently. So it can be concluded that executive dysfunction in children with autism has decreased along with the provision of intervention in karate training.

DISCUSSION

This study showed an increase in the number of social, emotional, and executive functions in ASD children involved in this study. For children in general and children with ASD, executive, social, and emotional abilities are needed in their growth and development. Executive ability includes cognitive processes responsible for behavior when achieving certain goals, so executive abilities are very important for the learning development

process in children (Kashfi et al., 2019). Executive Function (EF) is a complex, non-unitary construct tapping several multiple and distinct cognitive processes that may follow different developmental patterns.

Social abilities play the main role in the development of children in the community, including academic achievement, social interaction, and participation in existing activities or activities (Rios & Scharoun Benson, 2020). Children's emotional abilities, which include self-control, will help them behave positively and regulate their thoughts, learning, and actions (emotions as regulators) (García-Andrés et al., 2010). Therefore, if children with ASD have these three abilities and do not get the proper intervention, it will further hamper their daily growth and development.

Traditionally, interventions through martial arts could improve their emotional, social, and executive functioning. In this study, it was found that martial arts intervention in the form of karate training was able to have an impact on children with autism (Movahedi et al., 2013). This study is in line with another research by (Bahrami et al., 2012) which showed that karate training improved communication deficits in children diagnosed with ASD. This condition is also supported by the results of research from (Greco & De Ronzi, 2020) on twenty-eight children with ASD who participated in the Karate training program showing that treatment for children with developmental disorders can be done through sports, one of which is karate which can help improve the motor behavior characteristics of children with ASD and their social skills. Karate training can better develop executive functions, social behavior, and emotions. That study shows executive functions such as cognitive abilities, working memory, and inhibitory control began to improve. In addition, social and emotional behaviors such as communication, cooperation, and involvement have also increased (Greco & De Ronzi, 2020). Interventions with martial arts positively affect ASD-related symptoms with effect sizes ranging from moderate to high, so martial arts should be included in a rehabilitation program to help with ASD symptoms (Zou et al., 2017). Martial arts-based interventions positively impacted ASD-related symptoms (e.g., social interaction/communication

skills, self-regulation, memory, postural control, and cognitive function) with effect sizes ranging from medium to high (Zou et al., 2017). Students can improve mental endurance through other martial arts such as Pencak silat (Nur Kholis, 2016).

Martial training programs can be included in physical education learning in schools. Finding longitudinal project by (Oakley et al., 2021) indicates that physical well-being and school support for ASD are key priorities for clinical research and practice. Therefore, support from the school, peers, and teachers s needed to enhance the mental, social, and motor development of students with disabilities (Widyawan, 2020). A teacher can also involve children without disabilities in a martial art program. It can contribute o positive experiences for all involved (Bell et al., 2016).

CONCLUSION

Karate training in children with autism has been shown to reduce emotional, social, and executive dysfunction in children with ASD. This research also strengthens the belief that martial arts can impact several aspects of the development of children with autism. This research is not without flaws.

Although, in general, the results show a positive contribution from the existence of karate training for children with autism, this study itself has several limitations, especially regarding the small sample involved. Further research related to the impact of karate on children with ASD still has to be developed with a more significant number of samples of children with autism and a longer duration of time, so it is expected to strengthen this study and previous studies. Further research on other variables that influence the results of reducing social, emotional, and executive dysfunction also needs to be known to control variables outside of treatment or treatment.

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REFERENCES

- American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. American Psychiatric Publishing.
- Bahrami, F., Movahedi, A., Marandi, S. M., & Abedi, A. (2012). Kata techniques training consistently decreases stereotypy in children with autism spectrum disorder. *Research in Developmental Disabilities, 33*, 1183–1193. <https://doi.org/10.1016/j.ridd.2012.01.018>
- Bell, A., Palace, K., Allen, M., & Nelson, R. (2016). Using martial arts to address social and behavioral functioning in children and adolescents with autism spectrum disorder. *Therapeutic Recreation Journal, 50*(2). <https://doi.org/10.18666/trj-2016-v50-i2-7287>
- Billstedt, E., Gillberg, I. C., & Gillberg, C. (2011). Aspects of quality of life in adults diagnosed with autism in childhood: A population-based study. *Autism, 15*, 7–20.
- Busti Ceccarelli, S., Ferrante, C., Gazzola, E., Marzocchi, G. M., Nobile, M., Molteni, M., & Crippa, A. (2020). Fundamental motor skills intervention for children with autism spectrum disorder: a 10-year narrative review. *Children, 7*(11), 250. <https://doi.org/10.3390/children7110250>
- Chan, A. S., Sze, S. L., Siu, N. Y., Lau, E. M., & Cheung, M.-C. (2013). A Chinese mind-body exercise improves self-control of children with autism: a randomized controlled trial. *PLoS ONE, 8*(7), 68184. <https://doi.org/10.1371/journal.pone.0068184>
- Cosso, J., de Vivo, A. R. R., Hein, S., Silvera, L. P. R., Ramirez-Varela, L., & Ponguta, L. A. (2022). Impact of a social-emotional skills-building program (pisotón) on early development of children in colombia: a pilot effectiveness study. *International Journal of Educational Research, 111*(August 2021), 101898. <https://doi.org/10.1016/j.ijer.2021.101898>
- Damayanti, P., Sy, M. A. R., & Suherman, M. M. (2018). Pengaruh beladiri taekwondo terhadap kemampuan komunikasi dan prestasi anak dengan gangguan autis. *FOKUS, 1*(6), 110–116.
- Diamond, A., & Lee, K. (2011). Interventions Shown to Aid Executive Function Development in Children 4 to 12 Years Old. *Science, 333*, 959–964.
- Doria, C., Veicsteinas, A., Limonta, E., Maggioni, M. A., Aschieri, P., Eusebi, F., Fanò, G., & Pietrangelo, T. (2009). Energetics of karate (kata and kumite techniques) in top-level athletes. *European Journal of Applied Physiology, 107*(5), 603–610. <https://doi.org/10.1007/s00421-009-1154-y>
- Duquette, M.-M., Carbonneau, H., Roullet, R., & Crevier, L. (2016). *Sport and physical activity : Facilitating interventions with young people living with an autism spectrum disorder*. 4(June), 4--49. <https://doi.org/10.16926/par.2016.04.05>

- Epp, K. M. (2008). Outcome-based evaluation of a social skills program using art therapy and group therapy for children on the autism spectrum. *Children and Schools*, 30, 27–36.
- Filingeri, D., Bianco, A., Zangla, D., Paoli, A., & Palma, A. (2012). Is karate effective in improving postural control? In *Archives of Budo* (Vol. 8, Issue 4, pp. 203–206). Medical Science International. <https://doi.org/10.12659/AOB.883521>
- García-Andrés, E., Huertas-Martínez, J. A., Ardura, A., & Fernández-Alcaraz, C. (2010). Emotional regulation and executive function profiles of functioning related to the social development of children. *Procedia - Social and Behavioral Sciences*, 5, 2077–2081. <https://doi.org/10.1016/j.sbspro.2010.07.416>
- Greco, G., & DE RONZI, R. (2020). Effect of karate training on social, emotional, and executive functioning in children with autism spectrum disorder. *Journal of Physical Education and Sport*, 20(4), 1637–1645. <https://doi.org/10.7752/jpes.2020.04223>
- Hassani, F., Shahrbanian, S., Shahidi, S. H., & Sheikh, M. (2020). Playing games can improve physical performance in children with autism. *International Journal of Developmental Disabilities*, 0(0), 1–8. <https://doi.org/10.1080/20473869.2020.1752995>
- Hochhauser, M., & Engel-Yeger, B. (2010). Sensory processing abilities and their relation to participation in leisure activities among children with high-functioning autism spectrum disorder (HFASD). *Research in Autism Spectrum Disorders*, 4(4), 746–754.
- Hodges, H., Fealko, C., & Soares, N. (2020). Autism spectrum disorder: definition, epidemiology, causes, and clinical evaluation. *Translational Pediatrics*, 9(1), 55.
- Huang, J., Du, C., Liu, J., & Tan, G. (2020). Meta-Analysis on Intervention Effects of Physical Activities on Children and Adolescents with Autism. *International Journal of Environmental Research and Public Health*, 17(6).
- Kaplan, H., Sadock, B. J., & Grebb, J. (1996). *Sinopsis of Psychiatry*. Williams & Wilkins.
- Kashfi, T. E., Sohrabi, M., Saberi Kakhki, A., Mashhadi, A., & Nooghabi, M. J. (2019). Effects of a Motor Intervention Program on Motor Skills and Executive Functions in Children With Learning Disabilities. *Perceptual and Motor Skills*, 126(3), 477–498. <https://doi.org/10.1177/0031512519836811>
- Klein, N., & Kemper, K. J. (2016). Integrative approaches to caring for children with autism. *Current Problems in Pediatric and Adolescent Health Care*, 46(6), 195–201.
- Movahedi, A., Bahrami, F., Marandi, S. M., & Abedi, A. (2013). Improvement in social dysfunction of children with autism spectrum disorder following

- long term Kata techniques training. *Research in Autism Spectrum Disorders*, 7, 1054–1061. <https://doi.org/10.1016/j.rasd.2013.04.012>
- Musyarofah. (2018). Pengembangan Aspek Sosial Anak Usia Dini Di Taman Kanak-Kanak Aba Iv Mangli Jember Tahun 2016. *INJECT (Interdisciplinary Journal of Communication)*, 2(1), 99. <https://doi.org/10.18326/inject.v2i1.99-122>
- Nugraheni, S. A. (2016). Menguak Belantara Autisme. *Buletin Psikologi*, 20(1–2), 9–17. <https://doi.org/10.22146/bpsi.11944>
- Nur Kholis, Moh. (2016). Aplikasi Nilai-Nilai Luhur Pencak Silat Sarana Membentuk Moralitas Bangsa. *Jurnal SPORTIF*, 2(2), 76–84.
- Oakley, B. F., Tillmann, J., Ahmad, J., Crawley, D., San, A., Cáceres, J., Holt, R., Charman, T., Banaschewski, T., Buitelaar, J., Simonoff, E., Murphy, D., & Loth, E. (2021). How do core autism traits and associated symptoms relate to quality of life? Findings from the Longitudinal European Autism Project. *Autism*, 25(2), 389–404. <https://doi.org/10.1177/1362361320959959>
- Pan, C. Y. (2010). Effects of water exercise swimming program on aquatic skills and social behaviors in children with autism spectrum disorders. *Autism*, 14(1), 9–28.
- Phung, J. N., & Goldberg, W. A. (2021). Mixed martial arts training improves social skills and lessens problem behaviors in boys with Autism Spectrum Disorder. *Research in Autism Spectrum Disorders*, 83(February), 101758. <https://doi.org/10.1016/j.rasd.2021.101758>
- Prelock, P., Paul, R., & Allen, E. (2011). Perawatan Berbasis Bukti dalam Komunikasi untuk Anak-anak dengan Gangguan Spektrum Autisme. In *Perawatan berbasis bukti untuk anak-anak dengan Autisme* (pp. 93–170). Springer US.
- Rios, P. C., & Scharoun Benson, S. M. (2020). Exploring caregiver perspectives of social and motor skills in children with autism spectrum disorder and the impact on participation. *Frontiers in Psychology*, 11(June). <https://doi.org/10.3389/fpsyg.2020.01260>
- Ruggeri, A., Dancel, A., Johnson, R., & Sargent, B. (2020). The effect of motor and physical activity intervention on motor outcomes of children with autism spectrum disorder: A systematic review. *Autism*, 24(3), 544–568. <https://doi.org/10.1177/1362361319885215>
- Saxena, A., & Chahrour, M. (2017). Autism Spectrum Disorder. *Genomic and Precision Medicine: Primary Care: Third Edition*, 301–316. <https://doi.org/10.1016/B978-0-12-800685-6.00016-3>
- Sorensen, C., & Zarrett, N. (2014). Benefits of physical activity for adolescents with autism spectrum disorders: a comprehensive review. *Review Journal of Autism and Developmental Disorders*, 1(4), 344–353. <https://doi.org/10.1007/s40489-014-0027-4>

- Trimarco, B., Manti, F., Nardecchia, F., Melogno, S., Testa, M., Meledandri, G., Carducci, C., Penge, R., & Leuzzi, V. (2020). Executive functioning, adaptive skills, emotional and behavioral profile: A comparison between autism spectrum disorder and phenylketonuria. *Molecular Genetics and Metabolism Reports*, 23(February), 100577. <https://doi.org/10.1016/j.ymgmr.2020.100577>
- Virués-Ortega, J. (2010). Applied behavior analytic intervention for autism in early childhood: Meta-analysis, meta-regression and dose–response meta-analysis of multiple outcomes. *Clinical Psychology Review*, 30(4), 387–399.
- Widyawan, D. (2020). Inklusi dalam pendidikan jasmani: perspektif siswa penyandang disabilitas. *Jurnal SPORTIF: Jurnal Penelitian Pembelajaran*, 6(3), 746–762. https://doi.org/10.29407/js_unpgri.v6i3.14891
- Wilson, M., Whelan, T., Milne, L., Hamilton, D., Jacobs, D., & Pilkington, P. (2021). A thematic analysis of influences on parents' autism intervention decisions. *Research in Developmental Disabilities*, 117(February). <https://doi.org/10.1016/j.ridd.2021.104035>
- World Health Organization. (2021, June 1). *Autism spectrum disorders*. <https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders>
- Yazici, M. S., & McKenzie, B. (2019). Strategies used to develop socio-communicative skills among children with autism in a turkish special education school and implications for development of practice. *International Journal of Disability, Development and Education*, 1–21.
- Zou, L., Xiao, Z., Wang, H., Wang, C., Hu, X., & Shu, Y. (2017). Martial arts for health benefits in children and youth with autism spectrum disorder: a systematic review. *Archives of Budo*, 13, 79. www.archbudo.com
- Zulherma, & Suryana, D. (2019). Peran executive function brain dalam perkembangan kemampuan kognitif anak usia dini pada kurikulum 2013. *Jurnal Pendidikan Tambusai*, 3(2), 648–656.